OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

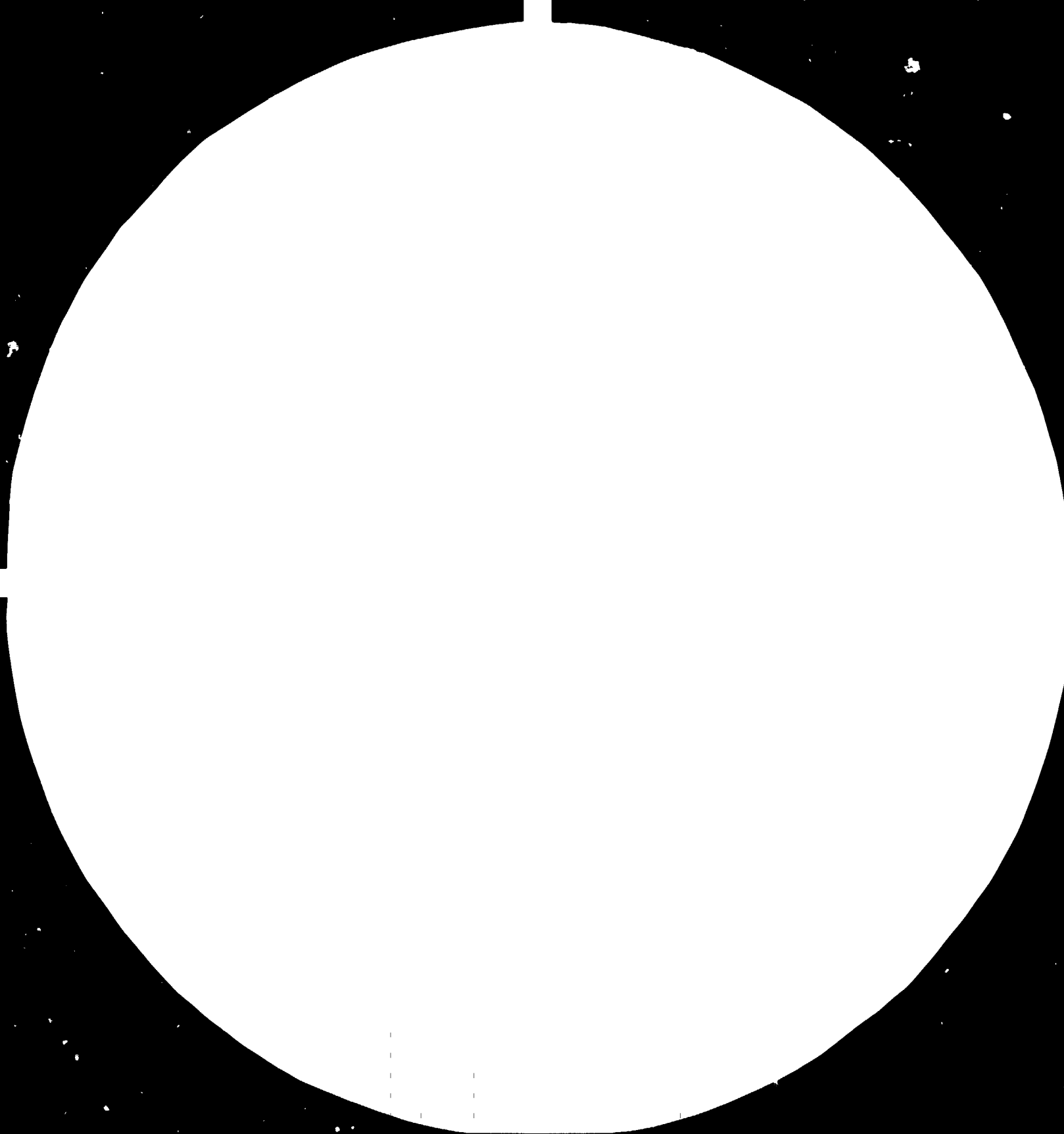
FAIR USE POLICY

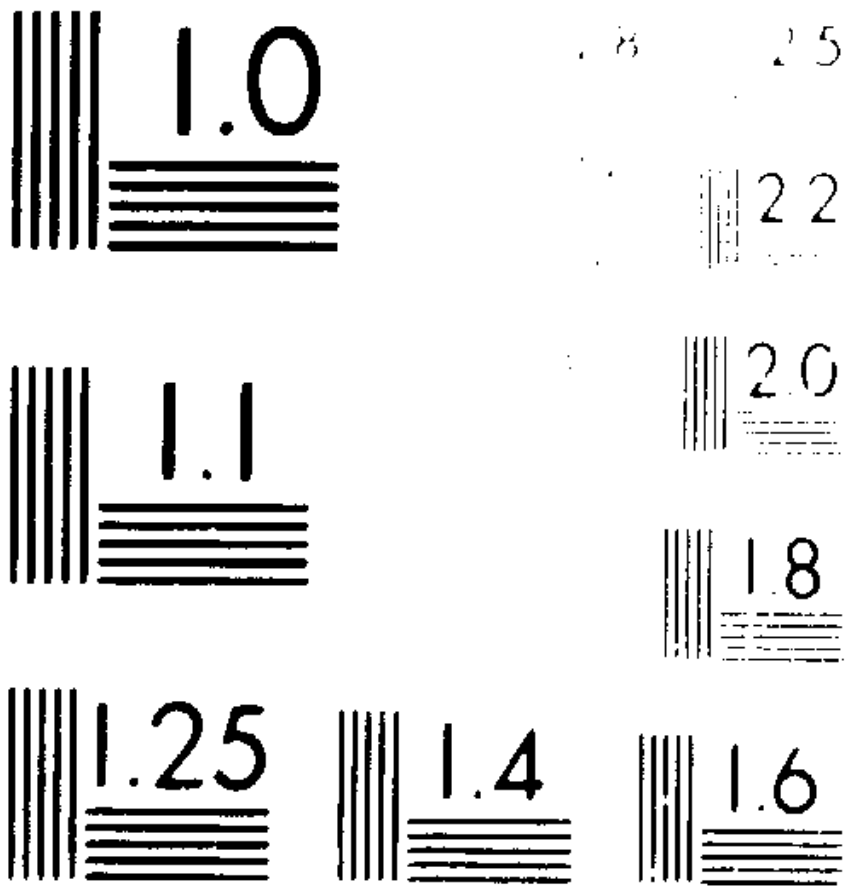
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org




1.0
2.5
2.2
1.1
2.0
1.8
1.25
1.4
1.6

12249

Distr.
RESTRICTED

UNIDO/IO/R.41
3 November 1982

ENGLISH

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

TECHNICAL EVALUATION OF LOW POWER TRACTORS IN KENYA

US/KEN/78/268

REPUBLIC OF KENYA

Final report *

Prepared for the Government of the Republic of Kenya
by the United Nations Industrial Development Organization

Based on the work of D. Bordet of
the Centre d'Etude et d'Expérimentation du Machinisme
Agricole Tropical (CEEMAT) under UNIDO subcontract No. 80/40 to CEEMAT

* The views expressed in this paper are those of the author and do not necessarily reflect the views of the secretariat of UNIDO.

