CHAPTER 6

AGRICULTURAL MECHANIZATION POLICIES & STRATEGIES IN KENYA

by

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INTRODUCTION

The agricultural sector is the most important in Kenya's economy, as it employs about 70% of the country's population, produces about 30% of the GDP, and 60% of the foreign exchange earnings are obtained by export of agricultural commodities. Further, a large proportion of the manufacturing industry relies on raw materials from the agricultural sector. The current population is estimated at about 22 million increasing at quite a high rate of about 4% per annum and is expected to be about 35 million by the year 2000 AD. The urban population which was only 9% of the total population in 1965, is now about 25% of the total population and is growing at an even faster rate of about 7% per annum. At this rate, it is expected that by the year 2000, there will be about 10 million people living in urban areas, (almost the same as total population in 1965) who will need to be fed from food produced in the rural areas. At independence in 1963, Kenya inherited a dual size structure agricultural sector, which had quite a sophisticated large scale commercial sector, dominated by the white settlers, and a small scale sector dominated by African farmers, who were largely subsistence farmers, but also there was an emerging small scale commercial farming sector which was becoming increasingly important in the economy of the country. In order to appreciate the framework under which agricultural mechanization policies have been formulated in Kenya over the past 30 years, and the implementation strategies adopted, it is necessary to give a brief background on the changes which have occurred in the agricultural sector over the past 3 decades. This paper begins therefore by giving a brief historical overview of the structure of the agricultural sector at independence, policies which were adopted by the Government of Kenya then with the objective of incorporating more African farmers in the commercial agriculture sector, and the impact of these policies on the agricultural mechanization scenario in Kenya. Next the current status of agricultural mechanization will be presented, together with the problems which have constrained increased utilization of mechanical and draught animal technologies. This analysis will also include, an examination of the agricultural machinery industry in Kenya, as well as, the institutional framework within which agricultural mechanization technologies are provided to farmers and finally we shall attempt to project the likely scenario for the future in so far as agricultural mechanization is concerned. Compared to other African countries,

in so far as agricultural mechanization is concerned, Kenya presents an interesting case; for the use of mechanical technologies in agriculture is as old in Kenya as perhaps in some of the European advanced countries. There are however other physical, technical and economical factors which have greatly influenced the pace of agricultural mechanization in particular that of small holder farmers and this has made the level of agricultural mechanization in Kenya to be similar to the situation pertaining in other African countries.

AGRICULTURE IN KENYA DURING COLONIAL PERIOD

During the colonial period, agriculture in Kenya was carried on, under two separate systems. On one hand, there were about 3000 white farmers who had been allocated large tracts of land in the high and (the so called "scheduled" lands) and medium potential areas of Kenya and who grew cash crops for export or food crops for feeding the emerging and increasing urban population. Many of these farmers had been officers in the British Army who had been demobilized and given the land by the Colonial Government. The "scheduled" lands were reserved for European farmers and covered about 2.9 million hectares. On the other hand, the African native farmers, were engaged in subsistence agriculture in the "unscheduled" areas, which were mostly in the low and medium potential areas. These unscheduled lands comprised of about 13 million hectares of land. The main crops grown on the white highlands included coffee, tea, pyrethrum, wheat, maize as well as dairy and beef production. The African farmers on the unscheduled lands grew mainly maize, sorghum, pulses and were also engaged in livestock production mostly for subsistence and for meeting of social obligations. African farmers were not allowed to grow cash crops such as coffee, tea, wheat, etc. for fear of introducing plant diseases which could have affected the white farms. The holdings on the unscheduled areas were often fragmented and the land was basically communally owned. Many of the African farmers on these unscheduled lands or "reserves", were employed as labourers on the European farms. The European farms were capital intensive and from 1945, most of them were highly mechanized. The tractor population in the country increased from less than 1000 tractors by 1940 to over 6000 tractors by 1960. Prior to the introduction of tractors, draught animals were used (this technology was imported from South Africa) and the 'victory' plough was the common tillage implement.

Due to, among other things, the pressure for land, in particular in the Central Province, where a significant proportion of the scheduled lands were located, the *"Maumau"* war broke out in the early 1950s, and the Kikuyu tribe was the main one involved in this struggle. At this time also the Colonial Government had formed a commission, to study ways and means of improving agriculture in the unscheduled areas. This commission came up with the so called Swynnerton Plan (Swynnerton (1954)). This plan called for intensification of agriculture through cultivation of cash crops such as coffee and tea previously cultivated primarily by Europeans, and livestock production

through improved cattle for dairying. The plan also emphasized the need for the African farmers, in addition to cultivating commercial crops, to grow their own food. In addition the plan recommended a campaign to promote land consolidation and enclosure, in the unscheduled areas, issuance of land titles, with the broad objective of enabling farmers to use these titles for obtaining credit, and enabling the more progressive farmers to buy out those farmers who were incapable of developing their own holdings. In the lower potential areas the Swynnerton plan called for improvements in livestock production through better marketing channels to increase offtake levels; controlled rotational grazing, development of rangelands through provision of watering points and eradication of the tsetse fly as well as controlling the stocking levels. The period between 1954-1962 was therefore used to implement this plan, and land consolidation and registration was undertaken throughout the unscheduled areas. Further African farmers started growing cash crops - coffee, tea, pyrethrum, in addition to growing their own food. There was also intensification of livestock production through dairying, and some horticultural production.

The consolidation of the fragmented land holdings into plots varying in size from 1.5 ha to 10 ha, and the adopted farm layout and plans for each individual holding (there were two standard farm layouts) as well as the fact that perennial cash crops such as coffee and tea were introduced, and grown by the farmers, has severely restricted the mechanization options in these unscheduled areas to either handtool or animal powered technologies in exceptional areas. This is particularly the case in the high potential areas where a significant proportion of the population lives. The process of consolidation and layout of farms was however constrained by lack of adequately trained manpower and other logistical problems. Therefore although many farms had been registered and title deeds issued, the actual surveying and laying out of the farms took a long time to complete. By the end of 1965 a total of 1.631 million acres had been consolidated and registered (GoK (1967)).

