Public Tractor Hire and Equipment Hire Schemes in Developing Countries (with special emphasis on Africa)

by

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SUMMARY and CONCLUSIONS

1. The study was undertaken by the Overseas Division of the National Institute of Agricultural Engineering (OD/NIAE), in collaboration with the Agricultural Research Unit (ARU) of the World Bank. The objective was to collect information on Public Tractor and Equipment hire services in developing countries and develop hypotheses regarding the successes and failures of these schemes.

2. Information was collected from 38 hire schemes in 34 countries. Twenty-one of these schemes are included in the report, with the African examples predominating. Nineteen of the twenty-one examples refer mostly to Tractor hire schemes. There is not much evidence of Public Machinery hire schemes in developing countries.

   The bulk of the report is taken by the two Appendices containing the Case Studies and the Country Notes. At the beginning of the report there is -

   - Background to this report and Hire Schemes in general
   - A summary table of information from the 21 profiles
   - Hypotheses and lessons developed from the examples.

3. Tractor Hire Services (THS) in developing countries first started after the second world war, mostly in what was then Colonial Africa. The introduction of THS was seen as the only way of initiating multi-farm use of medium range tractors (35-55 hp) on the typically small farms that occurred in these countries. Initially the objective was to increase export revenue. Since that time, other objectives have included modernising the agricultural sector, settling new areas, producing for import substitution, release of specific labour or technical constraints.

   The emphasis of the report is on the relative merits of public services versus private services. There are some comments on the absolute merit of tractorisation/mechanisation, but by and large, that side of the argument is kept to a minimum.
4. **Costs:** Eighteen of the schemes always operated under a government subsidy, ranging from marginal (10%) to very high (estimated 94%). This is often a high % of the Ministry of Agriculture's development budget (up to 75%). When calculating what hire rate to charge farmers, the capital cost of equipment is usually omitted, and the aim is to cover operating costs. This leads to uneconomically low hire rates, so even if a revolving fund were operated, which is rarely the case, the operation will not be self financing. Another serious consequence is that since the Public THS will set the rates for an area, those uneconomically low rates will hinder the entry of private contractors into the hire market. Since government often states that the intention of setting up a THS is to create the demand and then leave the market for private operators, setting low rates is self-defeating.

5. **Success:** Out of the 21 examples, only one seems to have been a success from an economics viewpoint. This is the land rehabilitation and levelling in Pakistan using bulldozers. All others have cost the nations more than they benefited them. Has the loss been greater with Public Hire Services than it would have been with Private ones? Yes for all the tractor operations; no for some of the bulldozer operations. Bulldozers and associated heavy equipment are essential for the heavier work and often represent too large an investment for a private contractor. In these cases only a public organisation can bear the cost, and also they operate with greater technical efficiency than do tractors - higher annual utilisation, longer working life, less break-downs. There have been some technically successful schemes; this is very closely associated with rigid management and good availability of spare parts. Most schemes are of some financial benefit to the farmers, but this is due to the low hire charges. In the end these low charges enable poor farming to be profitable, and also mean the demand exceeds supply which in turn leads to certain farmers wielding political power to secure the service at optimal times to the disadvantage of the less influential farmers.

6. **Potential:** The economic potential is dependent on total effective annual utilisation. This in turn is dependent on the farming system, field sizes, spatial distribution of farmers using the service, operations for which the machine is used, and management. Empirically, tractors are most used for primary cultivation and transport in short fallow systems for cotton or multiple cropping and bush fallow systems for rice. In the short fallow cotton systems, potential is limited because it is
rainfed agriculture which is not only time bound on the individual farms, but time synchronous between farms. With only one crop a year, annual utilisation is low. With the multi-cropping rice systems cultivation is usually the last operation to be motorised (after threshing, pumping, spraying) and occurs where rural populations are falling in relative and absolute terms. In cases where these conditions occur, it does not require a public hire service to encourage tractorisation. In the bush fallow systems, the potential is there but can only be justified by long-term economic benefits since this system coincides with the settling of new areas. Results have been poor, and it is possible that the subsidies would be better spent on private tractor purchase and training schemes.

Hire schemes are usually based on tractors carrying out primary cultivation and transport. This limits the potential because, even if those areas were constraints previously, then the expansion of area or yield will bring other constraints to bear, such as weeding, harvesting, threshing.

Bulldozer operations are the one area where the potential is borne out. Reasons are; government is more able to bear the high capital costs than private contractors; operations are not so time bound or synchronous; work is slower and carried out on larger areas than for tractors, therefore easier to manage and field efficiencies are greater; operators are prepared to work longer hours.
A. BACKGROUND

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A. BACKGROUND

1. INTRODUCTION

1.1 Objectives of Study

Public Tractor and Equipment Hire Schemes have been introduced in many developing countries from the mid-1940s to the present. The predominant opinion is that the Public hire schemes have not, in general been successful. The objective of this study was to collect as much information on such schemes as possible, summarise the findings and, where possible, develop hypotheses for the successes and failures of these schemes, and determine what lessons can be learnt. Are Public hire schemes intrinsically doomed to failure; under what conditions do they have a chance of success, and how appropriate are they to the agricultural problems faced by developing countries?

1.2 Method

Information was collected on 38 hire schemes in 34 countries. From these, case studies were written on 8 schemes, and less detailed Country Notes were made on 13 others.

Africa — 14 (7 West Africa)
Central America — 2
South America — 1
Asia — 4

These Case Studies and Country Notes are included in the Appendices. As much of this information as possible is summarised in the table (see p.7). The table is described highlighting the important points, and then hypotheses and generalisations about Public hire schemes are made with the table and appendices giving supporting evidence.

1.3 Terms and Definitions

THS: Tractor Hire Scheme: This term is used frequently in the report. Strictly speaking, the report is about machinery hire schemes, rather than tractor hire schemes, but in actual fact, all but two of the schemes referred to are, for the most part, concerned with tractor hire. Of the other two, the Pakistan one is entirely bulldozers, and the Belize one
is bulldozers, tractors and combines, with tractors playing a minor part. From all the information seen, there is little evidence that public hire schemes for other agricultural machinery, such as threshers or motor tillers, are common.

**Public:** Public does not only mean directly administered government schemes; it is any scheme that has a government input in the form of management, administration or financial. Financial includes any subsidy at any stage of purchasing or running the machine. In fact, most of the examples in the report are from schemes which have very close and direct government influence.

**Mechanisation/Tractorisation/Motorisation:** In many cases in this report and in the general literature, these terms are used interchangeably. The overall brief of this report is to address the issues to agricultural motorisation, i.e. any agricultural machine that is powered by a motor. As explained, the majority of the examples actually refer to tractorisation.

In the literature, mechanisation is the most widely used term, and can be confusing, since, strictly speaking, mechanisation refers to anything from the use of a planting stick to a $500,000 bulldozer.

2. **BACKGROUND AND HISTORICAL PERSPECTIVE ON PUBLIC THS**

The use of tractors in both developing and more developed countries was at a low level leading up to World War II. During the war, many European governments organised machinery hire services in an effort to raise agricultural production in a time of labour shortage. Together with the Soviet Union's experience with tractor and machinery stations, a pattern for centralised tractor and implement services was formed. In the late 40s and early 50s, increasing amounts of effort went into raising agricultural production in the then European colonies. This was seen as a way of supporting industrial recovery in Europe, and repaying some of the debts incurred during the war.

This led to the introduction of mechanised cultivation schemes, some specific to a particular crop, others offering a wider service. Colonial organisations were formed to supervise these efforts.
Among them:

- UK Colonial Agricultural Machinery Advisory Committee
- La Section de Mechanisation Agricole au Ministere d'Outre-Mer (France)
- Netherlands Advisory Board for the Mechanisation of Agriculture in Overseas Territories

Immediately post-war tractor exports to Colonial countries were restricted by low production capacity in Europe and lack of dollars to import tractors from the USA. As production capacity in Europe expanded, the large tractor manufacturers became active in promoting exports. Many of these tractors went to government run THS.

The four main purposes for government involvement in THS have been:

- Increase production of an export crop. Cotton and sugar cane are good examples of this, being crops that lend themselves to mechanisation. Government promotes their development in order to increase export revenue. Most of the initial Public THS were of this sort, sometimes in conjunction with land settlement schemes.

- Land settlement schemes were started in response to land pressure, often moving farmers from upland areas of intensive farming to savannah areas where it was hoped extensive mechanised systems could be used.

- Modernisation: A government decides that existing agricultural methods need changing to be in line with development policies for other sectors of the economy. Extensive tractorisation ensues.

- If a new technology is being introduced, governments have sometimes started a machinery hire scheme if there are special technical problems involved. Examples are; the cultivation of very heavy soils or the levelling of large areas of land for irrigation.
3. **RATIONALE OF THS**

The previous section states the objectives given by developing country governments for becoming involved in THS. These are objectives that are transferred more or less directly from the more developed countries. There are further rationale for promoting multi-farm use through THS, rather than just encouraging farmers to own their own tractors. Most agricultural holdings in developing countries are too small to be able to use efficiently a conventional (30 hp or over) 4-wheel tractor. THS have been seen as the most promising way of introducing medium sized tractors (50-80 hp range) for multi-farm use.

The other solutions, so far as tractorisation is concerned, are:

- Develop small 6-10 hp single axle tractors. This has been adopted in some areas, mostly for intensive padi production.

- Develop small 4-wheel tractors. This has been tried, but up to now, these scaled down versions have had severe technical limitations and have not been able to compete with larger tractors in terms of cost/ha for cultivation.