This report has been reproduced without formal editing.

V.82-33334

ACKNOWLEDGEMENT

The author wishes to thank the Ministry of Agriculture, government of Kenya, most sincerely for the valuable assistance rendered during his thirteen-month stay in Kenya to study the aspects of small tractors testing and manufacture.

Special thanks are due to Mr. M.M. MUKOLWE, Head, Land Resources Development Division, Ministry of Agriculture, Mr. KITHEKA, Head, Soil Conservation Services and A.M.T.U. station, Dr. P.M. MISIKO, Head, Agricultural Eng. Dpt. Egerton College, without their interest in the project, this report would never have achieved its present form.

I am also grateful to Mr. BEKELE, UNIDO Representative and Mr. PEDERSEN, Junior Professional Officer, Nairobi, Mr. T.B. MUCKLE, H. OTTEN Mr. S. POLLARD, Experts on the F.A.O. Agricultural Equipment Improvment Project, for their precious help.

Lastly, I wish to thank MM. W. M'UNGALA, G. KAGANE for their friendly collaboration.

TABLE OF CONTENTS

INTRODUCTION

C.E.E.M.A.T. has been contacted by UNIDO to provide assistance to the government of KENYA in carying out the project : "Technical Evaluation of Low Power Tractors". The project has taken place in the Agricultural Mechanization Testing Unit, Nakuru, between the 23rd of March, 1981 and the 22nd of April 1982. This report aims at recalling the different stages of the project and giving its main findings and recommendations.

SUMMARY AND CONCLUSION

1. Testing activities

A reasonable amount of small tractors of different makes, countries of origin, technology of fabrication have been tested by the A.M.T.U. and it is thought that the criteria to be considered for the selection of the most suitable tractor are well known. But these criteria can vary a lot according to the great variation of the set of conditions (altitude, rain, soil, crops) that can be encountered in Kenya.

2. Manufacturing prospects

Thus the main constraint to the extension of small tractors in Kenya is not technical but, obviously, economical.

The small tractor market in Kenya is at the moment very low : less than 40 tractors sold per annum. There could be a potential market of about 200 hundred tractors a year if the class of farmers cultivating between 20 and 100 hectares could have an access to small tractor distributing, repairing and maintaining facilities. One could expect an even greater potential market if an institutional effort was made to provide loans to individuals or groups of farmers, or to replace conventional tractors by small tractors when it is possible.

This could be sufficient, from an industrial managing point of view, to justify the setting up of a small tractor assembly plant in Kenya, providing that such assembly plant would be integrated in a larger unit producing some other agricultural implements ; in that case some of the operations already performed by some agricultural machinery manufacturers - such as cutting, welding, simple machine tooling, painting - could be applied to the tractor manufacture, using local or imported raw material, thus producing additional value inside Kenya. This could be followed in later stages of the project by the importation of new manufacturing equipment and new technologies in the manufacturing process, since the human and financial capacities to do so seem to be here.

In fact, it appears that nothing could be implemented in that field if the government does not provide financial assistance to the farmers as well as to the manufacturers and dealers who are ready to take the risk of the manufacture, and if the eventual newly created market was not protected institutionally (restriction of imports, taxes ...). But this is obviously a costful policy ...

1. WORK REPORT

The work of the Project Coordinator in Kenya has been as follows :

- 23, March 1981 :

  . Arrival Nairobi

- April, May 1981 :

  . Réception and purchase of the project equipment, mounting and first adjustments of the measuring devices.

  . First adjustments and modifications of the MOUZON tractor, drivers training and first tests in A.M.T.U. station.

  . Contacts with the Ministries of Agriculture and Industry.

- June, 1981 :

  . Mouzon tests outside A.M.T.U. (field tests).

- July, 1981 :

  . Delivery of the BOUYER tractor, first adjustments and modifications (linkage).

- August, September, 1981 :

  . Field tests of BOUYER modifications

  . Test of BOUYER in various conditions (ploughing test)

  . Comparative tests of BOUYER, MOUZON and other tractors

- October, November, 1981 :

  . Last field tests of BOUYER and MOUZON (harrowing-cultivating)

  . Mid-term C.E.E.M.A.T. consultant's mission, analysis of tests results, meetings with Development, Extension and Industrial organization, new work schedule.

  . BOUYER dynamometer test.

- December 1981, January, February 1982 :

  . Drawing up of the test reports

  . Documentation on Kenyan farming systems, Kenyan industrial network, testing procedures

  . Drawing up the low power tractor test code report

- February, March 1982 :

  . Analysis of possible local manufacture
  . Contacts with governmental, non-governmental organizations
  . Survey of Kenyan agricultural machinery manufactures
  . Setting up of BOUYER long-life test and extension work

- April, 1982 :

  . Drawing up of preliminary analysis of possible manufacture report
  . Transfer of project equipment

2. DELIVERY AND TRANSFER OF THE PROJECT EQUIPMENT

2.1. Delivery

The equipment (specified in annex F of the contract and equipment specification report, August 1980) was delivered according to the following schedule :

- The measuring instruments were received on the project site (A.M.T.U., Nakuru) at the beginning of May.

- The project vehicle, a locally assembled pick-up, was ordered after the expert's arrival in Kenya, and was delivered in June.

- The BOUYER tractor, with implements and spares had been sent to Kenya one year before the project implementation, to the University of Nairobi, Faculty of Agricultural Engineering. This tractor was transfered to the project site in mid-july.

- The MOUZON tractor, implements and spare parts were delivered a few months before the expert's arrival on the project site and were in a good state.