AGRICULTURE IN KENYA AFTER INDEPENDENCE

With attainment of independence in 1963, the whole question of land took a different turn. The British Government had provided a loan to the independent Kenya Government for purchasing some of the land owned by the European settlers in the so called "white" highlands (the scheduled areas). This land was intended to be taken over by African farmers and by 1969 about 800,000 hectares had been taken over in this way. This land which was taken over by African farmers was farmed at four different levels. The high density settlements which were primarily designed to accommodate the landless and unemployed and the size of the individual holdings here was in the region of about 12 ha, and about 300,000 ha were settled under this category (Maina & MacArthur 1970). The second category was the low density settlements which were intended for farmers with some advanced agriculture and who could provide some working capital. The average size of the holdings here was about

20 ha. By 1970 about 100,000 ha. of previously owned white highlands had been settled in this way. The third way was through the 'Yoeman' farms scheme where experienced African farmers with substantial amount of capital were assisted to acquire some European farms and run them as medium scale farms (50 ha - 100 ha). They were provided with loans from the Government. The fourth way was by individual African farmers, or syndicates of Africans, grouped in cooperatives or companies, purchasing land from Europeans through their own capital funds and loans secured from Agricultural Credit Banks and Commercial Banks.

The acquisition of large individual farms for settlement of either smallholders, or medium scale African farmers, often led to a marked drop in output and income due to the time required for new farmers to adjust to the new farming system. In addition acquiring these farms was rather an expensive undertaking and led to a review of this policy in the late 1960s. It was felt then that the settlement schemes were benefiting only a few farmers in relation to the whole population still remaining in the unscheduled areas, and it would have been better to spend more money to improve the agriculture in these unscheduled areas where a majority of the African farmers lived. In addition in view of the importance of the large scale farms in producing the required cash crops for export, as well as the marketed food crops, it was felt that it would have been better to avoid subdividing these farms to small holders as this was likely to have a serious impact on commercial agriculture. From the late 1960s therefore, a policy whereby Africans were encouraged to form syndicates or cooperatives to purchase the large farms and run them as commercial entities was encouraged. (de Wilde (1967), Maina & MacArthur (1970), Mercer (1970), Clayton (1973)). A number of medium scale and large scale farming ventures run by African farmers were therefore established in the late 1960s and early 1970s and these have significantly influenced the pace and form of agricultural mechanization policies in Kenya (Mercer 1970, Mettrick 1970).

AGRICULTURAL MECHANIZATION POLICIES IN KENYA

As noted above, Kenya has had a dual size agriculture, with a large scale farm sector, originally dominated by European settlers and a small farm sector dominated throughout by African subsistence farmers and who also grow some cash crops. The large farm sector was after independence in 1963 taken up by African farmers, or was used for small holder settlement schemes. The commercial large scale farmers grow cash and food crops for the market and their farms are located in the high potential areas of Kenya. The major steps towards the mechanization of Kenyan agricultural followed the arrival of European settlers. Indigenous and improved varieties of oxen were trained for transport and other farm tasks including ploughing, harrowing and ridging. They became the main source of draught power on large farms, though still heavily supported by hand labour for many operations. The first tractors were introduced on a few large farms in the 1920s but they were widely adopted

only from the time of World War II when great efforts were made to raise agricultural output. In 1945 the number of tractors and combines in use in Kenya was still small, but by 1960 they had risen to 6400 and 1000 respectively. They were owned almost entirely by large farmers or contractors working in the large farm sector.

Tractors were first used by the small farmers in the 1950s in Kericho district. This was a consequence of the consolidation of the small holdings and this led to some of the more progressive farmers being able to acquire tractors for their own use and for hiring to their neighbours. Some small and medium scale farmers in the Central Province also acquired tractors following the consolidation of land as a result of the Swynnerton plan. The Government also assisted by establishing a tractor hire unit which had a few tractors. Through its soil conservation unit the Government set up a soil conservation service machinery unit with the following objectives:

(a) To ensure that every acre of cultivated agricultural land is maintained at its maximum level of production, consistent with the use of appropriate soil and water conservation measures.

(b) To bring more land into agricultural production by:

- applying appropriate conservation treatments;
- implementing drainage measures;
- providing dams and water holes in marginal areas;
- planning minor irrigation projects in areas with irrigation potential.

(c) To be responsible for informing farmers and agriculturalists on the appropriate conservation techniques and requirements and to carry out services in accordance with approved plans and conservation principles.

This was part of the overall Swynnerton plan. After independence in 1963 and the initiation of the programme of settling smallholder farmers on formerly European owned land (the million acre settlement scheme), this increased the demand for tractor hire services for primary cultivation (Mettrick 1970). During the first year of settlement and to ensure timely land preparation, virtually all the settlers had several acres of their newly acquired land plowed for them by tractors provided by the settlement department or hired by this department from private contractors. The cost of this operation was defrayed out of the portion of the loan earmarked for crop establishment. In subsequent years, a large number of these settlers, who had previously in their reserve farms relied on hand hoe and animals for primary cultivation, once they had experienced the convenience of mechanization continued to rely on tractors for seedbed preparation (de Wilde 1967, Mettrick 1970, Clayton 1973). Thus the demand for tractor hire services increased quite significantly

during the period 1963-69. The Government therefore, decided to launch a programme whereby small farmers could be assisted to acquire tractors through provision of credit. Through a loan provided by the World Bank through IDA; 210 tractors and auxiliary equipment were purchased by farmers (mostly small scale) between 1967 and 1968. There was little training of the farmers on the technical maintenance of these tractors as well as economical use of the same. The Government was keen to provide the loans and farmers were eager for one reason or another to acquire the tractors.