Against these alternatives, governments have persisted with hire schemes of medium sized tractors.
B. SUMMARY OF THE STUDIES

1. SUMMARY

Information gathered from Public Machinery Hire Schemes in 21 countries is presented and discussed. The countries are:

<table>
<thead>
<tr>
<th>AFRICA</th>
<th>CENTRAL AMERICA</th>
<th>SOUTH AMERICA</th>
<th>ASIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kenya C</td>
<td>Nicaragua N</td>
<td>Peru N</td>
<td>Pakistan C</td>
</tr>
<tr>
<td>Egypt C</td>
<td>Belize N</td>
<td></td>
<td>Sri Lanka C</td>
</tr>
<tr>
<td>Sierra Leone C</td>
<td></td>
<td></td>
<td>Malaysia N</td>
</tr>
<tr>
<td>Swaziland C</td>
<td></td>
<td></td>
<td>Bangladesh N</td>
</tr>
<tr>
<td>Sudan C</td>
<td></td>
<td></td>
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<tr>
<td>Uganda C</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Malawi N</td>
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<td></td>
<td></td>
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<tr>
<td>Gambia N</td>
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<td></td>
<td></td>
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<tr>
<td>Ghana N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Toga N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Benin N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ivory Coast N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Central African Republic N</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nigeria N</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

The table summarises as much of the information as possible. The main features of the table are described below. The table, in conjunction with the Case Studies and Country Notes, is then used to support a series of hypotheses concerning the reasons for failure, success, potential etc of Public Machinery Hire Schemes.
<table>
<thead>
<tr>
<th>COUNTRY</th>
<th>(a) GDP/CAPITA US $</th>
<th>(b) IMPORTANCE OF AGRICULTURE</th>
<th>(c) GRAIN IMPORTS TONNES/1000 POPN.</th>
<th>(d) PART OF COUNTRY</th>
<th>(e) START OF SCHEME</th>
<th>(f) POPULATION DENSITY</th>
<th>(g) TYPE OF MACHINE</th>
<th>(h) OBJECTIVES OPERATIONS</th>
<th>(i) ESTIMATE AV. SIZE OF FARM (ha)</th>
<th>(j) AV. SIZE OF FARM (ha)</th>
<th>(k) ANNUAL UTILISATION (Hrs)</th>
<th>(l) % REVENUE</th>
<th>(m) PREDOMINANT FARMING SYSTEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>MALAWI</td>
<td>200</td>
<td>43</td>
<td>18.2</td>
<td>Lower Shire Lakeshore</td>
<td>1965-67</td>
<td>High</td>
<td>Tractors 65 HP</td>
<td>Demonstrate Open new land Cultivation</td>
<td>16-450 0-10%</td>
<td>Smallholder short fallow</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UGANDA</td>
<td>220</td>
<td>75</td>
<td>2.9</td>
<td>All rainfed fertile soils</td>
<td>1948 to 1970's</td>
<td>High</td>
<td>Tractors 703 (1968)</td>
<td>Increase Production Modernise</td>
<td>46-82% 1-2</td>
<td>450 Large</td>
<td>Shortholder annual cropping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BENIN</td>
<td>320</td>
<td>44</td>
<td>10.0</td>
<td>-North Savannah</td>
<td>1950 to present</td>
<td>-</td>
<td>Tractors Bulldozers</td>
<td>Demonstrate Cultivate, land clear</td>
<td>Cotton</td>
<td></td>
<td>Short fallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CENTRAL AFRICA REPUBLIC</td>
<td>320</td>
<td>37</td>
<td>5.8</td>
<td>All forest and Savannah</td>
<td>1950 to present</td>
<td>-</td>
<td>Tractors Bulldozers</td>
<td>New areas export crops Reclamation spraying</td>
<td>Cotton Coffee  Heavy</td>
<td>350 Small</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SIERRA LEONE</td>
<td>320</td>
<td>31</td>
<td>16.1</td>
<td>All Humid Tropical</td>
<td>1950 to present</td>
<td>Low Limited</td>
<td>Tractors Bulldozers 100, 300</td>
<td>Increase Rice prod Clearing, cultivation</td>
<td>Rice High (94% estimated)</td>
<td>144 1-2</td>
<td>Bush Fallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOGO</td>
<td>380</td>
<td>24</td>
<td>23</td>
<td>North Savannah</td>
<td>-</td>
<td>-</td>
<td>Tractors Bulldozers 53, 4</td>
<td>Mechanise cotton Cultivate, spray</td>
<td>Cotton High</td>
<td>60 1-2</td>
<td>Shifting, bush fallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SUDAN</td>
<td>380</td>
<td>38</td>
<td>15.9</td>
<td>Nuba Mtna Open tree/ Savannah</td>
<td>1970 to 1980 Limited</td>
<td>Low</td>
<td>Tractors (70-800hp) 62 - 149</td>
<td>Smallholder modernisation Cultivation</td>
<td>Cotton Sorghum 67</td>
<td>1-2</td>
<td>Short Fallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GHANA</td>
<td>400</td>
<td>60</td>
<td>21.7</td>
<td>North SE Savannah</td>
<td>1960s' High</td>
<td>-</td>
<td>Tractors Bulldozers 1500, 300 (1967)</td>
<td>Plough, clear harvest</td>
<td>Rice Maize 50-70</td>
<td>62 Shifting, bush fallow</td>
<td>Short Fallow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KENYA</td>
<td>420</td>
<td>32</td>
<td>31</td>
<td>All Desert &amp; Tropical</td>
<td>1966 to Present</td>
<td>Varied</td>
<td>Tractors earthmoving 196, 120 (1983)</td>
<td>New areas, inc. prodn. Clearing cultivation</td>
<td>All Heavy</td>
<td>50 Hostly small</td>
<td>Short Fallow Annual cropping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>COUNTRY</td>
<td>(a) GDP/CAPITA US $</td>
<td>(b) IMPORTANCE OF AGRICULTURE</td>
<td>(c) GRAIN IMPORTS TONNES/1000 POPN</td>
<td>(d) PART OF COUNTRY AGRO-CLIMATIC</td>
<td>(e) START OF SCHEME</td>
<td>(f) POPULATION DENSITY LABOUR AVAILABILITY</td>
<td>(g) TYPE OF MACHINE</td>
<td>(h) OBJECTIVES OPERATIONS</td>
<td>(i) MAIN CROPS</td>
<td>(j) ESTIMATE OF SUBSIDY (ha)</td>
<td>(k) AV. SIZE OF FARM (ha)</td>
<td>(l) ANNUAL UTILISATION (hrs)</td>
<td>(m) PREDOMINANT FARMING SYSTEM</td>
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</tr>
<tr>
<td>EGYPT</td>
<td>150</td>
<td>21 - 50</td>
<td>168</td>
<td>Nile and Delta Irrigated</td>
<td>1950 to Present</td>
<td>Very high Becoming limited</td>
<td>Tractors 20,000+</td>
<td>Increase Cereal Prod., Plough Thresh</td>
<td>Cotton Rice</td>
<td>Some</td>
<td>0.5 to 1.5</td>
<td>550</td>
<td>Multi crop smallholder</td>
</tr>
<tr>
<td>NIGERIA</td>
<td>1920</td>
<td>23 - 54</td>
<td>27.9</td>
<td>North West Savannah</td>
<td>1950</td>
<td>Low</td>
<td>Tractors 16 Pools</td>
<td>Demo Pre-Planting</td>
<td>Maize</td>
<td>TSome</td>
<td>-</td>
<td>-</td>
<td>Short fall</td>
</tr>
<tr>
<td>IVORY COAST</td>
<td>1200</td>
<td>27 - 70 - 80</td>
<td>72.8</td>
<td>All Equatorial to Savannah</td>
<td>1960</td>
<td>Variable Decreasong</td>
<td>Tractors (40-55 HP) 29-34</td>
<td>Diversify Cultivate, Spray, Transp.</td>
<td>Tree Crops Cotton</td>
<td>Maize High</td>
<td>2.75 to 1010</td>
<td>72</td>
<td>Annual Cropping</td>
</tr>
<tr>
<td>SWAZILAND</td>
<td>-</td>
<td>30 - 80</td>
<td>-</td>
<td>All Temp. grass Scrubland Savannah</td>
<td>1969</td>
<td>High</td>
<td>Tractors Small</td>
<td>Demo Plough Irrigate Transport</td>
<td>Rice</td>
<td>High</td>
<td>0.5</td>
<td>-</td>
<td>Multi Cropping</td>
</tr>
<tr>
<td>BANGLADESH</td>
<td>140</td>
<td>54 - 74</td>
<td>11.9</td>
<td>Comilla, Homsoon Fertile</td>
<td>-</td>
<td>High</td>
<td>Tractors (40-70 HP) Many</td>
<td>Rehabilitate Tillage Threshing</td>
<td>Rice</td>
<td>0-77</td>
<td>-</td>
<td>400</td>
<td>Annual Cropping</td>
</tr>
<tr>
<td>SRI LANKA</td>
<td>300</td>
<td>28 - 54</td>
<td>44.6</td>
<td>Dry Zone Tropical</td>
<td>1944</td>
<td>Low</td>
<td>Tractors (40-70 HP) Many</td>
<td>Rehabilitate Tillage Threshing</td>
<td>Rice</td>
<td>0-77</td>
<td>-</td>
<td>400</td>
<td>Annual Cropping</td>
</tr>
<tr>
<td>PAKISTAN</td>
<td>350</td>
<td>30 - 57</td>
<td>3.6</td>
<td>Sind Flood plains Low rain</td>
<td>1972</td>
<td>High</td>
<td>Bulldozers (75-125 HP) 175-300</td>
<td>New land &amp; rehab. Clearing Levelling</td>
<td>Rice Wheat Cotton</td>
<td>50</td>
<td>4.5</td>
<td>1600</td>
<td>Multi Cropping</td>
</tr>
<tr>
<td>NICARAGUA</td>
<td>860</td>
<td>20 - 60 - 43</td>
<td>23.9</td>
<td>Pacific Coast plain 1300mm rain Fert. Volc.</td>
<td>1980 to 1984</td>
<td>Low</td>
<td>Tractors Hundreds</td>
<td>Run large Co-ops Cult. Transport</td>
<td>Cotton</td>
<td>50%+</td>
<td>100</td>
<td>Low</td>
<td>Annual cropping</td>
</tr>
<tr>
<td>PERU</td>
<td>1170</td>
<td>9 - 40</td>
<td>73.2</td>
<td>Amazonian Humid Tropical</td>
<td>1976</td>
<td>Low</td>
<td>Tractors (80HP) Bulldozers 42 -</td>
<td>New area Cult. clear</td>
<td>Tobacco Rice</td>
<td>0-20</td>
<td>-</td>
<td>-</td>
<td>Short fall</td>
</tr>
<tr>
<td>BELIZE</td>
<td>1200 (Est)</td>
<td>25 - 60</td>
<td>Low</td>
<td>South Humid Tropics</td>
<td>1970</td>
<td>Low</td>
<td>Tractors Bulldozers Combines 2,7,5</td>
<td>New land Import Subst. Clear, plough harvest</td>
<td>Rice</td>
<td>50%+</td>
<td>10</td>
<td>Bulldozers High Others low</td>
<td>Bush fall</td>
</tr>
</tbody>
</table>
2. DESCRIPTION OF TABLE

a) GNP: 14 are low income countries, 6 low middle income and 1 (Malaysia) upper middle income.

b) Importance of agriculture: the subcategories that give an idea of the position of agriculture in the economy are:

   i) % GDP from agriculture
   ii) % Export revenue generated from agriculture (data only for 4)
   iii) % Working population in agriculture.