2.2. Transfer (at the end of the project)

As this point was not specified in the contract, the Project Coordinator decided to transfer the equipment as follows :

- The BOUYER tractor, two-furrow plough, tine cultivator and spares have been given to a non-government organization, in the area of Eldoret, for following up the long-life test.

- The MOUZON tractor and implements have been given to the Agricultural Training Institute,Egerton College, Njoro.

- The pick-up vehicle has been sold in Nakuru.

- The testing equipment has been re-exported back to C.E.E.M.A.T., France

3. BACKGROUND OF THE PROJECT

3.1. Relation with Kenyan authorities

Initially, C.E.E.M.A.T. had been asked through UNIDO by the Department of Mechanical Engineering, University of Nairobi to provide assistance in the field of Small Tractors Evaluation - cf contract, annex E, substantive terms of reference dated October 79 - In June 1980, a contract was signed by UNIDO and CEEMAT, the project equipment was purchased and shipped to Kenya.

Due to the withdrawal of the Faculty of Agricultural Engineering, the Ministry of Agriculture involved itself with the implementation of the project. The Land Resources Development Division offered the facilities of the A.M.T.U. (Nakuru), and appointed all the necessary staff to work on the project (unskilled workers, mechanics and counterpart engineer). The relations with the A.M.T.U. staff and the Division Hq. have been constantly good during the project time.

Relations with the Ministry of Industry have also been good, but due to lack of personal, have been limited to meetings and exchanges of views.

3.2. Relations with non-governmental organizations

The project took place in A.M.T.U. where the F.A.O. Agricultural Equipment Improvement Project was also stationed. The work relations have been good, and the discussions about methods and findings of the project occured frequently.

The Coordinator was also in touch with some non-governmental organizations which were doing some extension work in rural area, and were interested in small tractors. Tests have been effected with their assistance.

4. TESTING ACTIVITIES

4.1. Testing facilities

The expert has been able to use the mechanical workshop of the A.M.T.U. which was being fitted up with the help of the F.A.O. project team. The testing equipment purchased by the project was limited, but the A.M.T.U. as well as the Egerton College, situated not far from Nakuru, provided all the equipment to perform the necessary tests.

4.2. Result of the tests

For full details, see the Low Power Tractors Test Report, published under UNDIO/IO/R.37.

The expert was in charge of testing the BOUYER and MOUZON tractors. To sum up very shortly, we would say that the BOUYER tractor has been working satisfactorilly, but not the MOUZON tractor. The first one has been developed since almost 10 years and provides sufficient power, good traction under hard conditions ; but it has been necessary to make a few modifications (linkage, additional weights) to obtain good results. The second tractor is still a prototype and is not delivering a sufficient power at high altitude, and was more difficult to operate.

They both have been tested under very different field conditions, but due to the first results, only the BOUYER tractor has been tested with a dynamometer, and on a long-life test basis.

But the expert could not limit himself to the testing of these two tractors, as they are not the only low-power and simplified tractors proposed for the development of African farming systems, and they represent specific technological solutions which need to be compared to others. Some comparative tests have been effected with the SWARAJ 720 and FIAT 300 tractors. It would have been also very interesting to make comparative tests with the EICHER-GOODEARTH and TINKABI tractors which were in A.M.T.U. But they were out of use, due to important breakages or missing parts.

The expert was often asked to give advice in selecting the best tractor, suitable to Kenyan conditions, but it is quite impossible to answer this question, due to various reasons :

- it is difficult to evaluate all the tractors comparatively, unless they are all tested the same day in the same field, or unless the testing procedure allows to collect datas about the variable parameters of the test conditions, which was not technically possible to do in A.M.T.U.

- different tractors may each one of them represent the best solution for different solutions (e.g. a heavy tractor is more suitable for heavy works, but will waste fuel in light works ; a high ground clearance is helpful for weeding, but is not stable in slopy lands).

The best tractor does not exist, a compromise between the different characteristics of the tractor must be done to answer a wide range of conditions.

4.3. The test code report

The "Test Code for the Technical Evaluation of Low Powered Tractors in Africa" was written after the tests have been done. See publication under UNIDO/IO/R.38 for full details.

Taking into account the experience of the project, this report emphasized a few points :

- The proposed testing procedures are simple, in the way that they should suit what is technically possible to do in Africa. In particular, we limit the laboratory tests to the brake-dynamometer test because we think that this equipment is available in most African countries. For any other laboratory test the level of available test equipment is bound to the level of technology of the existing mechanical engineering manufacturing network in the country and to the level of the design and research realized by these manufacturers. Most African countries import PKD or CKD manufactured goods, do very little research, and have none of this testing equipment.

- The results of the test must be comparable, i.e. all the parameters varying during the test must be recorded. This is quite easy to perform during a dynamometer test, but not for a field test, and we believe that the field test is of a greater usefulness for the decision maker, making sure all necessary details have been provided for a comprehensive use of the report.

5. APPROACH OF THE SMALL TRACTORS POTENTIAL MARKET IN KENYA

5.1. The present market of small tractors in Kenya.

The total number of tractor sales recorded by the "Motor Trade and Allied Industries Association", which includes most of the tractor dealers in Kenya, is of 1116 tractors for 1981. Out of these, only 217 were less than 50 horsepower tractors. We estimate that in the range of 15 to 30 hp, which we are interested in, about 40 tractors only, or even less, have been sold. Out of these 40 tractors, some are conventional but low-powered tractors, most of which have been sold for horticultural or gardening purpose, and some are simplified tractors the design of which can cope with the needs of small farmers. But anyway very few of these tractors have been sold to farmers. Therefore, we can see that there is virtually no existing market for small tractors in Kenya, though at least four companies have been proposing to the customers different models for the last three years. The only actual - and small-market concerns only conventional tractors, due to the existence of the large farms sector and the tractor contractors who buy new or second-hand tractors.

But there might be, among small and average size farmers, a potential market for small tractors, which has not yet been explored by the distribution networks of the different companies which are present on the market.

5.2. Estimate of the small tractors potential market

C.E.E.M.A.T. has been studying a few projects of motorization in some West African Countries, where about 300 small tractors have been distributed or purchased by farmers. In these experiences, it has been ascertained that to be able to afford economically as well as technically the use of a small tractor, a farmer and his farm had to answer the 3 following conditions :

- His annual net income must be higher than an equivalent of 40 000 kenyan shillings.
- The area under cultivation (or planted) in this farm must be superior to 20 hectares.
- The farmer must own at least two pairs of oxen and two ploughs.