In an evaluation of this project, White and Downing (1968) who were working in Ministry of Agriculture headquarters, were quick in condemning the project as a costly failure which did not result in any increment in production and employment. We should add here however, record keeping by these small scale farmers, as is common elsewhere in the developing countries, was quite poor and how they came to this conclusion is difficult to say. Their report was quite critical of the project - and they made some rather strong claims like:

> *"... farmers in numerous cases, seem to have purchased tractors for prestige purposes and have made little effort to increase the cultivated area on their farms ..."*

The main reasons for the failure of the scheme is attributed by Clayton (1973) to the Kenyan farmers inadequate knowledge of the nature of capital investment; his unawareness of the need to provide for repair and replacement and of the technical requirements for the maintenance and efficient operation of machinery and his inability to plan for efficient use of tractors on his own farm and on those of his customers. A number of these small scale farmer however expanded their scale of operation and continue to provide tractor hire services, as private contractors up to today.

GOVERNMENT TRACTOR HIRE SERVICES

Concurrently with assisting small holder farmers to acquire their own tractors, the Government started its own tractor hire service in 1966. This was also started with assistance of the International Development Association of the World Bank. Initially this tractor hire service was intended for primary land preparation and planting for the Masai Wheat Scheme, through which wheat was produced in large land blocks so that the advantages of large scale operation could be attained through use of machinery. Payment for the tractor hire services was assured through the Wheat Development Authority which was responsible for marketing the farmer's wheat. The tractors were also intended for land preparation for cotton production which took place at a different time from that of wheat, and thus helped to utilize excess and off season tractor capacity. The main objectives of the tractor hire services as established in 1966 included among others:

Table 13: Tractor Hire Service Operation

Performance, costs and income	1966-67	1967-68
Tractor months	300	600
Total hours	35 317	50 849
Productive hours	27 175	38 621
Hours per tractor month	118	85
Productive hours per tractor month	91	64
Productive hours as percentage of total	77.0	75.0
Operating cost per productive hour (shs.)	38.70	36.76
Total expenditure (shs.)	1 055 255	1 419 546
Earned revenue (shs.)	1 068 912	1 544 872

Source: Downing and Goldsack (1968)

(i) To open new areas for agricultural production.

(ii) To introduce modern agricultural techniques to farmers and to stimulate private ownership of farm machinery.

(iii) To supplement land preparation (especially in family farm areas) where private contractors are not sufficiently operative.

(iv) To increase agricultural productivity, especially cash crops such as cotton which are important to the Kenyan economy.

The THS started with 50 tractors which were primarily intended for the Masai Wheat Scheme. The Government realized that the tractor hire service was merely a means of stimulating development and it was felt that ultimately a private hire service would have a better chance of lasting success. Initially the THS operated quite successfully and was able to meet all its operating costs as well as generating a small surplus between 1966-68 (Downing & Goldsacks (1968), Clayton (1973)). The tractor service operated in mobile units, with no permanent base, and virtually year round utilization of machinery was possible as the tractors could be moved from area to area to follow work given Kenya's diverse ecology and agriculture. In the first few years the THS was managed by experts provided through various donor agencies and their reports do indicate that they were operating at a surplus (see Table 13)

It is difficult however from the figures shown in Table 13 to categorically state that the undertaking was really profitable at this stage, and had a firm business foundation. The record keeping was rather sketchy and

only overall records are available. It is thus difficult to determine how many tractors were really operational in any one month, how the tractor hours were achieved, and the cost analysis would in our opinion be doubtful as the salaries of the experts have been excluded. The project however appears to have faced a number of problems from 1969-onwards and became rather unreliable and farmers relied to a greater extent on private tractor hire services provided by farmers who owned tractors with some of the tractors coming as far away as from Tanzania.

From 1974/75 onwards the THS was re-equipped and expanded, and its fleet became increasingly mixed. The proportion of work carried out for small farmers rose, and the geographical spread of operations widened. Originally all major repair work was carried out at a central workshop in Nakuru, but three new regional workshops were constructed in 1979-1981 at Machanga, Mariakani and Migori under a Netherlands technical assistance programme. Since the creation of AMSB (Agricultural Mechanization Service Bureau) the tractors and their implements have been assigned to 17 of the 21 stations which fall under the new organization, and their mobility has thus been greatly reduced. The rapid expansion of the organization (to 197 tractors by 1981), the increased emphasis on small farm cultivation, and the geographical dispersion of the machines, has led to a fall in efficiency resulting in official criticism of THS. Of the 197 tractors currently (1990) in the fleet, 73 are in good condition and operational, 61 require repairs and can be put into service if the required spare parts are procured, and 62 are unserviceable and are being boarded off.

In addition AMSB operates the heavy crawler tractors under the Plant Hire Service programme. The Plant Hire Service (PHS) of AMSB has its origins in the Soil Conservation Service (SCS) machinery unit of pre-independence days. Its main objectives have been given earlier in this paper. In addition to its soil and water conservation operations, PHS has undertaken other activities which contribute directly or indirectly to increasing agricultural output, e.g. bush-clearing and farm road construction. This is partly due to a change in role since 1980. Prior to then, PHS concentrated mainly on the implementation of Government programmes which were considered to be of national or provincial priorities. The service has subsequently become essentially revenue earning, providing construction services almost exclusively to private farmers. Until 1978 the plant operated from seven stations: Kitale, Eldoret, Kipkelion, Nakuru, Nyahururu, Ruiru and Mariakani. Additional stations were established as "Pilot Soil Conservation Stations" in the period 1978-81 so that at amalgamation into AMSB there were 19 stations in all, although some of them had virtually no facilities. As the new stations were opened plant was transferred to them from the older stations. The PHS fleet increased from 54 in 1974 to 113 in 1982, largely due to a re-equipping and expansion programme for crawler tractors during 1978-79 which resulted in a fleet of many different makes. The Plant Hire Service operates mostly crawler equipment with angle dozer blades and many also with rippers. These are backed up by motor

graders, self-propelled scrapers, and some small plant including towed scrapers, terraces, rollers and front loaders. There are machines from 9 different manufacturers in all creating many problems of spares, supplies and dealer service. The total recorded fleet size in 1990 is 107, including 39 which are operational, 41 serviceable (if spares can be provided) and 27 unserviceable which are due for boarding.