Overall GDP figure is in the 20 - 40 % range. Uganda 75%, Ghana 60% and Peru 9% are outside this range. Compared to higher income countries these figures are high.

Export % The 4 countries with data; 9%, 60, 70, 85 show how vital agricultural exports can be in generating foreign exchange. The middle range for the other countries is probably 40 - 60% with foreign exchange earnings often a Government priority. This indicates how much importance will be placed on agriculture.

The population %figures indicate how important the agriculture sector is in most of these countries. Figures range from 40% (Peru) to 88% (Central African Republic). There will often be a conflict in improving conditions for the majority of the farmers, mostly small subsistence type, and increasing export earnings. The conflict is often highlighted in THS policy.

c) Total Grain Imports^1^: Tonnes/'000 head of population. Figures vary from "low" (Belize) to, 168 tonnes per '000 people for Egypt. 11 of the 21 countries import 20 tonnes or more per '000 head. Many of these countries will have import substitution policies, often backed up by a mechanisation policy.

^1^ This figure is Gross ie not a balance after accounting for any grain exports.
d) **Agro-environmental:** Region of the country, rainfall and natural vegetation. This shows, with the machinery data (g), how big and widespread the scheme was. Also it gives the rainfall and vegetation type. Types vary from low rainfall irrigated to, high rainfall tropical forest type areas.

e) **Date of scheme:** THS first started during and just after World War 2, many of them started by Colonial Development Boards. There is not enough information by which to assess if they continue to be set up at the same rate, or not.

f) **Population density and labour availability:** All variations exist. These parameters with others (see d above) have a large bearing on the potential for mechanisation. If there are labour shortages at particular times and machines can be used to ease the shortage there is more likely to be a demand for the service. This is seen, for example, in Egypt, Malaysia, Ivory Coast.

g) **Machinery data:** Sub sections are; category of machine and, numbers. All examples, bar Pakistan and Belize, deal with tractors or, tractors and bulldozers. The Pakistan example deals exclusively with bulldozers and other land shaping equipment. It is not clear from the available information if Governments in other places become involved in the hire of other machinery or not. The impression is, not to any great extent. Tractor numbers vary from 1592 in Ivory Coast for a country wide service to, 5 in Malawi for a small isolated scheme. These figures are not necessarily an indication of the country's total stock of tractors, they are just the figures from the schemes for which information was obtained.

h) **Objectives, Operations carried out:** The objectives vary from; modernising the farming systems to, increasing production of a particular crop through to, settlement of new areas. The main operations are usually ploughing/primary cultivation and transport.
i) Main crops: Rice and cotton are the most common. Apart from Swaziland (subsistence maize) THS is used on cash cropping.

j) Estimate of subsidy: Most of the schemes (18 out of 21) have never operated without a subsidy. All schemes have operated on a subsidy for the majority of their existence.

k, l, m) Farm size. Annual utilisation. Farming system. Information is incomplete but the impression is that farm size and field size are usually small. Annual utilisation varies from 144 hours to 450. Even the upper limit is low, and when the % of this that are non-revenue earning hours (ie travelling) are taken into account, the figures are considerably lower.

C HYPOTHESES AND LESSONS

1. COSTS

1.1 Subsidies: The most striking observation from the examples given is that 18 out of 21 schemes were always under a degree of subsidy. These range from marginal (Malaysia) to an estimated 94%, Sierra Leone in 1982. For the other 3 schemes the non-subsidised period was short lived.

This means that public THS nearly always imposes a financial burden on the Government. The question to be looked at in some of the following sections is whether this can be justified on economic grounds of there being a net gain to the nation in the short or long term.

1.2 Proportion of Government Budgets: The examples show that financing for THS comes from the Governments, either directly from the domestic budget and, or in many cases a large proportion of financing is from foreign aid, channeled through the Government. THS are usually run through the Ministry of Agriculture, and can account for a large proportion of the Ministry's Development Budget. Not much data is available on this, but in the cases of Malawi, Uganda and Sierra Leone, THS was estimated to use 60, 75 and 75%, respectively, of the Ministry of Agriculture's Development budget. This raises serious questions
regarding the distribution of resources within the agricultural sector, ie to extension services, research projects, etc.

1.3 Financing of Operations: Usually the schemes operate on an annual rate from the vote of the Ministry of Agriculture, and revenue is returned to central funds. Attempts at establishing a revolving fund have had minimal success (eg Kenya, Sierra Leone). It is therefore, difficult to give the management of such schemes financial incentives or targets.

Often the stated intention of the Government or Ministry when setting up the THS is that revenue from the service should cover operating costs. Even if this objective were met, which is rarely the case, it is very common that the capital costs are omitted from the calculation. For a high capital cost item such as a tractor this leads to uneconomic pricing. Apart from causing financial losses to Government, these charges also set rates that prohibit Private contractors from competing.

2. Objectives

THS are formed for a variety of reasons. This section considers which objectives under which conditions are likely to lead to success or failure, and how valid these objectives are from a developmental point of view.

2.1 Modernising Agriculture: In some cases; Uganda, Malawi, Kenya modernisation of smallholder agriculture was the main objective. These schemes have not worked and have been costly failures. In these cases the main system of farming was the use of a hand hoe on small plots. Problems of dispersed and small fields make hire schemes costly to operate and difficult to manage. In addition, THS usually only carry out a few operations, so labour constraints for the non-mechanised operations will constrain the amount of work available for THS. In the Uganda example it is expressly stated that lack of demand was the main reason for the failure of the THS. Finally, if the only objective is to modernise existing systems of farming, and those systems are smallholder subsistence, then there will be a shortage of cash to pay for an input that previously only took time rather than cash. In most of these areas
there are few off-farm cash earning opportunities.

2.2 New crops: Many schemes are linked to the introduction of a new crop, or an increase in emphasis of an existing crop. These are crops either for export eg cotton or for import substitution of cereals, eg rice. In 10 of the 21 examples cotton is the crop, or one of the main crops. This is for most of the African countries plus Pakistan and Nicaragua. Rice is the main crop in the humid tropical areas such as Belize, Nigeria and Malaysia, and an important crop in the drier irrigated areas, ie Egypt, Pakistan and Sri Lanka.

2.3 Foreign Exchange: The improvement of a country's foreign exchange position can be a major objective in starting THS. Some of the cotton schemes are examples of trying to export earnings (eg Sudan, Ivory Coast, Uganda). Alternatively the improvement of the foreign exchange position through import substitutions can be the method. Good examples of countries attempting this are, Malaysia, Belize and Egypt. It is not clear that some of these countries take all parts of the foreign exchange equation into consideration. The foreign exchange cost of the tractors and fuel may outweigh the foreign exchange gains earned by the product. Egypt is an example.

2.4 New Areas: There are three main reasons for settling farmers in new areas.

- Alleviate land pressure
- Increase production of a crop
- Strategic political.

There can, of course, be a combination of these reasons. Examples of resettlement and THS due to land pressure are; Kenya, Peru, Central African Republic and Belize. In these cases people are being encouraged to move from upland areas to lower lying savannah or tropical rain forest areas. The results of such schemes will not be fully apparent for a long time since the move usually means a drastic and sudden change in farming systems; ie from slash and burn to mechanised lowland rice (Belize). The learning and settling process takes a long time. The short
to medium term results have been poor and if, as is arguable, a subsidy is justified in these cases it is probable it could be administered more efficiently than by THS. For example, train drivers and mechanics, direct subsidy to farmers to run private contracting services, subsidised spare parts etc.

Public THS in new areas for the increase in production of a particular crop have not been successful. Again, subsidies could have been distributed in ways that would encourage more efficient production.

There are sometimes strategic political reasons for settling new areas, ie close to national borders, or to strengthen a claim to the area. Another political motive is to have a visible development input into what may have been a neglected area. In these cases, the political gesture may override economic considerations.

2.5 Demonstration: As an objective this is not far removed from the introduction of THS to modernise traditional agriculture. This does imply, however, a more gradual educative process, rather than a summary dismissal of existing farming methods. Examples of THS for demonstration are Swaziland, Malawi, Gambia and Nigeria. The THS is usually attached to a Ministry of Agriculture station, and in the case of Nigeria was intended, initially, for the long serving member of the station. Demonstrations will be carried out on the station land, and this is linked to the overall extension effort. As far as the economic feasibility is concerned this method is preferable to outright modernisation. The initial input is small, and there is more time to evaluate the potential for the particular area. The problem comes when the effectiveness of tractors are demonstrated on the basis of subsidised prices. This can ben lead to all the normal problems of THS.
3. Evidence of Success

The commonly held opinion on "Government Tractor Hire Schemes" is, that almost without exception they have been dismal failures. From the Economics point of view this is, for the most part, borne out by the examples. Public THS have been a poor allocation of resources from the nation's point of view. In many cases tractorisation whether Public or Private would have been a poor idea, eg modernising traditional systems per se (Uganda, Malawi). In other cases, some resettlement and/or export crops, the idea of tractorisation is feasible, but the reality of Public THS has, mostly, been an economic failure. There are better ways of introducing multi-farm use of tractors. Financially, from the farmers point of view (see below) some schemes have been successful. This is only due to large subsidies that have undesirable effects on both the farmers involved and other parts of the agricultural sector.

3.1 Financial: There are no examples of schemes that can be considered financial successes from the Government point of view. Most schemes for all their existence, and the others for most of their existence have relied on Government subsidies to remain operational.