Explanation of these criteria :

- This minimum of 40 000/= is the annual fixed costs and operating costs of the tractor, calculated on a basis of a 5 year period of depreciation (see annex 2), supposing that the farmer would invest his whole net income in the tractor.
- A minimum cultivated acreage of 20 ha : a guarantee that the tractor will cope with the work requirement of the farm, and also that the farm can yield a minimum cashable produce.
- The owning of an important ox-drawn equipment and oxen shows the existence on the farm of a power constraints as well as a technical knowledge of the farmer favouring his access to more sophisticated forms of mechanization. (But we do not consider that, in Kenya, the development of small tractors should be supported by the class of farmers well equiped with ox-drawn equipment, this could be a way of jeopardizing the efforts in developing ox-drawn cultivation).

Let us try to apply these criteria to Kenya :

The number of kenyan farmers earning more than 40 000 shillings is difficult to evaluate and there is few accurate information about that.

In 1980 the CBS, Central Bureau of Statistics estimated that the number of farms covering more than 20 ha and less than 100 ha - we assume that, over 100 ha, a farmer would prefer a conventional tractor - was 906 (♦), without differenciating cultivated or planted acreage and not cultivated and not planted acreage in these farms.

On the other hand, A.M.T.U. and C.B.S. enumerated in 1981 (♦♦) about 4100 farmers owning more than two ploughs and two pairs of oxen (see annex 1).

Therefore, the most realistic evaluation of the small tractor potential market would be of less than one thousand tractors. It means that if the tractors were to be manufactured in Kenya, the average yearly production would be less than 200 hundred tractors, 5 years being the average life of a tractor.

5.3. Discussion

5.3.1. Small tractors for contracting

The question "why not to include in the small tractors potential market the private owners, not necessarily farmers, who would use their tractor on a hiring or contracting basis, like already some contractors with conventional tractors do ?" needs to be discussed.

The comparison of the cost of ploughing with small tractors and conventional tractors (annex 2 and 3) does not let appear an important difference between the two forms of mechanization : the small tractor plouhing cost varies between 350 and 600 K.Sh./per hectare and the conventional tr. ploughing varies around 500 K.Sh. per ha.

Compared to the present price of ploughing usually charged by private contractors (375 to 675 K.Sh. in ol Kalau area, 400 K.Sh. according to the C.D.M.U. of the Ministry of Agriculture) we can see that, the cost being almost equal to the return, there is vitually no profit for contractors.

(♦) Source : Statistical abstract, 1981, CBS

(♦♦) Source : National Farm Power Ownership Survey, Agricultural Economics Unit, AMTU, CBS data.

The reason why there still exist some private contractors working in Kenya is that most of them work with second-hand conventional tractors for which they do not have to pay a great cost of depreciation. The second-hand market offers conventional tractors at a price which is lower than the price of a new small tractor. For instance, the following prices have been recorded in march 1982 in Nakuru :

FORD 3600 (42 hp),	1975	: 50,000 K.Sh.
FIAT 850 (85 hp),	1976	: 50,000 K.Sh.
FORD 7000	1974	: 75,000 K.Sh.
FIAT 850 (85 hp),	1978	: 68,000 K.Sh.
I.H. 824 (69 hp),	1971	: 28,000 K.Sh.

The annex 4 shows the cost breakdown for a second-hand tractor bought at 65,000 K.Sh. For these tractors the ploughing cost of one hectare is 310 K.Sh., which is much better than for a small tractor, and allows making a profit with the above-mentioned contract ploughing charges.

Moreover the rate of work of a conventional tractor is twice to three time better than the small tractor one, allowing a better profit per hour for the entrepreneur.

This is the reason why we do not consider the group of the ploughing contractors to be a potential market for small tractors.

5.3.2. The association of small farmers and the credit facilities for tractor purchase

The grouping of small farmers for the purchase of a tractor could allow the access to that kind of mechanization to a larger number of farmers than the one we have recorded. But this kind of association seems to be unrealistic, for both sociological and institutional reasons, as the institutions do not provide any incentive support for it. The Agricultural Finance Corporation provides credit only for individuals and the Kenya Farmers Association, major supplier of agricultural equipment to Kenyan farmers does not offer special conditions for grouped purchases of a tractor.

The access to loans given by AFC for agricultural machinery is very difficult due to the problems AFC meets in being repaid - the amount of arrears for tractor loans was 665,000 shillings in March 1981.

The conditions required to obtain a loan are :

- minimum size of 40 hectares
- 25 % of the tractor new value as loan payment
- 5 years at 12 % rate of interest
- ownership title deeds superior to the price of the loan

And the AFC loan is the cheapest : a bank asks for 50 % down payment, 14 % rate of interest on 1 1/2 years.

As a result, in 1981, only 101 tractors loans have been approved by AFC, for the whole of Kenya.

Therefore, we cannot expect the market for small tractors to be enlarged if new credit schemes are not set up to help small farmers to buy expensive agricultural equipment. But in the present state of the repayments it is not very probable that the financing institutions will take this risk.

6. CHARACTERISTICS OF A SMALL TRACTOR SUITABLE TO KENYAN CONDITIONS

The suitability of a small tractor to Kenyan conditions can be analysed from two different points of view :

- the tractor must meet the needs of the farmer, his work requirements on the farm, and it must also cope with the repair and maintenance facilities in the rural areas.

- the tractor must suit the technical capacities of the local manufacturers of agricultural machinery with a view to a possible local assembly or a partial local manufacture.

The criteria of suitability which have been choosen in this report are the result of the expert's work in Kenya but also of the Agricultural Equipment Improvement Project (F.A.O.) experience and of the experience of C.E.E.M.A.T. in tropical countries.

6.1. The needs of Kenyan small farmers

The tractor should be able to cope with the major constraints to farming activities which have been identified. The first constraint experienced by the farmers is ploughing, another one is transportation.

Plougning is made mostly during the dry season when the soil is hard, difficult to penetrate and till ; without talking about the design of the plough, the tractor must offer a good balance and a good pulling capacity, i.e. enough adherence and power at the driving wheels.