Generally the plant operated by PHS is unnecessarily large for the bulk of the work carried out. The larger crawler tractors (>140 hp) are essential only for the heavier bush clearing operations and for ripping of rock during dam construction, and while they carry out the lighter work more quickly and generally more efficiently than small machines, the jobs are often so small that disproportionate time and effort are involved in organizing and transporting the equipment. The large, self-propelled scrapers are of use only on large dams, where there is room to manoeuvre and the rate of earth moving can be critical: they are of no use on the small water holes which form by far the greater proportion of the water conservation activities of AMSB. In summary the current agricultural mechanization situation under the Government is that, there are 21 agricultural mechanization stations offering both plant and tractor hire services. They are supported by the Central Workshop based at Nakuru for repairs. The farm tractors stock now stand at 73 operational, 61 serviceable and 62 which have been recommended for boarding. The industrial tractors stock of the plant hire services now stands at 39 operational, 41 serviceable and 27 recommended for boarding.

In addition to the above two services THS and PHS under AMSB, there are also small units responsible for Small Farm Mechanization Programme and post harvest processing and storage. The main objective of the Small Farm Mechanization Programme (SFMP) is to extend the range of handtools and ox-drawn implements to small farmers, in particular to cater for more than one operation and include other operations such as planting and weeding. Under a UNDP/FAO assisted project - Agricultural Equipment Improvement Project the following prototypes have been developed and a limited number distributed to farmers since 1977 - multipurpose tool carrier; mouldboard plough attachments, wheel hoe for weeding which is hand pushed, punch planter, maize sheller, chaff cutters, squirrel traps. The number of these prototypes under this programme so far distributed to farmers is however quite small:

Punch Planters	- 50
Maize shellers	- 100
Multipurpose tool bar	- 600 (with plough)
Multipurpose tool bar	- 100 (with ridger)
Light weight plough	- 300

Given the numbers of traditional handtools and animal drawn implements in use and annual demand, as shown in Table 14, it is obvious that

this UNDP/FAO project has so far had very limited success in popularizing its 'improved' handtools and animal drawn implements to the small holder farmer. Thus the programme despite over 10 years in existence has not even approached 0.001% of the handtools and ox-drawn implements in use.

Table 14: Handtools and Animal Drawn Implements in Use in Kenya 1990

Estimated no. of handtools in use	1 039 000
Estimated no. of ox-ploughs in use	150 000
Estimated annual demand for handtools	60 000
Estimated annual demand for ox-ploughs	14 000

The post harvest processing and storage programme of AMSB has the main objective of reducing on-farm food storage losses currently estimated at 16-30%. This is mainly aimed at the grain stored by small scale subsistence farmers for their own consumption as the marketed grain is catered for by the National Cereals and Produce Board. The programme is supported in Western & Nyanza Province by the USAID supported On-Farm Grain Storage Programme and in other districts, some 2000 demonstration improved on-farm grain storage structures (storing up 2 tonnes of grain) have been constructed under the Rural Structures Programme. There are also programmes for oil seed processing supported by the East African Industries.

Performance of Government Agricultural Machinery Service

The cumulative total of work executed by the Plant Hire Service is shown in Table 15. Overall, given that PHS has had to operate under the civil service system its achievements are, by and large, quite reasonable. Generally most of the work undertaken were for government sponsored projects and there has been a decline in output since 1981 due to a decrease in Government sponsored projects as a consequence of the financial austerity measures. The PHS has therefore since 1981 been more involved, on hire basis, in work on private large and medium scale farms where the scale of operation is often not that big hence the 'decline' in output. The performance of the tractor hire service is given in Table 16. It is evident from this table that the output of THS is dismally low. The number of tractor hours per year averages 154 hours which is quite low compared to private contractors. Even by standard of tractor hire services run by Governments in other parts of the World, this is comparatively low.

A number of factors have influenced the performance of the tractor hire service run by AMSB. Compared to 1968, as shown in Table 13, the performance has declined significantly. The reasons for this include:

(i) Operational autonomy: In 1967-69, when the THS was started with donor funds, it was run as a project and not subjected to

Government financial regulations. Hence the project managers had autonomy in running the service as a commercial project, whilst now it is run under Government financial regulations which at best are quite cumbersome.

Table 15: Performance of Government Plant Hire Services (1963-1988)

Activity (Unit)	Target*	Achievement*	% Performance
Bush clearing of Ripping (ha)	31,100	18,125	58
Dams (No.)	708	649	91.6
Water holes (No.)	5,080	1,108	22
Farm roads (km)	12,000	6,900	58
Terraces (km)	21,200	9,500	45
Cut-off drains (km)	7,100	4,845	68

(Cumulative total 1963-1988)

(ii) Fragmentation of land holdings: The period 1967-69 was the peak one for the resettlement programme and a lot of the farms were still new. Since then however, the land on these settled areas has been fragmented through inheritance etc. and perennial cash crops such as coffee, tea, etc. have been established on part of the land thus leaving only small areas for the annual arable crops which require tractor ploughing.

(iii) Lack of fuel: Fuel shortages in many of the sub-stations of AMSB has been a main cause of down time. This is in part caused by the bureaucratic procurement system followed under the civil service system.