From the farmer point of view some of the schemes have been successful. In Swaziland it was shown that ploughing by tractor was half the cost of ploughing with draught animals. In Pakistan the returns to the land owners of land levelling/reclamation operations were shown to be very high returns at the subsidised rates, and would have been reasonable even if economic rates were charged for the service. In many of the examples the benefit to farmers is demonstrated by the excess level of demand for THS. This is very much the case in Egypt, Pakistan, Nicaragua, Belize, Malaysia and Ivory Coast. Apart from some novelty value THS will not be used by farmers unless there is financial benefit in doing so. A few schemes have failed due to lack of demand for the services (Uganda, Malawi) but the majority cease because the financial burden on the Government is too great, or the machinery and management become inoperative.
3.2 Economic: Rarely is analysis of the costs and benefits of these schemes carried out, so judgement has to be subjective. The cases of modernising traditional farming systems (Uganda, Malawi) have been failures by any criteria. Tractorisation of any form was inappropriate under these conditions. Large amounts of financial and managerial resources were diverted to these schemes with no discernible benefit.

In the case of settling new areas the benefits are expected to be long term and from the examples it is difficult to make a judgement on success or failure. As said in the introduction to this section it is probable that, accepting some degree of initial subsidy is necessary, there are usually more efficient ways of using it than on Public THS. However, there does seem to be one area where Public Machinery Hire functions efficiently. This is with heavy land clearing and shaping equipment eg Pakistan, Peru and Belize.

When new areas are being developed, roads will often be inadequate and maintenance infrastructure limited leading to high overhead costs. Also wear and tear on machinery will be high leading to high operating costs. Further, heavy machinery is so expensive, it is unlikely that Private contractors become heavily involved. In these instances there is a strong case for public involvement since the machinery can be operated efficiently and the "development" subsidy can be justified.

In examples where demonstration is the main objective there has been some success evidenced by demand for the THS and subsequent starting of private hire schemes, eg Malaysia and Egypt. As noted previously, several times, there has been success, but Public THS has reduced severely the degree. This is due to the continuation of subsidies beyond the introductory stage, which encourages misallocation by the farmers and slows down the entry of private services into the hire market.

Government THS remains the main source of tractor service and the farmers are restricted to what is usually a rather unreliable service. In the Malaysian, Egyptian and Swaziland cases, even though the THS rates are low, some farmers do start buying their own tractors for their own use and for hiring because they cannot afford to be at the mercy of the unreliable service. They will provide a limited hire service, but
not to their full technical potential because economically it is, at best, marginally profitable and more usually they only cover running costs.

In cases of setting up a THS for the production of export crops or for the production of crops for import substitution the objective is to improve the foreign exchange position of the country. In straight accounting terms only the Ivory coast scheme seems to have been successful. Some of the schemes such as those in Uganda, Belize, Malawi have been failures from any perspective. The judgement on some of the others hinges on what premium the country puts on foreign exchange earnings or savings. Sudan and Nicaragua are examples. With a very high "shadow" (economic) rate these schemes might be judged successful just on the foreign exchange criteria.

3.3 Technical: Success or failure from this point of view refers to the operational efficiency of the scheme; down time, annual utilisation, quality of operation. The examples show that the most important factor is the quality of the management. Swaziland and Ivory Coast are examples where good management has raised the performance indices above those of the other THS. Crucial factors in both these cases were; high maintenance standards, well trained and well paid operators given good overtime allowances to ensure long hours at peak periods and, close monitoring of all operations by the manager. This shows that it is feasible for factors to operate efficiently from a technical standpoint under developing country conditions if the management is good enough. What is discouraging is that there are so few examples in public THS of, good management and resultant technical success and since this is a prerequisite for any chance of financial and economic success the potential for public THS seems limited.
4. Potential of THS

Many of the schemes demonstrate the misconception that Government have regarding the capabilities of THS. The conception often is, that the mere introduction of a THS will increase area or yield, free labour constraints, etc. This shows a poor understanding of the farming systems and the capabilities of tractor operations. Governments often see THS as a means of rapid expansion of Agricultural output. This is usually unrealistic as they are expecting things to change too fast, without realising that one needs a stock of trained personnel, good infrastructure and good management, as minimum requirements to enable tractorisation to be viable and successful.

4.1 Primary cultivation and transport: In all the examples involving tractor hire primary cultivation and usually transport are the most important jobs done. In some cases, (Sri Lanka, Egypt, Malaysia) tractors are also used to power threshers. In only one case, Belize, are harvesters included in the hire scheme. Attempts to use tractors for other operations have mostly been restricted to spraying of cotton. There is little evidence to show that yields will increase due to ploughing by tractor, and the potential to increase the cultivated area is restricted by power constraints at other points in the farming system. If ploughing was the binding labour constraint then there is some potential for THS to help expand the area, but this is limited by subsequent constraints they come into play as area increases such as weeding and harvesting.

Operations to which tractors are best suited (ploughing and transport) may represent a constraint in the farming system, but the releasing of these particular constraints is unlikely to make large differences as far as field or area are concerned unless other constraints (less easily tractorisable) are released simultaneously. Depending on the particular system and labour availability these other areas will include; planting, weeding, harvesting, threshing, milling and irrigation.
4.2 Expansion in area: There is insufficient data from the examples to determine in which case THS leads to an expansion in area. It does seem that some of the cotton schemes are such cases eg Sudan. If this is so it is because these schemes are more regimented than most THS and provide mechanisation for all operations from ploughing through to weed and pest control. The Sudan example also showed that an overly regimented mechanisation scheme can be self-defeating. On the one hand, to get the full benefit of transforming agriculture by mechanising through multi-farm use of machinery, one needs control. On the other hand farmers resent this regimentation, loss of control, and relegation to observers and will not be willing cooperators.

4.3 Time synchronic and time bound operations: Much of the problem regarding THS is that the operation to which tractors are best suited ie ploughing, usually need to be done within a short period (time bound) and within a particular region at the same time on all farms (time synchronic). This is particularly so in rainfed agriculture where commonly there are only 6 - 8 weeks to plough and plant following the first significant rains. The problems are difficult enough when dealing with one farm only, but these are increased with multi-farm use and even more so with public schemes where management is often rather poor. Firstly, the % of non-productive working time is higher for multi-farm use due to travelling. Secondly, with public THS the start of the peak season often finds many of the tractors still out of commission. Finally, at a time when the machines should be working 12 hours a day or more, public THS are often held back by incentive problems with operators only doing a regulation 8 hour day.

4.4 Bulldozers: The better economic performance of bulldozers compared to tractors as evidenced by the Belize and Pakistan examples demonstrates, by comparison some of the shortcomings of Public THS. In these examples bulldozers are being used for land clearing, some cultivation and, land shaping. This tends to be on larger blocks of land than for most tractor operations and the work rate for these operations is slower, therefore there is a much smaller % of travel/non productive time. Also, the period over which these jobs can be carried out is usually longer than for ploughing, hence higher annual utilisation
rates. For some reason, bulldozer operators are often prepared to work longer hours, and one finds that one bulldozer with two operators may be working almost round the clock. Again this means higher annual utilisation rates.

4.5 **Harvesting:** Rice harvesting by public hire service in Belize offers a good example of problems associated with time bound and synchronic operations. 90% of all mechanised rice is the same variety, and it all germinates at the same time. Hence one has 4 - 6 weeks maximum for harvest. The logistical and political problems involved have resulted in utilisation rates of around 80 hours/machine/year.

5. **THS as an Evolutionary stage**

By considering the farming systems, population densities and dynamics, market involvement etc one can determine the stage of agricultural development for an area. Successful motorisation does tend to occur beyond well definable stages and forcing this evolution is usually a recipe for failure.

a) Motorisation in intensive farming is widespread and successful when the rural population is falling in relative and absolute terms.

b) Cultivation is usually one of the latter operations to be mechanised. Threshing, milling, irrigation and transport will usually be mechanised beforehand. Mechanisation includes tractorisation, but not exclusive to other machine operated jobs.

c) Motorisation in extensive farming is widespread and successful when there is a labour shortage, strong domestic markets for the produce and usually good export markets as well.
5.1 **Intensive systems:** These generalisations/hypotheses are historical observations a) is evident in Asia today. Of all the countries with intensive bunded rice farming systems only those countries with rural populations that are declining in relative and absolute terms have what could be described as widespread mechanisation. These countries are; Japan, Taiwan, Korea and Burma. Of the examples in this report Malaysia is the one that comes closest to these conditions and THS has been moderately successful. The Malaysian example also demonstrates that the evolution of the system is that threshing and milling are mechanised before cultivation.

5.2 **Extensive systems:** The limited success of mechanisation schemes in the savanna areas of Africa is curious. It would seem that the land abundant, labour shortage conditions hold, and in the case of cotton there is an export market. Judging by some of the examples in this study (ie Sudan, Malawi, Togo) this lack of success demonstrates that the evolutionary process cannot be forced too hard. The step from limited or no animal draught to mechanisation is too big unless the management and back up is very strong. The individual technical skills and general back up do not exist, infrastructure is poor and often the product prices are not high enough.

6. **Distributional effects**

With the introduction of a THS it is unlikely that the status quo will be maintained. New resources are being introduced into the system, and there is almost bound to be an uneven distribution of these resources. Unless there are firm directives as to how the resources should be distributed, as in the Uganda and Ivorian schemes, the benefits will go to the richer more influential farmers.

- The wealthier farmers have better access to cash, and in view of high default rates, preference is often given to those who have cash. This is seen very clearly in Swaziland.
These more influential farmers are often able to use their political power to gain access to the service and, often more importantly, they have more chance to get it at an optimal time. Where ploughing or harvesting is concerned the timing can be critical.

The very poor/small farmer, or those farming under communal land rights can be in the position of not being able to offer land titles or leases as security against a credit arrangement for hire services.
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APPENDIX 1: COUNTRY NOTES

1. MALAWI
2. THE GAMBIA
3. GHANA
4. NICARAGUA
5. TOGO
6. BENIN
7. IVORY COAST
8. PERU
9. CENTRAL AFRICAN REPUBLIC
10. BELIZE
11. NIGERIA
12. MALAYSIA
13. BANGLADESH
1. Introduction

There has been no large-scale government tractor hire in Malawi, but there have been a number of small regional schemes.

The first one mentioned was in the Lower Shire District of Southern Malawi (1953-56) but no details are known. There was another scheme in the same area (1964-67), and further tractor hire schemes were operated by several Regional Development Projects in the 1970s, e.g. Central Region L.D.P., and Salina Lakeshore R.D.P.

There is a power-tiller hire scheme in the south of the country under Taiwanese management.