For transport as well as for any other operation (harrowing, planting, weeding, stationnary work ...) the tractor design must also enable the linkage of the implements available in Kenya.

Considering that the small tractor should be used by farmers who have not yet got - or only few of them - any experience of motorization, this tractor should offer some characteristics of simplicity :

- simplicity of use and driving

- simplicity of design in order to decrease the risk of breakage and to facilitate any repair and maintenance operation, i.e. easy access, easy dismounting of any part to enable repairs in areas which are remote from the repairing workshop, or bring them to the workshop.

And a simple design is also a guarantee of low manufacture cost and purchase price.

6.2. The existing manufacturing facilities

A simple design is also the main feature required from a small tractor in view of local assembly or manufacture, in order to cope with the level of technology of the Kenyan manufacturers.

In the field of agricultural machinery the existing production in Kenya can be specified as follows :

- Hand tools or ox-drawn equipment manufacture for which Kenya is almost self-sufficient and can even export (to Uganda). The main problems of this manufacture are the poor quality of the steel, locally produced, and the ineffective control of the import of hand and ox-drawn tools (cf. The local manufacture and distribution of hand and ox-drawn farm tools, S. POLLARD, A.M.T.U. 1981).

- Heavy sheet-iron work or metallic construction for some agro-industrial projects (pipes, valves, tanks, silos, rollers ...).

- Tractor, engine, gearbox or any other item assembly. This activity is more a typical importer's activity than a manufacturer's one. The rate of import taxes being 30 % for CKD equipment and 65 % for built up units, most of the importers prefer to import CKD kits. But, considering the tractor assembly, only the few importers who sell a sufficient number of tractors, say more than 100 a year, i.e. only 5 or 6 importers out of a total of 26, have afforded to set up an assembly plant. In fact these assembly plants do more PKD kits assembly than C.K.D

- Manufacture of tractor implements and stationnary, eng or p.t.o. driven equipment (ploughing and tilling equipment, planters, trailers, rotary mowers, hammer mills ...).

This manufacture mainly consists of cutting, welding, sheet iron work, simple machine tooling - lathing, grinding, slotting, drilling - and painting. Some of the manufacturers are equipped with a small foundry producing low quality grey cast iron, only small parts for non heavy duty work. None of them can produce high quality foundry or perform machining of castings, banding, forging, heat treatment or specific machining. Only some mechanical engineering companies, which are not specialized in agricultural machinery, can perform some of these operations but with some manufacturing equipment working on very specific patterns, and to answer a very specific demand (e.g. : Dynamics Engineering Ltd. produces leaf springs - forming, oil bath heat treatment, tempering - for the truck assembly plants).

Therefore, these agricultural equipment manufacturers mostly do frame building with locally produced mild steel sections (recycled scrap iron) on which they mount imported elements : hardened soil contacting parts, shaves, tines, blades, discs, bearings, gearbox, rims, hydraulic components. See in Annex 5, the list and prices of the major agricultural equipment manufacturer in Kenya.

In fact most of the manufacturers who have been met emphasized the difficulty for them to go further in the manufacturing process, i.e. to invest in more sophisticated technology and industrial equipment. This can be due to the lack of government policy in that field :

- lack of protection of the market for the Kenyan products which allows the penetration of imported goods at cheaper price.

- lack of quality raw material - hard steel, alloys - which must be imported costfully, due to the payment of import taxes.

- lack of incentive for the industrial investments in Kenya (exoneration of taxes).

Nevertheless, it is felt that some manufacturers would be able to develop their activities, as they have the technical knowledge to master new technologies and they seem to have capitals ready for investment.

Apart from the agricultural machinery sector we must mention the Kenya Railways Chief Mechanical Engineer's Workshop's Nairobi, which provide manufacturing facilities which are far above what is existing in Kenya and bordering countries. The foundry can produce more than 2,000 tons of iron, brass or other alloy castings each year, some of these made by shell moulding. The blacksmith shop handles hammering heat forming, punching, shearing and heat treatments. The machine shop provides machining for any size of casting or metal section, lathing boring, surface and cylindrical grindings, shaping, slotting, planning, drilling, milling. The machining of most of the dies and tools used in these workshops are made by their own toolshop. It is believed that the Railways workshops could go through most of a small tractor manufacturing process including gears cutting and hardening, casings foundry and machining, rims forming, assembly jigs building. Only some parts of the engine should be imported (injection, carburettor, distribution, head cylinder). The Railways workshops are used to answer specific orders for the production of any part from other Kenyan manufacturers ; they can also redesign a given element or analyse the quality of a given metal sample in their laboratory.

6.3. The characteristics of a small tractor suitable to Kenya.

6.3.1. Engine

The engine should be a diesel engine, with two cylinders to avoid the vibrations damageable to the structures of the tractor.

The engine with a big cylinder capacity and a slow rev. speed (less than 2400 r.p.m.) will have a longer life and a good torque for heavy works.

The fuel consumption is a very important choice criterion, according to its increasing part in the running costs. A good specific consumption should not be higher than 190 g/h hp. at a nominal rev. and full load (diesel engines).

The filtrating systems will be widely dimensionned :

- at least one oil bath air filter
- fuel filter with changeable cartridge and decantation bowl.

The coolant can be water, with a large enough radiator, or air, with an easy access to the cooling fins for cleaning.

The engine power, measured at the p.t.o. should be over 18 horsepower (13. 2KW) to cope with the loss of power at high altitudes (20 % loss at an altitude of 2 000 m).

The engine should be started by hand to avoid the use of an electrical system, important source of breakage.

6.3.2. Transmission

A mechanical transmission is the most long lasting type (more than belt transmission) and is more suitable for repair and maintenance than a hydraulic transmission.

The clutch should be larger than necessary to avoid quick wearing off with unskilled drivers.

The gearbox : straight spur gears can easily be made in Kenya and heat treatment can also be made.

A minimum of four forward gears, one reverse should be provided by the gear arrangement.

The back axle : a differential lock will be necessary if the weight on the driving wheels is relatively low.

The back axle must be able to bare the additionnal weight required for heavy works.

A single axle is sufficient, provided there is enough adherence on this axle (see size of the wheels, weight).

6.3.3. Power take off

A power take off is necessary. It should be of a standard type (1 3/8", 540 r.p.m.), centrally mounted, gear driven, and designed so that it can deliver the full power of the engine.