(iv) Machine breakdown: This is responsible for a high proportion of down time. The frequency of breakdown may result from inadequate routine servicing and from improper use by unskilled operators. Breakdowns are however inevitable if machines work in difficult conditions and where a high proportion of work is on uncultivated land. Long delays in repairing machines occur because of lack of spares, either because spares are not available in Kenya and have to be imported from Europe or because there are no funds at AMS-stations to buy the spares.

(v) Seasonality and lack of incentives: The seasonality of demand, and inflexibility in deployment of THS tractors is responsible for many idle months in many stations. It should be remembered that when the THS started in 1967 the tractors could be moved from one part of the country to another in pursuit of ploughing work. However since the establishment of 21 stations this has created inflexibility in movement of these tractors. Secondly the tractors should be operated as long as possible when the work is available. Under the civil service system however there is no incentive for the tractor operators and their managers to work late as they are not remunerated for such late work. This is in part due to the financial regulations they have to operate within and the fact that hire rates are fixed centrally.

PRIVATE HIRE SERVICES

Crawler Tractors

The private sector is operating mainly in road construction and repairs, on buildings sites, and on dam construction. To a limited extent the plant is also used for bush clearing, e.g. by large estates such as those owned by sugar companies. Private forestry operations also absorb a significant number of old crawler tractors. Most major makes of plant are in use, including *inter alia*, Caterpillar, Aveling Barford, Champion, Komatsu, Fiat, MAN, JCB Hymac and Terex Poclain. The number of items is difficult to estimate, but from indication given by plant agents and contractors, there is approximately a total of up to 2000 units, although a large proportion are inappropriate for agricultural activities because of their type or size (for example, large scrapers, or dump-trucks and excavators). Although the agents have recently been having great difficulties in importing spares, the contractors have had few difficulties in obtaining their requirements up to now. The private sector has therefore not been greatly restricted by lack of spare parts, and a down time of 2 to 3 weeks for even a major repair appears typical. Although this will probably change in the near future as import restrictions affect spare stocks even more, this downtime is in great contrast to the PHS situation, when repair times have often been in terms of months or even years.

Consultation with local contractors, indicates that there is spare plant capacity which could be utilized on works in the same way as Plant Hire Services. However, there are three main factors preventing the private sector from getting more actively engaged in agricultural activities as the Government PHS. These include:

- Geographical distribution of plant is unsuitable, being concentrated around Nairobi, and to a lesser extent near Nakuru and Mombasa. A job would need to be large (e.g. dam or large scale bush clearing) to attract a contractor to areas away from these centres;

- Minimum costs for a contractor are approximately double the present level of PHS charges, and effectively no private farmers are interested in approaching contractors even now when the Government PHS operations are quite limited.

- Difficulties in obtaining payment for small, casual jobs is a strong deterrent for a contractor. This reluctance by farmers to pay has also affected the Government operated Plant Hire Services.

A prospective area for private contractors to get involved in place of PHS is in the construction of dams in high potential areas, where the economics of irrigation of large farms are able to bear the higher cost of using the private sector. Indeed, some dams which were designed by the old Soil Conservation Service were subsequently constructed by private contractors.

TABLE 16: Performance of the Government Tractor Hire Service

YEAR	TOTAL NO. OF TRACTORS AVAILABLE	AVERAGE NO. OF TRACTORS ON ACTIVE DUTY	ACTUAL NO. OF PRODUC-TIVE HOURS	ACTUAL NO. OF HA. PLOUGHED	NO. OF HA. PLOUGH PER TRACTOR
1975/76	54	-	15442	3861	-
1977/78	57/104	-	15302	4694	-
1978/79	104	75	14221	4132	55
1989/80	102	67	19485	5056	75
1980	159	61	26656	6664	109
1981	185	80	33112	8647	108
1982	191	90	22300	5600	62
1983	197	85	16928	4232	50
1984	197	85	11084	2771	33
1985	197	85	11676	2919	34
1986	203	90	14180	3545	39

SOURCE OF DATA - MINISTRY OF AGRICULTURE RECORDS

Tractor Hire Services by Private Sector

The private tractor hire service provides crucial service to small scale farmers. It is by far larger than the Government Tractor Hire Service although the exact number of tractors in use is difficult to estimate. Tractor contractors vary in

scale and type of operation. At one extreme there are large specialist operators with as many as ten or more tractors who undertake mainly large-scale jobs for organizations such as Kenya Breweries Sugar Estates, etc. and who obtain very high rates of machine utilization by travelling over a wide area to find work. They employ high horsepower tractors, in many cases with 4-wheel drive, and hence can achieve fast work rates on large and well-cleared fields. In the longer term, it seems inevitable that as farms and estates are subdivided the demand for large-scale contracting will decline. At the other extreme is the operator with just one tractor who cultivates his own farm first and then looks for additional work either in his immediate neighbourhood or further afield. This is the most common type of contractor in Kenya today, and the majority of tractor cultivation in the small family farm sector is performed by such operators. It is not unusual for a tractor to be owned by a group or partnership of 2, 3 or 4 farmers and Agricultural Finance Corporation loans are available for such group purchases. Small contractors usually go for the lower hp tractors (e.g. the 40-60 hp MF 265, IH 384). There has been very little uptake of 4-wheel tractors of less than 40 hp. An increasing proportion of total tractor sales are to such operators with only one machine undertaking a mixture of their own work and contracting to other small scale farmers.

Estimates of total number of tractors involved vary widely and in particular determining the numbers which are operational and those which have broken down beyond repair in any one year is quite difficult. Although import figures show that Kenya has been importing on the average about 1095 wheeled tractors per year, it is difficult to estimate how many of the old tractors are boarded off each year. The total number of tractors on large farms are shown in Table 17. These large farmers are defined as those with cultivated area of 8 hectares and above.