Most tractor hire operations appear to have now closed or to be winding down their activities. Animal draught is now seen as more appropriate for small farmers in Malawi.

2. Background

1) High population density and little undeveloped land.
2) Rainfall unimodal (Nov-March) and timeliness of cultivation and planting important.
3) Smallholder sector has low average farm size and tradition of manual cultivation
4) Ox cultivation is well established in north and central areas, but relatively new in South.
5) The estate sector uses tractors, but very few smallholder farmers
6) Government is actively involved in ox-training, development of implements, and extension.
3. Schemes

3.1 Lower Shire District (A64-1967) - Department of Agriculture

Objectives: Not clearly stated but included:
- Demonstration
- Opening new land
- Increasing cotton acreage
- Raising cotton yields
- Stimulating private contracting

Equipment: 5 MF 165 tractors with disc ploughs

Operation:
- Customers canvassed by DoA staff
- Payment in advance
- Minimum field size 2 acres (not adhered to)
- Cheaper rates for larger blocks
- Fields should be stumped (not always done)
- High proportion of newly cleared land
- Two drivers per tractor

Performance:

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres ploughed</th>
<th>Number of tractors</th>
<th>Acres per tractor</th>
<th>Hours per acre</th>
<th>Hours per tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>1760</td>
<td>5</td>
<td>352</td>
<td>2.01</td>
<td>708</td>
</tr>
<tr>
<td>1966</td>
<td>1741</td>
<td>5</td>
<td>348</td>
<td>1.51</td>
<td>525</td>
</tr>
<tr>
<td>1967</td>
<td>573</td>
<td>5</td>
<td>115</td>
<td>1.13</td>
<td>130</td>
</tr>
<tr>
<td>Mean</td>
<td>1358</td>
<td>5</td>
<td>272</td>
<td>1.55</td>
<td>421</td>
</tr>
</tbody>
</table>

- Output deteriorated as tractors aged
- Work rates satisfactory and improving
- Output limited by low demand
- Breakdowns high - stumps caused damage

Financial:

<table>
<thead>
<tr>
<th>Year</th>
<th>Costs per acre</th>
<th>Charge per acre</th>
<th>% subsidy</th>
</tr>
</thead>
<tbody>
<tr>
<td>1965</td>
<td>5.97</td>
<td>5.00</td>
<td>16%</td>
</tr>
<tr>
<td>1966</td>
<td>5.78</td>
<td>5.00</td>
<td>13%</td>
</tr>
<tr>
<td>1967</td>
<td>11.67</td>
<td>6.00</td>
<td>49%</td>
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Initially small subsidy per acre increased as performance deteriorated.
Spare and repairs costs rose substantially as machines aged.

Breakdown of costs (for 1966) as follows:

<table>
<thead>
<tr>
<th>% of Total</th>
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<tbody>
<tr>
<td>Admin</td>
<td>8.7</td>
</tr>
<tr>
<td>Depreciation (20%)</td>
<td>26.1</td>
</tr>
<tr>
<td>Fuel</td>
<td>17.5</td>
</tr>
<tr>
<td>Oil</td>
<td>2.3</td>
</tr>
<tr>
<td>Spares</td>
<td>21.5</td>
</tr>
<tr>
<td>Repairs</td>
<td>3.0</td>
</tr>
<tr>
<td>Wages of drivers</td>
<td>18.5</td>
</tr>
<tr>
<td>Wages of mechanic</td>
<td>2.4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>100</td>
</tr>
</tbody>
</table>

Other Notes: Scheme wound up after large losses in 1967
Inappropriate in view of high population density and small farm size
High repair costs reflect use on poorly cleared land
Farmers unwilling to pay full costs
Small range of operations, therefore low utilisation

3.2 Salina Lakeshore Rural Development Project (1972-1982?)

Objectives: Opening up new land especially for rice
Non-profit, non-loss making

Equipment: 8 tractors plus ploughs, ridgers, rippers, and a gang filler

Operation: Small farmers should group together, so block of at least 2.5 ha available for cultivation
Cash or credit payment
Tractor weeding proved impossible as land too wet
Plots scattered, so travel time high
Tractors worked in two groups to ease servicing/repair
Repair work and stores: used Project facilities, not separate for THS
Two drivers per tractor. 3 grades of pay so promotion of good workers possible
Overtime payments made

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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of farmers served</td>
<td>1373</td>
<td>1099</td>
<td>447</td>
<td>690</td>
<td>60</td>
</tr>
<tr>
<td>Hectares ploughed</td>
<td>779</td>
<td>630</td>
<td>236</td>
<td>402</td>
<td>103</td>
</tr>
<tr>
<td>Working hours</td>
<td>2850</td>
<td>2114</td>
<td>1165</td>
<td>1987</td>
<td>511</td>
</tr>
</tbody>
</table>

Tractor numbers declined from 8 in about 1972 to 1 in 1981 as machines broke down.
If work for smallholders inadequate, work also done for estates and for RDP to raise utilisation. On average:
- 55% of work for smallholders
- 17% of work for estates
- 28% of work for project

Financial: Charges usually fixed to cover costs completely
Overall subsidies in a couple of years only
Higher charges for estates and project than smallholders so some cross-subsidy

Other Notes: Farmers found tractor hire uneconomic compared to oxen, especially when fuel prices increased.
Scheme allowed to die because of lack of demand
May have been useful in bringing newly cleared land under cultivation
Weeding a major labour bottleneck, but not mechanised
Utilisation maintained at reasonable level only by work on estates and projects.

3.3. Power Tillers

About 40 power tillers are available on hire through 5-8 centres in the south of the country. Main problems are:

i) Fuel provision
ii) Obtaining spare parts (from Taiwan)
iii) Bureaucracy of project
4. Conclusions

When charged at or near the full costs of mechanised cultivation, farmers have found it uneconomic compared to animal cultivation.

The schemes have operated on small, scattered, and sometimes poorly cleared fields. The high proportion of newly developed land raises repair costs.

The small range of operations performed by tractors, and their seasonality, has reduced the possibility of achieving high utilisation. Work on estates and projects has helped to raise it.

Schemes appear quite well run: good information on performance and costs; tractors operated in shifts; driver training and incentives.
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The Government of Gambia started a tractor ploughing scheme in 1950 with the aim of demonstrating and popularising the mechanised production of riverain rice. Initially, the service was provided free of charge, and then subsidised charges were introduced and it was planned to reduce the subsidy over time.

Land is cultivated during the dry season (March to June) and ends when the rains build up in July. During the growing season the land is flooded. Labour shortages are evident for cultivation and planting operations, limiting the area of rice which is grown. The usual land preparation operations were chisel ploughing followed by disc harrowing, and 60 hp wheeled tractors were used. Out of season, the tractors did haulage work.

In 1965, there were 26 tractors which cultivated 2100 ha. By 1972, there were 24 tractors and about 1800 ha were cultivated. The average area cultivated per tractor was therefore about 80 ha. The number of tractors in the scheme subsequently reached 69 (date not known). In 1965 the charge was D28/ha for ploughing, plus D9/ha for cultivating. By 1981, charges were still at the same level, and were estimated to cover less than 1/3rd of the costs of the service. Payment was made either directly by the farmer or via Cooperative Societies. The Coops arranged contracts directly with the THS before the season began, and so reduced the task facing the scheme's management. Plots were supposed to be at least 4 ha in size, so as to reduce the amount of travelling.

Constraints on the operation of the scheme were identified as:

a) Shortage of good operators and mechanics
b) Lack of incentives (e.g. overtime payments limited to 10 days per month)
c) No central base for the scheme
d) Shortages of spares and fuel
e) Breakdowns due to poor maintenance and poorly cleared land
f) Delayed payment resulting in late start of work
g) Inability to meet demand at peak times
h) Fragmentation of holdings
i) Inappropriate equipment
j) Poor management
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1. **Introduction**

There was a large government mechanisation scheme in Ghana in the 1960s run by the Mechanisation and Transport Department of the Ministry of Agriculture. In 1967, there were reported to be 1500 wheeled tractors and 300 crawlers in the scheme, operating through 32 district mechanisation stations in the savanna area of the country. In addition, machinery services were provided by parastatal crop boards such as the Cotton Development Board and the Grains Development Board, as part of an extension service to promote their specific crops. Little information has been found on the schemes.

2. **Background**

Mechanisation stations were intended to be in areas suitable for extensive mechanical cultivation, primarily the Northern Savanna (which has one rainy season) and the South-east Savanna (on the coastal belt, with two rainy seasons). The Northern Savanna is the main crop producing area, and rice, maize, guinea corn, millet, and ground-nuts are the principal crops. Most holdings are individually owned and less than 2 ha in size.

3. **The Scheme**

There was a head office and central parts store at Accra, a number of regional centres with offices and workshops, and 32 district stations with basic tractor storage, parts store, workshops and offices, controlled by an officer-in-charge. The districts stations had mechanics to carry out simple repairs and maintenance, and the tractors were taken to regional centres for major repairs and seasonal servicing.

The services offered included land-clearing, cultivation, and harvesting, with ploughing the dominant operation:
TABLE 3.1  Relative Importance of THS Operations, N. Ghana

<table>
<thead>
<tr>
<th>Operation</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ploughing</td>
<td>87%</td>
</tr>
<tr>
<td>Ridging</td>
<td>2%</td>
</tr>
<tr>
<td>Harrowing</td>
<td>2%</td>
</tr>
<tr>
<td>Planting</td>
<td>2%</td>
</tr>
<tr>
<td>Combining</td>
<td>3%</td>
</tr>
<tr>
<td>Clearing</td>
<td>4%</td>
</tr>
</tbody>
</table>

In addition, a considerable amount of transport work was undertaken, amounting to 70% of all work in some more isolated areas.

Details of the equipment used are not known, but apparently much of it was of East European origin.

A farmer wanting to hire a tractor was supposed to arrange it in advance via the District Agricultural Officer or the local THS unit direct. A schedule was drawn up and followed until the onset of the rains made further cultivation impossible. Charges were assessed on completion of the work, and could be paid immediately or after the harvest of the crop.

Data are not available on the costs or revenues of the scheme. In 1973/4, it was estimated that hire charges for ploughing and harrowing were 50% less than the real cost, and the subsidy on land clearing by government machinery was calculated at 70% in 1972.