6.3.4. Linkage, lifting system

The implement attachment should be a three-point linkage, conform to the standard category ISO n° 1, as many tractor implements of that kind are already made in Kenya.

The hydraulics cannot be avoided for the lifting systems. A single effect hydraulic cylinder is the simplest and no depth or draft control system on the hydraulic command is required.

A drawbar or a hook, suitable for hauling a 2 ton trailer is required.

6.3.5. Chassis

The chassis made of simple straight mild steel sections, locally available, allows the manufacture of small series and avoid the use of expensive castings.

A carriage platform at the front of the tractor, suitable for 500 Kg load, is an asset in rural areas where transport is always needed.

The wheel track should be of more than 120 cm for a minimum stability and the possibility of use of a standard I implement. An adjustable track is also required.

The ground clearance underneath the axles should not be less than 40 cm to allow row-crop cultivation on lately grown crops.

But a compromise must be realized between ground clearance, height of the gravity centre above the ground and track, to make sure that the tractor can be used safely in slopy lands.

The wheels must offer an adhesion suitable to the power delivered by the engine as well as a good ground clearance under the reducers and the axle. A minimum size of 10" x 24" is required.

6.3.6. Weight

The weight on the driving wheels must be sufficient to offer a good adhesion, according to the various conditions of work. A weight of 35 Kg per horsepower on the driving axle is sufficient for light work (planting, weeding ...), 60 Kg/hp are required for heavy work (ploughing, harrowing). Additional weights must be made available to adjust the axle weight to the work effected and also to get a good balance of the tractor working (front weights).

7. RECOMMANDATIONS

7.1. Agricultural Machinery market study

It is at the moment very difficult to get an accurate estimate of the potential market for agricultural machinery, used at farm level, in Kenya. The only well-known sector is the conventional motorization sector, related to the existence of large farms. But the needs of the small farm sector (96,5 % of the farms cover less than 8 hectares) are very badly known. We propose a study of the potential market for various agricultural implements, based on the evaluation of the needs of small farms, which means :

- Analysis of the farming systems, for each agro-ecological area.

- Analysis of the constraints to farming systems, which can be solved by mechanization.

- Analysis of the mechanized solutions to these constraints which can be proposed.

- Evaluation of the number of machines that could meet the identified needs, with different hypothesis, high, mean, or low hypothesis covering whole or half, or a quarter of the needs, on 5, 10 or 15 years planning.

- Choice of the most sensable hypothesis, according to government policy in the field of agricultural machinery, and to macro-economical conditions in Kenya.

This study should be effected under the authority of the Central Bureau of Statistics, Ministry of Econc..ic Planning and Development. C.B.S. has already collected many data and manages an efficient sample surveying network in Kenyan rural areas. It is believed that this study would be an helpful instrument for the agricultural machinery manufacturers as well as for development planners.

7.2. Agricultural Machinery private industry and distribution survey

Provided these manufacturers would agree to collaborate, a survey of the agricultural machinery sector would be an instrument for the elaboration of the government policy in that field. This study would include :

- a census of agricultural machinery makers, and mechanical engineering companies supplying them, with the characteristics of these : investments, employment, level of technology, main products, outputs.

- the supply of raw material ; costs, quality ; local makes and importations.

- manufacturing cost of some agricultural implements.

- the organization of the distribution ; geographical areas ; repair and maintenance facilities.

National Farm Power Onwership Survey 1981. C.B.S.

- - : less than 0,5% or 0,005
- A : % of households owning the item
- B : average number of items per household
- C : % of households owning both one plough and one pair of oxen
- D : % of households owning both two ploughs and two pairs of oxen

District	Total number of household	Jembes (hoes)		Ploughs		Oxen		Tractors			
		A	B	A	B	A	B	A	B	C	D
KILIFI	79350	94	3.7	-	-	-	-	-	-	-	-
KWALE	49350	84	3.4	0.9	0.009	1.2	0.03	-	-	-	-
TAITA-TAVETA	28834	93	3.1	2	0.016	2.4	0.1	-	-	-	-
MACHAKOS	166025	95	2.8	43	0.44	30	0.68	-	-	21.8	1.0
KITUI	83816	91	3.0	31	0.37	14	0.33	-	-	8.7	-
EMBU	45380	68	1.3	11	0.11	18	0.44	-	-	6.0	-
MERU	135371	37	0.7	2	0.03	1.9	0.04	-	-	0.7	-
NYERI	88670	68	1.6	-	-	-	-	-	-	-	-
MURANGA	123657	74	1.6	0.9	-	2.5	0.05	-	-	-	-
KIRINYAGA	51132	48	0.7	12	0.12	17	0.52	-	-	8.6	0.7
KIAMBU	125978	68	1.1	-	-	-	-	-	-	-	-
NYANDARUA	39106	93	2.8	-	-	-	-	-	-	-	-
NAKURU	80940	94	2.7	1.5	0.01	-	-	0.9	0.01	-	-
NANDI	56442	90	2.4	23	0.24	23	0.57	-	-	9.1	-
KERICHO	114894	79	1.8	33	0.34	26	0.65	-	-	15.6	1.2
UASIN GISHU	46516	88	2.5	4.4	0.04	7.9	0.22	0.9	0.01	1.0	-
TRANS NZOIA	42463	94	2.7	3.0	0.03	2.6	0.07	1.3	0.01	0.9	-
BARINGO - LAIKIPIA	63037	82	2.3	1.0	0.01	4.3	0.12	-	-	-	-
WEST POKOT - ELGEYO-M.	61178	93	2.6	6.6	0.07	12	0.21	-	-	1.7	-
S. NYANZA	130739	86	3.1	43	0.43	34	0.94	-	-	21.4	-
KISII	135765	97	3.0	24	0.25	22	0.40	-	-	14.5	-
KISUMU	62540	93	3.4	11	0.13	12	0.35	0.9	0.01	4.9	-
SIAYA	38290	99	2.8	13	0.13	16	0.40	-	-	5.8	-
KAKAMEGA	199344	98	2.7	8.7	0.09	10	0.30	0.8	0.01	4.9	-
BUNGOMA	88130	98	3.0	37	0.37	34	0.83	-	-	22	-
BUSIA	49951	100	2.9	16	0.17	15	0.40	-	-	9.2	-
KAJIADO-NAROK	58163	70	1.9	5.2	0.05	20	0.70	-	-	4.2	-
KENYA	2,273, 784	84	2.4	12.5	0.12	12	0.3	0.31	0.0031	5.86	0.18

- Only 0.31% of kenyan households own a tractor, which gives an estimate number of 7155 tractors operated in Kenya.