In addition there are quite a number of farmers with less than 8 ha of cultivated land who own their own tractors and who do contract ploughing for other farmers for a larger part of the year to maintain their equipment. Such farmers and a number of the larger farmers who cultivate land near the region of 8-20 ha provide contract hire service to the small farmers. It is estimated that there are about 3400 tractors which are engaged wholly or principally in contracting work (AMSB (1990)). Some of the large farms do provide contract hire services especially to small-scale growers of sugar cane, rice and other crops in irrigated schemes. A survey undertaken in 1978 for AMSB shows that the large farm sector (over 8 ha.) owned about 80% of the tractors in the country and the remaining 20% were owned by farmers with less than 8 ha. Precise figures however will require more detailed survey and consistent record keeping a tradition which has not been developed in many developing countries. It is however clear that the Government and other public tractor hire services with a total of about 300 operational tractors, has less than 10% of the tractors owned by the private sector engaged wholly or principally in hire services. Efforts should therefore be directed at assisting this private sector to provide this service more efficiently.

TABLE 17: Mechanical Equipment on Large Farms (cultivated area 8 ha and above) 1980-1988

YEAR	TRACTORS			COMBINE HARVESTERS
	Wheel	Crawler	Self-Propelled	Tractor Drawn
1980	6180	366	302	111
1981	6075	324	205	100
1982	6322	322	193	106
1983	8200	368	238	315
1984	8077	317	250	195
1985	6330	338	347	93
1986	8760	464	416	173
1987	9050	362	522	169
1988	9050	362	522	169

SOURCE: (AMSB; 1990)

Standardization of the Tractor Fleet

Table 18 gives the figures for the various makes of tractors sold in Kenya between 1970-1989. Thus a total of 21900 tractors were imported between 1970-89 with the average annual importation figure being about 1095. These figures are from the major distributor (Farm Machinery Distributors) and others who keep records of their sales. It should be added that there are other tractors either imported directly through donor projects, and NGO projects which are not included in this number. This also excludes individual farmers/or other nationals who have access to foreign currency who import directly and thus their tractors are not recorded by the local franchise holders. In particular of late there has been an increase in importation of second hand tractors from Europe and North America. Table 18 shows that Massey Ferguson has dominated the local market with about 31% of the sales, followed by Ford with 24%, and Same and International Harvester/Case with 19 and 14% respectively. There are some suppliers who come on and off such as FIAT, Deutz, John Deere.

TABLE 18: Tractor Sales (Private and Government) 1970-1988

Year	Deutz	Fiat	Ford	Case IH	John Deere	Lambor-ghini		MF	Same	Others Total
1970	7	-	305	64	-	-	328	-	-	704
1971	6	-	213	70	33	-	321	-	-	643
1972	-	-	194	69	112	-	483	62	67	987
1973	1	-	325	74	19	-	376	71	51	917
1974	1	-	240	81	30	-	306	76	22	756
1975	-	-	213	21	113	-	387	142	20	896
1976	-	29	242	137	109	66	266	174	21	1 944
1977	-	109	335	417	-	170	417	283	57	1 788
1978	-	112	419	332	-	159	481	291	138	1 932
1979	-	94	236	338	-	109	311	184	93	1 365
1980	-	81	239	124	-	125	302	216	91	1 178
1981	26	117	213	174	-	110	254	207	91	1 192
1982	8	118	186	109	-	68	136	169	40	834
1983	-	57	150	68	-	61	127	126	25	614
1984	-	44	222	46	-	6	202	163	44	727
1985	-	62	285	74	-	-	277	259	56	1 013
1986	117	80	300	39	8	-	420	221	114	1 299
1987	154	72	241	60	8	-	500	174	86	1 295
1988	147	12	371	210	19	-	445	188	70	1 462
1989	-	55	257	185	-	-	478	220	62	1 257
TOTAL	**467**	**1 042**	**5 186**	**2 692**	**451**	**874**	**6 817**	**3 226**	**1 148**	**21 903**

DRAUGHT ANIMAL POWER

There is a wide disparity in the estimates of draught oxen numbers in use in Kenya partly because of differences of definition between the studies. In some

cases untrained animals are included, whilst in others donkeys which are used primarily for transport especially among the pastoral tribes have been counted as draught oxen. In a survey undertaken by a Dutch consulting firm in 1979/80, it was estimated that there were 90-100,000 working oxen in Kenya, while a study by the World Bank put the number at 100,000 to 200,000 and Pollard (1982) estimated the number of working oxen as 700,000 which would seem to be quite on high side in view of his enthusiasm for this technology. The annual demand for ox-drawn ploughs is estimated at 12,000-14,000. Thus we are not even sure of how many draught oxen are in use, given the above figures which vary by over 800%.

There is a marked regional concentration of oxen use, resulting from historical differences, tribal attitudes, and the spread of livestock diseases. The National Sample Survey found that the percentage of rural households owning oxen is highest in the south west of Kenya (34% in Bungoma and South Nyanza Districts, 26% in Nandi, and 22% in Kisii). The other main band of concentration is from Kajiado District (20%) and Machakos (30%), through Kitui (14%) and Embu (18%), to Kirinyaga District (17%) (Pollard 1982). The proportion of households owning ox ploughs was higher in many districts than the number owning oxen, which might indicate that when farmers hire oxen they use their own plough, or that some households have given up ox cultivation. Most ox owners provide a hire service to neighbouring farmers after completing their own cultivation. The per acre charges for ox cultivation appear to be equal to those for tractor hire, despite the reportedly cheaper cost of maintaining oxen.

Oxen have a limited work output per day and cannot plough heavy soils until they have been softened by the rains, so their seasonal work capacity is low. At a rate of work of 20 hours per ha. and a daily achievement of 5 hours work, it would take an ox-pair 4 days to cultivate a hectare. With the period available for ploughing after the onset of the rains seasonal output of an ox-pair would be only about 5 ha. In contrast, the grazing required per animal would be 0.5 to 1 ha. A large team of 4 or even 6 oxen (as sometimes used in Kenya) would achieve a faster work rate but have a higher grazing requirement.