Other points on the operation of the scheme are:
- machine distribution was poorly planned
- workshops were badly equipped and inappropriately located
- records of work undertaken, repairs, spares stocks etc. very poor
- shortages of trained operators, mechanics, and supervisors
- lack of training at all levels
Encouragement was subsequently given to private contractors, e.g. via training courses on operation and maintenance of tractors, Agricultural Credit Bank Loans, and doing repairs for private operators in MoA workshops. However, the development of contracting services was hampered by foreign exchange shortages, affecting fuel and spares supplies as well as machinery purchase.

4. Conclusions

Ghana learnt the lessons of trying to achieve widespread mechanisation in a short time. The problems of training manpower, developing maintenance, repair, fuel and spares facilities, and of managing a large fleet of machines, proved insuperable. The experiences argue in favour of a more gradual approach with greater reliance on commercial firms for provision of inputs. It is also apparent that the Government underestimated the recurrent costs of running a tractor hire service and that inadequate budgetary provision was made for these.
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BACKGROUND

1. Area 130,000 Km² situated between Costa Rica and Honduras in Central America.

2. Population: 2.8 million, growth rate 3.0%.

3. 3 Regions: 
   - Atlantic, tropical rainforest, sparsely populated.
   - Mountains, variable climate, intensive farming subsistence type farming, valley bottoms.
   - Pacific, 1000 mm-1500 mm rainfall, fertile soils commercial type farming.

4. About 43% adult population employed in agriculture. Overall population density low by Central American standards.

5. Agriculture 20% GDP and 60% total exports; cotton, coffee, cattle and sugar are the main export products.

6. Hired labour situation in Pacific region changed dramatically since revolution. Continuing redistribution of land gives former landless labourers rights to farm their own land, therefore reducing the hired labour market.

FARMING SYSTEMS

1. Atlantic - Slash and burn extensive farming by Amerindian groups.


3. Pacific - Mostly commercial, large farms. Northern zone predominantly cotton on rolling land, fertile volcanic soils. Average farm size 200 ha. Cultivation by tractors, spraying aerial, some mechanical harvesting. It is in this region that the THS are concentrated. Field size often restricted due to the slopes, and having to contour plough. The soils, being volcanic
are light and subject to erosion. The cotton is all marketed. Subsistence crop requirements will also be grown on the farm using mechanical cultivation.

The central region is mostly coffee, and the southern region mostly cattle: farm size for both is large and there is widespread tractorization.

MECHANISATION

1. There is a long tradition of mechanization in the Pacific zone. The land is readily mechanizable and population density is such that mechanization is the only way to increase the productive area.

2. Before the 1979 revolution, all farms were privately owned, and they had their own tractors. Post revolution, the land of those who emigrated was redistributed to landless farm labourers. This created the need for THS.

3. Legislation has been passed in 1984 to break up THS and allocate tractors to each of the communal farms. This is an attempt to overcome logistical problems and lack of incentive that occur with tractor pools and hired operators. The tractors will still receive the benefit of the various Government subsidies.

4. Operations:

- Cultivation is the main tractorised operation.
- Spraying is done almost entirely by aircraft.
- Harvesting mostly by hand, but there is some mechanised.
- Transport will be by tractor.
- Sprinkler irrigation has been attempted, with little success.
- There is little land levelling, and ought to be more, in order to increase field size and decrease erosion.
- Some land clearing, but since the revolution, much previously cleared land has gone out of production, so this will be taken up first as the cultivated area increases again.
- There is little variation in the timing of operations over the area.
- The cropping season can be stretched over 9 or 10 months.
- Dry season maize has been attempted using irrigation.
- This would increase the working season of the machines, but, as yet, the attempt has been unsuccessful.
- On average, machines are busy 4 months per year.
5. **Equipment**

- Pre 1979 mostly MF, John Deere and International Harvester
- Up to 500/yr being imported.
- Post 1979, mostly Eastern Bloc tractors, i.e. Deutz.
  Now 200-300/yr being imported
- Most tractors 60-80 hp range, some very large ones.

**MANAGEMENT**

- Central planning
- General schedules one year in advance, do not allow for local variation and late changes
- In the past, tractors have been shunted round the zone causing logistical problems
- Little formal recording, making data collection almost impossible
- Severe incentive problems; low salaries, poor training
- Lack of trained personnel from mechanic level to higher management levels

**FINANCIAL**

- Operate on a subsidy. Extent difficult to determine but probably 50% or more.
- Various stages to the subsidies:
  - Foreign Aid. Very favourable credit terms from the Soviets.
  - Distorted exchange rates
  - Domestic Credit: The Agricultural Banks offer interest rates of about 4%. Inflation rate is 20-30%.
    - There is a per ha charge, but rough and ready field measurements result in underestimates.
- Revenue is retained in the scheme
- No private hire operators. Economic rates would not compete with THS, and private farms mostly have to operate with pre 1979 machines, and want to keep them operable as long as possible.
PERFORMANCE

- There are few records by which to judge performance quantitatively.
- Annual utilization is low, and probably 50% of tractors are out of operation at any given time.
- Drivers have little interest in their jobs, resulting in poor quality, due to excessive work rates and heavy wear on the tractors.
- There is excess demand for tractor services.
- Repair facilities are poor:
  - Poorly trained personnel
  - Minimal preventative maintenance
  - Shortage of spares
  - Main cause of major breakdowns is engine failure after engine overhaul.
- The Eastern Bloc tractors are judged not to be as reliable as the American ones imported pre-1979.
- For private farmers with American tractors, it is very hard for them to obtain spares, due to foreign exchange restrictions on imports.
BACKGROUND

Togo, situated to the east of Ghana, has an area of 57,000 Km² and, from a coast-line of 56 Km, extends inland for 540 Km. Total population is 2.7 million with a growth-rate of 2.5%. 70% of the adult population is employed in agriculture. For Africa the population density is quite high. This is because all the land is agricultural apart from one chain of mountains. The coast is the most densely populated area with about 125 persons/Km².

There are two climatic regions; In the north there is only one rainy season (March to October) with a relatively cool dry season. The south has an equatorial type climate marked by two rainy and two dry seasons. Erratic distribution of rainfall does sometimes cause problems for the annual crops. Tropical latteritic soils are predominant. The hydro-morphic soils along the river courses are rich in organic matter, but sometimes hard to work. An estimated 20% of the soils are considered rich.

Growth of agricultural production is poor (1.5%) which has resulted in cereal imports rising from 6000 to 62,000 tonnes from 1974 to 1981. Agriculture's share in GDP has fallen from 55% to 24% from 1960 to 1981. Principal subsistence crops are; cassava, millet, maize and sorghum. The main cash crops are; cocoa, coffee, oil palm and cotton. Coffee and cocoa production has stayed level at about 12,500 tonnes each. Cotton production has risen by three times from 1977-1979 to a level of about 25,000 tonnes.

MECHANISATION

Animal and tractor draught power is utilised mostly in the cotton production regions. Spraying equipment is used quite extensively in cocoa production, and heavy land forming equipment is used in the south for land rehabilitation.

Most of the equipment is managed by SORAD the agricultural development agency.
Bulldozers (used in agriculture) 4 D4 and D6
Tractors, 35 to 60 hp 53
Cultivators 55
Spray machines 190
Swing lag 65

In overall terms, the extent of mechanization is very limited. The only examples of private motorisation are a few Chinese farmers using cultivators for rice production. Apart from that, all machinery is hired out at subsidised rates. The level of subsidy is not stated, but at such low levels of mechanization, the costs are extremely high due to high overheads and low annual utilisation rates.
BACKGROUND

Benin, a small West African State, lies between the 6th and 12th parallels, has an area of 113,048 km$^2$, and a population of about 3.62 million, with 80 to 90% being rural-based and concentrated on the coast in the south or in the far north.

There are 3 zones: Semi-equitorial, "Almost" Sahelian, and typically Sahelian. Tropical latteritic soils cover about three-quarters of the territory. Agriculture is predominantly a subsistence activity in Benin, and is concentrated on growing yams, cassava, sorghum, beans, millet, maize and rice. Sheep, cattle and goats are reared in the north, and pigs in the south. There are 30,000 ha of industrial oil palm plantations. Cocoa and cotton are the two other important cash crops.

MECHANISATION

Animal and motor draught power is used mostly in the northern cotton growing zones. This is because cotton is the only cash crop grown in Benin that lends itself readily to mechanisation. This may have changed recently with a large 5000 ha irrigation project being started in the Niger valley, mainly for rice.

In 1972 the stock of motorised machinery was:

- 110 wheeled tractors. Mostly Massey-Ferguson and International Harvester. 35 to 65 hp.
- 15 tracked tractors - mostly D4 caterpillar
- 3 Bulldozers
- 27 Cultivators
- Implements: ploughs, disc harrows, seeders, etc.

Mechanisation is in the hands of a Government development agency, SONACO. The cotton farmers arrange themselves in "pre-cooperative" groups, and hire the machinery on credit. At the end of the season, SONACO charge a per Kg tariff on the harvest. Maximum utilisation of the tractors is 600 hours/year. Costs were reported as being double those expected for the running of a tractor pool, but this was accepted as being necessary in the initial stages of popularising mechanisation of cotton production.
BACKGROUND

1. Area: 322,000 Km$^2$, situated in West Africa as Ghana's western neighbour.

2. Population: 8.5 million; growth rate 3.1% (reduced from 5% in the 1970 to 1981 period)

3. Equatorial climate apart from north-western fifth.
   - South - 1.25–2.40 m bimodal rainfall. Much valuable rainforest in south-west, the rest is mostly planted to tree crops - coffee, cocoa, bananas, oil palm.
   - North-west - 1.25–1.50 m, one rainy season of six months. Guinea savannah occurs here.

4. About 80% adult population engaged in agriculture

5. Ivory Coast is, commercially, the most important of the successor states of French West Africa. Agriculture accounts for about 70% of export earnings. These are almost exclusively from tree products. There are extensive multinational interests in these products.

6. Ivory Coast has the largest number of tractors in West Africa.

FARMING SYSTEMS

- Of the rural population, about 60% live in the forest region and 40% in the savannah region.

- There are a wide range of farming systems. About 50% of holdings practice monoculture. If one defines the system by the dominant activity, there are 14 principle categories, listed in order of declining importance with respect to number of tractors bought:
There is widespread cash cropping in both zones.