- 5.86% of the households, i.e. 133300 households, have one pair of oxen and one plough, and uses ox drawn cultivation constantly.

ANNEX 2

Small tractor cost breakdown (Kenyan shillings)

Tractor

	per annum	per hour
• Capital repayment purchase price : 67 000* - 10% residual value: 6700 to be depreciated : 60 300 over 5 years, 700 hours per annum	12 060	17.2
• Interest 10% 5 years	3 850	5.5
• Repair and maintenance (100% new value)	12 060	22.4
• License, insurance, housing (3% n.v.)	2 000	1.4
• Fuel (2 litres/hour, 5.29K.Sh./hour)	7 410	10.6
	37 380	53.4

Plough

• Repayment purchase price : 8700 * - 10% residual value: 870 to be depreciated : 7830 5 years, 500 hours/annum	1 570	3.1
• Interest 10% 5 years	500	1.
• Repair and maintenance (50% h.r.)	785	1.6
	2 855	5.7
	40 235	59.1

Cost of one hour of ploughing : 59.1 K.Sh. / hour

Cost of one hectare ploughed, average condtions (6 hours/ha): 355/=

difficult conditions(10 hours/ha):591/=

* Source: A.M.T.U. Small tractors invitation for tenders november 1981,average price of the tenders.

ANNEX 3

Con entional tractors (80 hp) cost breakdown

Tractor

	per annum	per hour
• Capital repayment purchase price 190 000* - 10% residual value 19 000 to be depreciated 171 000 (5 years, 700 hours/year)	34 200	48.9
• Interest 10% rate	10 910	15.6
• Repair and maintenance (100% n.v.)	34 200	48.9
• License, insurance (3% h.v.)	5 700	8.1
• Fuel (125g:hp. hour x 80=10Kg.hour) 10 x 4 sh/Kg	28 000	40.0
	113 010	161.5

Plough

• Repayment (16 000* - 10%) (5 years 500 hours)	2 880	4.1
• Interest 10%	920	1.3
• Repair and maintenance (50% n.v.)	1 440	2.1
	5 240	7.5
	118 250	168.

Cost of one hour ploughing : 168 K.Sh./hour
Cost of one hectare ploughed : 504 K.Sh./hectare (3 hours/ha)

• Price charged by private contractors in ol KALAU area, mouldboard ploughing :

one hectare ploughed: 375 to 625 K.Sh. (old land and new land

• Usual contract charges: *

Breaking new land	: 450 per hectare	(disc ploughing)
First ploughing	: 350 " "	" "
Second ploughing	: 300 " "	" "
mouldboard ploughing	: 400 " "	" "

* Source: yeld cost prices 1981, Ministry of Agriculture
Central Development and Marketing Unit.

ANNEX 4

Second hand conventional (80 hp) tractor cost breakdown

Tractor

	per annum	per hour
• Capital repayment 65 000, no residual value (5 years, 700 hours/year)	13 000	
• Interest 10%	4 150	
• Repair and maintenance (150% n.v.)	19 500	
• License insurance (3% n.v.)	1 950	
• Fuel	28 000	
	66 600	95.1

Plough

• Repayment	2 880	
• Interest	920	
• Repair and maintenance	1 440	
	5 240	7.5
	71 840	102.6

Cost of one hour ploughing : 102.6 K.Sh./hour

Cost of one hectare ploughed:307.8 K.Sh./hectare

ANNEX 5

NDUME LIMITED, GILGIL

PRICE LIST

W.E.F. 15.5.81.

RETAIL PRICES :

Ndume disc plough

1.	2 Furrow disc plough	SHS. 12,600
2.	3 Furrow disc plough	SHS. 16,500
3.	4 Furrow disc plough	SHS. 19,000
4.	5 Furrow disc plough	SHS. 23,500

KIFARU HARROW :

5.	16 x 22" Disc trailed with screw lift operated wheels	SHS. 34,000
6.	18 x 22" Disc trailed with screw lift operated wheels	SHS. 36,600
7.	20 x 22" Disc trailed with screw lift operated wheels	SHS. 38,100
8.	22 x 22" Disc trailed with screw lift operated wheels	SHS. 39,600

KIFARU HEAVY DUTY :

9.	16 x 24" Disc trailed with screw lift operated wheels	SHS. 36,700
10.	18 x 24" Disc trailed with screw lift operated wheels	SHS. 38,400
11.	20 x 24" Disc trailed with screw lift operated wheels	SHS. 40,100
12.	22 x 24" Disc trailed with screw lift operated wheels	SHS. 41,800

++ All these harrows can be supplied with hydraulic operated wheels instead of screw lift at an extra cost of ..... SHS. 6,000

NDOVU HARROW :

13.	24 x 22" Disc trailed with hydraulic wheels	SHS. 65,300
14.	26 x 22" Disc trailed with hydraulic wheels	SHS. 66,700
15.	28 x 22" Disc trailed with hydraulic wheels	SHS. 68, 00
16.	30 x 22" Disc trailed with hydraulic wheels	SHS. 69,500
17.	24 x 24" Disc trailed with hydraulic wheels	SHS. 67,700
18.	26 x 24" Disc trailed with hydraulic wheels	SHS. 69,300
19.	28 x 24" Disc trailed with hydraulic wheels	SHS. 71,000
20.	30 x 24" Disc trailed with hydraulic wheels	SHS. 72,500

.../...