The direct costs of keeping oxen are low when adequate grazing is available. Costs of veterinary inputs, harnessing, housing, and labour for herding are all modest. The major cost of keeping cattle is the opportunity cost of land used for grazing and this will vary very much from area to area. Some observers have argued that in Agricultural Ecological Zones (AEZ) II, III, and to some power extent IV, the opportunity cost of land is too high to make animal draught economically attractive, and that only in the lower potential areas can the allocation of land for grazing of draught animals be justified (Aldehem & Schmidt 1975). Even there, the opportunity cost of the alternative use of the land for dairy farming must be taken into account. Pollard (1982) considers that even allowing for the opportunity cost of land, animal draught

is cheaper both in financial and economic terms than tractor cultivation, at least in three areas which he studied. He also points out that costs of ox cultivation could be reduced, e.g. by increasing utilization of animals for operations other than ploughing; improved methods of feeding (e.g. growing of fodder crops and raising the quality of implements and standard of operations.

It suffices to say that a number of factors have inhibited widescale adoption of draught animal cultivation and despite over 90 years of use in Kenya the number of draught oxen in use is still very small (less than 200 000 animals) and it is unlikely that they cultivate more than 200 000 ha. of land (because of rainfall limitations a pair cannot do more than 5 ha. per season). Other economic factors such as shortage of grazing land in most parts of Kenya are likely to limit the future potential of this type of technology in many parts of Kenya.

RESEARCH AND TRAINING FOR AGRIC. MECHANIZATION

Research on agricultural mechanization problems has been, by and large limited. There was no particular institution established to handle research in this area. The Agricultural Machinery Testing Unit (AMTU) in Nakuru was established specifically to test agricultural machinery and implements imported or locally manufactured. It has however undertaken limited research on agricultural mechanization problems. This has been mostly in the form of projects sponsored by donor agencies to deal with specific problems and the research project is usually terminated once the donor funding stops and the foreign experts leave. The Agricultural Engineering departments at Nairobi and Egerton Universities also undertake limited research mostly in the form of undergraduate and postgraduate student dissertation research. A number of agricultural engineering projects/programmes have also been undertaken in various other departments at the Nairobi University, Jomo Kenyatta University, Ministry of Research and Technology, Kenya Agricultural Research Institute, and Kenya Bureau of Standards. There is also a strong professional society for agricultural engineers (Kenya Agricultural Society of Engineers) which organizes regular meetings/symposia/workshops for professional agricultural engineers.

Kenya has, in comparison to other African countries, had a relatively strong training programme for agricultural mechanization. The Egerton College, established in the 1940s through an endowment from Lord Egerton, was meant to train 'sons and daughters' of farmers the 'science and practice' of agriculture. Initially it confined its intake to 'sons and daughters' of the white settler farmers and it had a strong programme in agricultural engineering. In the 1950's however it begun to admit African students into its various diploma programmes. Many of the early agricultural engineering technicians in Eastern & Central Africa were trained at this college. The department of agricultural engineering at Nairobi University was established in 1976 to offer BSc. degree in agricultural engineering and it was the first

department in the Eastern & Central Africa region to offer such a programme. The annual intake is about 20 students. At the front-line level, the Ministry of Agriculture realized that there was something missing in training of manpower for agricultural mechanization and as a consequence started two institutions - the large scale training centre at Eldoret which trains secondary school leavers at certificate level. These certificate in agricultural engineering trainees are employed as technical assistants in farm power and machinery and form the front-line extension workers of the ministry in this field. They are also employed by the large scale farmers as machinery management operators/specialists as their training is quite practical and vocational. The second institution established is the Narosura Training Centre which trains plant (mostly crawler & heavy tractors) operators for agricultural mechanization service. These plant operators are in high demand as many of them have been employed by the private plant hire operators.

Therefore on the research and training front, there have been significant developments over the past 15 or so years. It is however too soon to say that these efforts have led to significant improvements in agricultural mechanization. Both training and research are long term investments and the fruits of current investments in this area are yet to be fully realized. Some of the institutions recently established should have been established in the 1950's and 1960's rather than now. There is also a need to coordinate the efforts of all these institutions involved in agricultural engineering research and training and develop a more focused and long term research strategy.

MANUFACTURING OF AGRICULTURAL MACHINERY

Although Kenya has by African standards, a comparatively large industrial sector, the manufacturing of agricultural machinery and implements is relatively limited. There are quite a number of small and medium sized firms producing handtools (hoes, fork hoes, wheelbarrows, machetes, etc.) and animal drawn implements (mostly the victory plough). There are also some firms which fabricate specialized equipment for the large scale estate farms - coffee pulperies, tea processing equipment, sisal processing equipment, etc. and the large scale millers. These are found mostly in Nairobi, Nakuru, Eldoret, Kisumu, which are the major towns for the high & medium potential agricultural areas. Some of these firms also produce, on a comparatively large scale such agricultural equipment and implements as hammer mills, disc and chisel ploughs, trailers, etc. Recently however the Government has been encouraging small scale fabricators and manufacturers under the *Jua Kali* (under the hot sun) programme to venture into manufacture of agricultural tools, and implements. Such *Jua Kali* enterprises are found all over the country and are equipped with basic metal working equipment and welding sets and they can make quite a range of handtools and domestic appliances. The major constraint of the manufacturing sector is lack of raw materials and marketing problems.