Forest Zone: Cocoa and coffee are cash cropped by small-holders. Pineapple, and oil palm and bananas, tend to be cropped on a larger area. For these crops tractors are used mainly for transportation. Back pack sprayers are used in coffee and cocoa. In the plantation crops, tractor mounted units and back pack sprayers will be used. 70% of all tractors are used in this zone.

Savannah Zone: Cotton, rice and sugar-cane are grown. When tractors are used it is for cultivation, spraying and transport. This zone accounts for about 30% of the tractor stock.

DRAUGHT POWER

- In the forest zone the reasons for mechanisation are:
  - Shortage of labour means that transportation has to be mechanised, especially as they are dealing with bulky products pre processing.
  - For high yields, tree crops need to be sprayed and this is a job that has to be mechanised.
  - Land clearing for large areas of plantations needs to be mechanised.

- In the savannah zone, large scale commercial farming has actively been promoted since 1966. MOTOAGI, a mechanisation agency was formed to promote the production of rice, sugar-cane and cotton. This was part of the overall agricultural policy to break the dependency on cocoa and coffee. The objective of mechanisation
in the savannah zone is to expand the usable area.

MACHINERY

- Ivory Coast has the largest stock of agricultural machinery in West Africa.

- State societies accounted (1973) for 47% of tractor purchases

- Numbers: In 1973 there were 1,592 usable tractors in the country, and numbers were growing by 20% per year

- Make: There were 25 makes of tractor in 1973, but three particular makes contributed 72% of total stocks. These were:

  - Massey Ferguson 135, 105, 178
  - Renault 56, Super 6D, N and V 73
  - John Deere

- Tracked Machines: About 240; mostly Caterpillar and Allis-Chalmers. These are used for land clearing, and in some cases, rice for example, the smaller machines are used for cultivation.

- Forestry: This sector is important, and there has been a policy of conservation and rehabilitation, showing a degree of longer term planning. In 1972 there were 900 Bulldozers and 150 tractors used in the Forestry Sector.

MACHINERY HIRE

- There are and have been many schemes organised by the State. The Government realises the importance of agriculture and forestry to the country, and takes an active, constructive, interest in promoting it.

- The biggest and most successful mechanisation scheme has been MOTORAGRI which started operations in 1966.

- Following diversification study, the Government of Ivory Coast, in cooperation with the private coop society in Israel, (Agridev) signed an agreement to supply equipment and some technicians, and to train nationals.
- **Work:** Land clearing, subsoiling, cultivation, seeding and fertilising.

- **Organisation:** Initially by Israeli expatriates with a planned phase-out over ten years.

- **Management:** Very tight control over all operations, careful record keeping, mobile, very competent managers. Communications facilitated by short-wave radio.

- **Equipment:**
  - 127 crawler tractors - half Caterpillar, half International, ranging from D8 to D4 size + associated landclearing and preparation equipment.
  - 78 Massey Fergusons for THS
  - 22 small Renaults for carrying labourers and implements.
  - 400 items of tractor associated equipment

- **Performance:** 85% of tractors are kept operational. This is due to a rigid maintenance schedule and well equipped regional workshops, with a good central workshop for major overhauls etc. A good supply of spares are kept, approximately 10% in value of total value of machinery.

**FINANCIAL**

The scheme is part paid for by the Ivorian Government. Much of the first stock of equipment came under a USAID programme.
BACKGROUND

1. Area: 1,285,000 Km²

2. Population: 17 million; growth rate 2.3%. About 40% population in agriculture

3. 3 Zones:
   - Coastal (Pacific strip, 8 to 50 miles wide, extremely dry. Intensive irrigated agriculture takes place here (rice, sugar cane, cotton). 50% of population
   - Mountains: inhabited up to 4,000 m. Varying from very arid to cloud forest to high plateau (alti plano). Intensive agriculture in valleys, extensive livestock and traditional crops other areas. (Potatoes, local grains.)
   - Amazonian. Flood plains to mountainous rain forest.

4. Agricultural production has stagnated in recent years. It now accounts for 9% of G.D.P. and 9% of export earnings. 1,245,000 tonnes of grain were imported in 1981 as well as large quantities of other food products, such as powdered milk.

5. There is considerable government involvement in the agricultural sector. There was extensive Agrarian land reform started in the 1960s which was overseen by government. Large haciendas, mostly in the Sierra were formed into cooperatives, and handed over to the former labourers. Government is also taking a leading role in initiatives to develop the little utilised lands east of the Andes. Credit for agriculture comes from the Government-run Agrarian Development Bank.

MECHANISATION

There is widespread mechanisation for the intensive agriculture in the irrigated parts of the coastal zone. In the Sierra, some mechanisation occurs in the Inter-Andean valleys. There is heavy population pressure on these limited areas of productive land and highly fragmented land holdings. The predominant methods of cultivation are by hand and by animal draught. The predominant method of farming in the large,
populated area east of the Andes is slash and burn shifting farming. It is this zone which has the biggest potential for expansion of agricultural activity. Great care will have to be taken in how the fragile soils are exploited. One particular area which has been undergoing development is the Central Huallago Region.

Central Huallago Region

- A sub-tropical region, fertile alluvial soils. A main road has been built in recent years linking it to the coast. Spontaneous colonisation has occurred as a result. Initially, mechanisation only occurred on large farms near towns, and the tractors were privately owned.

- Multifarm use of machinery began with the start of a bilaterally funded tobacco project, introduced as a cash crop. Machinery used for land clearing and preparation. In 1975, there were 1,000 ha in the mechanised system.

- Programmes were also developed to promote the production of maize and rice. In 1976 the National Service of Farm Mechanisation (SENEMA) was started to provide tractor pools and larger machinery for contract services.

- In conjunction with SENEMA the Central Huallaga Project was formed to accelerate rural development. US $30 m was provided, 3.7 m of which was for machinery and equipment.

Multi-farm use of machinery was proposed for 20,000 ha. Bulldozers were provided for forest clearing.

Cultivation equipment: Tractors 42 79 hp.
Implement 66
Threshers 9
Transport and mobile workshop

Farm Size: Average size 5-8 ha with a small % in the over 20 ha range.

Management: The mechanisation aspect of the rural development project is entrusted to SENEMA. Overall supervision is from the Prime Minister's office with the Ministry of Agriculture providing the coordination.
Performance: In one area Rioja, for which data is available, the production of rice paddy over 3 years increased from 5000 to 25,000 tonnes. It was found that the small farmers were constrained by operations subsequent to land preparation. Financially, the track laying (clearing and some cultivation) equipment ran at a small profit. This was principally due to high utilisation rates of about 1500 hrs/yr/machine. The wheeled tractors were not able to cover their costs. Utilization was lower (supposedly 1000 hrs/yr) and work rates are faster, which means a greater proportion of non-revenue to revenue earning hours due to moving between farms.

Financial: SENEMA are empowered to fix the rates. These were (1977):

<table>
<thead>
<tr>
<th>Type</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>D6</td>
<td>US $52-58/hr</td>
</tr>
<tr>
<td>D5</td>
<td>45-50</td>
</tr>
<tr>
<td>MF 290</td>
<td>16-18</td>
</tr>
</tbody>
</table>

The rates are changed every 10 months due to the high rates of inflation. An amount of depreciation is included in the charges, and a separate bank account is kept for the payment to go towards replacement costs. Administration and management costs are not charged to the farmers.
COUNTRY NOTE 9: CENTRAL AFRICAN REPUBLIC

BACKGROUND

1. Area: 623,000 km$^2$ landlocked country making a geographical link between the Sudanese zone and the Congo basin.

2. Population: 2.4 million with a 2.3% growth rate.

3. There are two climatic geological zones:
   - S.W. forest vegetation. 1250 mm rainfall; rains July-October. Extensive natural rain forest; cocoa, coffee, rubber and oil palm grown commercially. Biggest development potential.
   - Savannah type vegetation, throughout the rest of the country. Cotton is the main commercial crop with cassava, maize, millet, rice and groundnuts grown for subsistence and domestic requirements.

4. Agriculture occupies 88% of the working population, generates 37% of G.D.P. and has a growth rate of 2.3%. Cotton and coffee are the most important export crops.

5. Extensive government involvement in agricultural development. Numerous development agencies, including two for mechanisation.

FARMING SYSTEMS

- Predominantly small farmer production of subsistence crops, plus coffee and cotton as the source of cash for most farmers.

- There are some larger, though diminishing numbers, of European owned coffee plantations.

- There is some use of machinery for land preparation, mostly land is prepared with hand tools. Animal draught is limited by tsetse fly and poor disease control in general. There were reports that 40% of cattle have tuberculosis.
As far back as 1950, tractors were "not uncommon", being used on some agricultural stations and being hired out to some farmers for land preparation operations.

In 1963, an agricultural association of Gringou created a THS in the Province of Ouaka to satisfy the demands of the agricultural station's better and older employees. This was for the growing of cotton and two services were offered:

- land preparation
- insecticide application. - if fertilizer was applied this operation was obligatory

"Operation Bokassa" has been the biggest and most active mechanisation undertaking. This was started in 1965 with the express objective of opening new territories. In fact, these operations were diversified after a few years.

Equipment: 1st Stage.

1 Continental CD8 )
1 Caterpillar D8 ) land cleaning and
1 Caterpillar D4 ) initial preparation

3 MF 165 )
1 John Deere )
2 Renault 35 hp ) Cultivation
1 Caterpillar D4 with Rome plough )
Associated cultivation equipment)

Vehicles for transport of personnel and equipment...
Equipment: 2nd Stage

1 Continental CD6
11 Continental CD6
1 Caterpillar D6 Land clearing and development
1 Allis Chalmer HD6
1 Mack Cormick FC9B

37 Ford 5000 Cultivation
4 Ford 4000

Operations carried out:

2904 ha reclaiming abandoned land
3872 ha cultivated
1790 ha Rome ploughed

In these early stages the operations were heavily subsidised, the rationale being that it was a long-term land development project with long-term economic benefits. Also, during the early learning stages, a subsidy is acceptable. It is also justified as being essential in promoting the expansion of cotton production, which was the pivotal part of the 1971-75 Agricultural Development plan and increase in export revenues.
COUNTRY NOTE 10: BELIZE

Background

1) Area: 21 000 Km² situated about 18° North of the Equator and to the East of Guatemala in C. America.