MBOGO HARROW :

21.	12 x 22" Disc mounted	SHS.	12,650
22.	14 x 22" Disc mounted	SHS.	15,500
23.	16 x 22" Disc mounted	SHS.	16,775
24.	18 x 22" Disc mounted	SHS.	17,600
25.	20 x 22" Disc mounted	SHS.	18,700
26.	22 x 22" Disc mounted	SHS.	21,175

TRAILERS - AGRICULTURAL/GENERAL PURPOSE :

27.	4 Ton non tipping - body size : 11 x 6' x 1.9" Tyre size : 10 x 750 x 16	SHS.	22,000
28.	4 Ton tipping - body size : 11 x 6' x 1.9" Tyre size : 10 x 750 x 16	SHS.	25,000
29.	7 Ton non tipping - body size : 14 x 7' x 1.9" Tyre size : 900 x 20 x 12 ply	SHS.	44,000

SEEDRES/PLANTERS :

30.	9 FT seed drill	SHS.	45,000
31.	9 FT tooth harrow suitable for above	SHS.	3,000
32.	Maize planter manual	SHS.	900

GYROMOWERS :

33.	Ndume jungle buster 60"	SHS.	21,000
34.	Ndume jungle buster 72"	SHS.	23,000

WELDERS :

35.	Ndume tractor mounted welder	SHS.	18,000
36.	Ndume bare shaft welder	SHS.	12,000
37.	Hand shellers	SHS.	550
38.	Wanjiko kuni stove	SHS.	2,400

MILLS :

39.	Dunia hand operated mill	SHS.	900
40.	N.D. 20 mill	SHS.	5,500
41.	N.D. 30 mill	SHS.	11,500
42.	G.M 40 mill	SHS.	12,000

++ The above mill prices are inclusive of sales tax.

BIBLIOGRAPHY

1. Trends in Smallholder Mechanization in Kenya.
   A report on a survey of the market for small scale mechanization devices.
   by C.P. CROSSLEY, N.C.A.E., May 1978, 30 pages.

2. Agricultural census of large farms, 1978
   Central Bureau of Statistics.
   Ministry of Economic Planning and Development.
   August 1980, 52 pages.

3. Statistical Abstracts 1980 and 1981.
   C.B.S.

4. Agricultural Machinery Production and Use : Country Paper for Kenya.
   by Gichuki MUCHIRI.
   Chairman, Dpt of Agricultural Engineering.
   University of Nairobi, May 1981, 98 pages.

5. Development of Agricultural Machinery Industry in Kenya.
   Ministry of Industry. 29 July 1980.

6. Economic Survey 1981.
   C.B.S.

7. Yelds - Costs - Prices, 1981.
   Ministry of Agriculture.
   Central Development and Marketing Unit. April 1981,
   256 pages.

.../...

8. Background paper on upgrading existing foundry, forging, ... for the manufacture of selected agricultural machinery in eastern and southern African countries.

   by A.K. MITRA
   ADIS ABEBA 20/3/ 82, 29 pages.

9. The local manufacture and distribution of hand and ox-drawn farm tools

   S. POLLARD A.M.T.U. 1981, 5 pages.
   by C.K. WAINAINA

10. National farm power awnership survey - Summary by district.

    A.M.T.U., Feb. 1982, 9 pages.

11. Kenya mechanization cost index.

    by C. KIMANI, A.M.T.U. NAKURU December 1981.

12. Etude sur l'équipement agricole au Kenya.

    by D. MAUGEST, H.E.C., PARIS.

13. Test report of low power tractors, UNIDO/IO/R.37

14. Test code for the technical evaluation of low power tractors in Africa, UNIDO/IO/R.38

15. Preliminary analysis of possible local manufacture of low power tractors in Kenya, UNIDO/IO/R.39

ORGANIZATION VISITED

Organization visited	Personnel consulted
Ministry of Industry	Mr. F.N. ONDIEKI, Permanent Secretary Mr. J.E.O. MWENCHA, Principal Project Officer Mr. S.S. GILL UNIDO ADVISER
KENYA INDUSTRIAL ESTATES LTD, NAIROBI KENYA INDUSTRIAL ESTATES LTD, NAKURU	Mr. ALUCHIO DEPUTY CHIEF Engineer Mr. BASKHAR MECHANICAL Engineer
MINISTRY OF AGRICULTURE	Mr. M.M. MUKOLWE Chief Land Ressources Development Division
AGRICULTURAL FINANCE CORPORATION	Mr. ORWA ONG'IRO Ag. Head
FACULTY OF ENGINEERING, UNIVERSITY OF NAIROBI	Pr. A.V. OTIENO, Dean Pr. G. MUCHIRI, Chairman Dpt. of Agr. eng. Pr. A. WEBER Dpt. of Agr. Economics
KENYA INDUSTRIAL RESEARCH AND DEVELOPMENT INSTITUTE, KIKUYU	Mr. B.N. MAJISU, Director
KENYA INDUSTRIAL TRAINING INSTITUTE	Director
AGRICULTURAL DEVELOPMENT CORPORATION	
FARMERS TRAINING CENTRE, BARINGO	Mr. KIMARU, Director
EGERTON COLLEGE, NJORO	Pr. P.M. MISIKO, Head Agricultural Engineering Department
THE MOTOR TRADE AND ALLIED INDUSTRIES EMPLOYERS ASSOCIATION, NAIROBI	Mr. KIBWAGE
PROVINCIAL PLANNING OFFICE, EMBU	Mr. S. WIGGINS

.../...

EICHER GOODEARTH LIMITED, NAIROBI	Mr. S.S. BRARA
HOLMAN BROTHERS (E.A.) LTD, NAIROBI	Mr. A.W. DYER- MELVILLE Managing Director Mr. D.M. GARNER Sales Director
GREEHAM KENYA LTD, NAIROBI	Mr. R.W. HUMPHREYS, ADVISER Mr. GRAHAM, DIRECTOR
MASSEY FERGUSON, NAIROBI	Mr. P.D. KUNIHIRA Manager Technical Sales
KENYA FARMERS ASSOCIATION AGRICULTURAL MACHINES LTD, NAKURU	Mr. L.K.M. KIPTUI ASSISTANT General Manager
DYNAMICS ENGINEERING LTD	Mr. M.S. SASTRY, General Manager Mr. D.D. SHARMA, Marketing Manager
NDUME INDUSTRIES, GILGIL	Development Manager
BURNS AND BLANE, NAIROBI	Mr. R. HUNT, Chief Engineer
KENYA RAILWAYS, NAIROBI	Mr. E.K. NGURE , Dep. Chief Mechanical Engineer Mr. MBAGO, Workshop Manager
EASTERN MOTORS LTD	Sales Manager
SUN UNIVERSAL ENGINEERING CO Ltd	Mr. G.W. GICHUKI
SMALL FARM MECHANIZATION	Mr. J. WAINAINA
INDUSTRIAL RESEARCH AND CONSULTANCY UNIT	Mr. G.O. NYANGASI, Director