ROLE OF DONOR AGENCIES

Several donor agencies have been associated with Kenya's agricultural mechanization efforts. The British Overseas Development Administration (ODA) played a key role in the earlier settlement schemes programme in the 1960's and 1970's including provision of commodity assistance for tractors and implements as well as technical advisors for agricultural mechanization. In 1978 ODA provided technical assistance to rehabilitate Averell Marshall tractors which had been provided in the 1960's as a commodity aid. The World Bank, as we described earlier, has also provided loans through its IDA affiliate for purchase of tractors which were sold to small holder farmers. In 1980's the Federal Republic of Germany provided a commodity aid programme in the form of Deutz tractors, spares and workshop tools. Indeed a majority of the Deutz tractors currently in the country were provided under this programme. The Dutch Government provided technical assistance to the Ministry of Agriculture to conduct a review on the status of agricultural mechanization in Kenya in the 1970's. This study conducted by the Dutch firm CEBECO was followed up by provision of some equipment to the ministry for construction of agricultural machinery workshops.

Other donors who have been involved in agricultural mechanization in Kenya include FAO/UNDP/UNIDO/ILO who have provided, as we noted earlier, some technical, and operational assistance to several projects involved in research, development and extension of agricultural mechanization technologies like: Agricultural Equipment Improvement Project, Regional Rural Structures Programme, Rural Oil Processing and Production Project, Farm Equipment Use in Small Holder Agriculture, and upgrading skills and facilities of *Jua Kali* artisans producing agricultural tools. Others like British Council, USAID and SIDA have been involved in technical training whereby Kenyans were availed training opportunities overseas in the field of agricultural engineering as well as provision of lecturers to the training institutions. In addition there have been quite a number of Non Governmental Organizations (NGO) involved in different aspects of agricultural mechanization - biogas plants, food processing, etc. All in all the donors have been relatively active in the field of agricultural mechanization in Kenya and some of their programmes have had very positive effects while others were only partially successful.

CONCLUSION

We have in the preceding sections reviewed the agricultural and agricultural mechanization developments in Kenya over the past four decades. Kenya's agriculture has since colonial times been characterized by a dual size structure. On one hand are the large commercial farms, which during colonial times were exclusively owned by European settlers producing high value cash crops such as coffee, tea, pyrethrum, wheat, and dairy products for the export and the internal urban market. These were and have remained highly mechanized enterprises and are quite important to the Kenya's economy. At independence

the area covered by these large farms was 3 million ha. and since then about 1 million hectares have been taken over under the various government schemes and subdivided for settlement of African farmers as small (less 5 ha.) and medium scale (5-25 ha.) farms. Most of these farms are in the high potential areas, where both the rainfall is adequate and soils are of high fertility. On the other hand are the small scale farmers found all over the country. A significant proportion of these farmers lived in the African reserve lands during the colonial period and owned fragmented parcels of land, from which they practised predominantly subsistence agriculture. As a consequence of the *Maumau* wars, in the early 1950s, the Swynnerton Plan was adopted in 1954 through which a land consolidation programme was instituted on these African farms and the small farmers were encouraged to grow high valued cash crops such as coffee, tea, and pyrethrum. At independence some of the landless people from these African reserves as well as the small scale farmers were settled in some of the land acquired by the Government from the European settlers. A number of mechanization schemes were started in 1960s to help these settlers in opening up their new lands as well as construct soil conservation structures. These were both Government as well as privately owned and operated.

Initially these tractor hire schemes (both Government and private) were quite successful as there was a high demand for their services as most farmers grew annual crops - wheat, maize, beans, etc. This also coincided with the time when hybrid maize was being introduced in Kenya with the resulting higher yields (Gerhardt 1975). Due to the high yields, and hence increased production, many farmers in the newly settled lands in the high potential areas shifted from cultivating annual crops such as maize into higher valued cash crops such as coffee, tea, pyrethrum as well as dairy cattle. These being perennial crops did not require that much of tractor tillage and hence this affected the tractor hire services which then moved to the dominantly cereal producing areas. With the fragmentation of the land due to population pressure, this has led to the handtool technology being the predominant type of technology in the small holder sector in the high potential areas. Agriculture however is quite intensive due to the favourable climate and the range of cash and food crops which can be produced. Draught Animal Technology is unlikely to be adopted in these areas as grazing is not available and the opportunity cost of land is too high to make draught animals economical. In the main cereal producing areas, the farms are cultivated by tractors and some of the medium and small farmers hire tractors for cultivation. It is estimated, in addition to the 300 public owned tractors available for hire, there are over 3400 tractors owned by small and medium farmers which are engaged wholly or principally in contracting work.

Even though yields can still be increased in the high potential areas (both on large and small scale farms) it would appear however if Kenya is to be able to feed her ever increasing population then significant increment in yields and overall production will have to be obtained from the medium and

low potential areas. At present time, less than half of the bio-chemical agricultural potential of these areas is being realized while the country is importing wheat, rice, vegetable oils and cotton all of which can be produced in these areas if mechanization and other inputs can be provided to farmers at affordable prices. It should be realized that agriculture in these areas is rainfed and timeliness of field operations is critical if reasonable yields are to be achieved. Draught animal technology can play a role in enhancing the production potential of these areas. However as Johnston (1975) has noted prior to 1975 very little has been done in Kenya by the Government to promote ox-cultivation and many policy makers and agricultural specialists in Government are of the view that the country's farmers should shift directly from hoe cultivation to tractors. A number of programmes to develop and popularize ox-drawn implements have been initiated but so far success has been elusive (Muchiri and Johnston (1975); Pollard (1982); Muchiri (1984)). Experience with Government tractor hire schemes also indicates that there are serious problems in taking this route. Private tractor hire services appear to be a viable option if however, these contractors are assisted to remove some of the constraints they face. There is need therefore to develop an agricultural mechanization strategy for Kenya which will have both short and long term objectives. Such a strategy needs to be developed by multi disciplinary teams of agricultural engineers, economists and agronomists. It should involve all the aspects of agricultural mechanization - both requirements on the farm as well as manufacturing and servicing of agricultural mechanization inputs. This is the challenge to Kenya's agriculture over the next two decades.

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