2) Population: 150 000, growth rate 2-3%.

3) Climate: Overall humid tropical. Rainfall 1300 mm in North to 4300 in the South.

4) About 60% adult population employed in Agriculture. Overall population density is low, but large areas are unsuitable for agriculture either low lying flat coastal areas or steep hilly areas.

5) Agriculture accounts for 85% of export revenue and about 25% of GDP. Sugar from the North, Citrus from the Central area, some beans from the South. Self sufficient in staple food crops.

6) Apart from the sugar and citrus areas the predominant form of farming is shifting slash and burn with maize being the main crop. Other important crops are rice, beans and cassava. Land is either privately owned or, communally owned with rights of usufruct. The main source of labour is family labour with a limited labour hire market.

Mechanisation

- Extensive mechanisation in the North for sugar cane. Privately owned with some hiring out.

- Tractors used in the citrus areas mainly for transportation

- Mechanised farming (maize, rice, beans). Throughout the country by Mennonite farmers. They also operate hire schemes.

- ½ the production (about 1000 tonnes) of rice in the South is mechanised, mostly through a Government hire scheme.
Shifting mechanised rice production is practised. Clear the land, produce for 2 to 4 years, until the weeds become uncontrollable, then move to a new piece of land.

Clearing is by bulldozer, simply felling and windrowing with one machine. Cultivation is by Rome Plough pulled by bulldozer. In a few cases there will be secondary cultivation, but this is the exception rather than the rule. Sowing is either mechanised or by hand. Herbicide and insecticide application by back pack sprayers, owned by the farmers. Harvest by hired combine harvester.

The equipment pool is:

4 Bulldozers Caterpillar, I H, Continental
4 Combines John Deere, Massey Ferguson, Allis Chalmer
2 Tractors Massey Ferguson.

There is one workshop which has the equipment to carry out most tasks but often lacks the spares. There are dealerships in the country, but even so spares often have to be ordered from Miami or New Orleans.

Hire charges are:

Bulldozer D6 or D7 US$ 45/hr
Combine US$ 45/hr
Tractor US$ 22.50/hr

The scheme works on a heavy Government subsidy. It is calculated that these rates cover the running costs for the bulldozer, but fall US$ 20/hr short of the running costs for the combine harvesters.

Utilisation rates are reasonable for the bulldozers - 1640 hrs/yr and low for the combine harvester 360 hrs.

The management of the scheme is poor. Maintenance standards are low, time is lost waiting for spares, political pressure leads to machinery being moved around unnecessarily. Budgeting is poor which has led to
money running out at the busiest times and operations grinding to a halt. Hire rates were doubled in 1982, but even at present rates they allow farmers to make a profit out of poor farming practice, i.e. minimal weed control which slows down harvesting and damages machinery. The low hire rates have discouraged private operators entering the field.

Harvest and post harvest are the major problem. 80-90% of mechanised rice is one variety which all comes to maturity at the same time. This means there is a large demand for the few combine harvesters. To make matters worse the drying and storage facilities are poor.
COUNTRY NOTE 11 : NIGERIA

BACKGROUND

1. Area: 924,000 Km\(^2\), situated between latitudes 4\(^\circ\) and 14\(^\circ\)N in West Africa.

2. Population: 87.6 m; growth rate 3.5%, increased from 2.5% in 1970-81

3. Vegetation: In the south (20% total) the vegetation is mangrove and forest; the rest of the country is savannah, induced by fire or natural

4. Rainfall: This varies from 3800 mm in the coastal area with year round rainfall, to 650 mm in the north with 5 months rain per year.

5. Agriculture's share of GDP has fallen from 63% in 1960 to 23% in 1981. 54% of the population are dependent on agriculture. Cereal imports have increased from 389,000 tonnes in 1974 to 2,441,000 tonnes in 1981. The preoccupation and subsequent dependence on oil have led to this situation. There is now an active agricultural development programme aimed at self sufficiency in staple food products.

MECHANISATION

The area considered here is the N.W. Savannah Zone. Since the 1950's there have been attempts to mechanise agriculture in this zone. In 1972 the Ministry of Agriculture was the principal agency operating tractor hire services. The service consisted of preparing the seed bed for farmers. There were 16 tractor hire stations, used by both government and private concerns.

Objectives: Tractor hire was started by government to demonstrate the effectiveness of mechanisation rather than provide a blanket tractor service. The hope was that private contractors would be encouraged, who, it was realised, would in the long run provide a more efficient service.

Operations: Tractor work is concentrated on pre-planting operations,
particularly ploughing and ridging. The tractors also carry out trans-
porting work, especially in slack agricultural periods.

FARMING SYSTEMS

Population density is low, and the supplies of cultivable land plentiful. All agriculture in this N.W. area is rainfed. In the southern part of the province are tropical rainforests (not included in the study). Rainfall decreases rapidly moving north as rolling savannah areas are entered. The main crops are; maize, yam, cassava, tobacco, rice and kenaf. Average size of farms with mechanisation was 4 ha. These were usually divided into four plots, only one of which would be mechanically cultivated.

PERFORMANCE

The most successful tractor hire schemes operated in the drier savannah areas where the principal operation was primary cultivation for annual crops. As a result of mechanisation, farmers reported increases in net income due to increase in yields and an easing of the planting labour bottleneck.

Government rates (1972) were US $13/ha for ploughing. Tractors in government pools operated about 300 hrs/year against 800 hrs/year for private contractors doing custom work and their own farms.

ASSESSMENT

Demand for tractor hire services has been created. 418 farmers in 1970 used tractor hire versus 3380 in 1973. Government tractor service is subsidised which has slowed down the entry of private contractors into the market. Private operators all bought tractors (usually secondhand) to avoid the disappointment of delays or non-availability from the government service. The fact that some farmers still buy tractors in the face of subsidised government hire rates indicates that those subsidies are a mistake. First of all, demand for hire services has been stimulated but is not being met; secondly the objective of private hire services taking over is being held up, and lastly, utilisation rates for private tractors are low because it is not profitable for them to undertake a lot of multi-farm work.
BACKGROUND

Malaysia has a population of 14.2 million (1981) and a population increase of 2.1%; 50% of the workforce is in agriculture. Area is 330,000 km². Agriculture's share in GDP has decreased from 36% in 1960 to 23% in 1981. Agriculture has a large share of export earnings, the main products being, rubber, palm oil, and cocoa becoming more important. As a % of total exports this has fallen over the past 10 years due to the production of oil. Grain imports have remained relatively stable; 1,017,000 tonnes in 1974 and 1,244,000 tonnes in 1981. The domestic price of grains is above world market prices, therefore the policy is to keep production at, or slightly below, domestic demand.

MECHANISATION

Government has become involved in the formation of tractor hire pools with 35-45 hp tractors. This is usually a subsidised service. Some of the stations are also involved in the training of private operators. Government claim that these services are started only in the absence of private contractor services. The subsidy is defended as being a means of encouraging new crops, techniques, or opening new areas to crop production. In the particular scheme reported on from Western Malaysia, Tractor Hire Schemes are seen as a way of encouraging double cropping of Padi.

In the MUDA Scheme area, there already are, or are planned, 26 government agricultural stations. There were (1972) 2 to 25, 4-wheel tractors per station in the 35-45 hp range. There were a total of 400 tractors. There was high demand for the service.

MANAGEMENT

The stations work on a fixed budget (exclusive of depreciation charges). Revenue goes back into the scheme, but since the hire rates are subsidised, these revenues need to be supplemented by the Ministry of Agriculture. In the long-term, the Ministry was hoping to have mechanisation services to cover the entire 105,300 ha of rice. It is estimated that they will need a gradual build-up to 2300 rotavators and tractors from the current 400 level.
PERFORMANCE

There was a high correlation between double cropping of padi and the use of tractors, 67% of tractor users double cropping versus a country-wide average of 20%. Average farm size of those using tractors was 2.3 ha. Tractor hire is used as a labour saving technique, essential for those trying to turn the land around for a second crop. The estimate was that tractors saved 25 man days/ha. At the going tractor and labour hire rates, this represented a saving. So far as Government tractor hire is concerned, it must be noted that the hire rates are below economic costs.

There is no information on annual utilisation rates, but they are probably quite high since there is double cropping, and at slack times the tractors are used for general transportation work and the clearing and re-planting of old rubber plantations.

Alternative Sources of Mechanisation

Government claims only to introduce THS to an area if there are no alternatives. Initially, this is the case, but often the demand for hire services is built up, a few private contractors enter the market, but the full transition from Government to Private is held up. This is because the "introductory" subsidised rates are often maintained. In West Malaysia, where Government just provides the institutional back-up for tractor operation, it was found (1972) that 69% of tractor owners offered a hire service, and 63% of farmers used the hire service.

At the time of these surveys (W.Malaysia and Muda) it was found that 2-wheel tractors were becoming increasingly popular. In a survey of 89 4-wheel tractors and 59 2-wheel tractors, the average age of the machines was 3.8 years, but all the tractors under one year old (20% of total) were 2-wheel power tillers. This was more than half of all the 2-wheel power tillers. Profit margins appear to be smaller with these 2-wheel power tillers, but small farmers can use them just on their own farms, or form themselves into small associations, thus having more control than if they have to hire. The hire market for 2-wheel power tillers is small or non-existent.
Village level cooperatives were established in Comilla, and these were grouped into local federations of cooperatives. Cooperatives provided credit and access to mechanisation. A mechanisation station was run by the federation under a separate manager, and sold its services to the local cooperative societies. The main operations were ploughing, irrigation, and transport. The scale of the organisation is not known, but tractor numbers appear to have been small.

The scheme was generally not successful, requiring excessive subsidies both from outside and from other cooperative activities. There was a lack of trained operators, and supervision was a problem. Training up local operators and mechanics resulted in some improvement. Other problems included:

1) Local management of cooperatives was incompetent in some cases, and external supervision was necessary.

2) Cooperatives were dominated by locally powerful individuals (large farmers, the politically influential, etc.) who obtained a disproportionate share of the benefits.

3) Cooperatives were established by government agencies, and were expected to act as channels for various government services as well as providing services to their members.

4) There were shortages of spare parts, and some implements were inappropriate for the area.
APPENDIX 2: CASE STUDIES

A. SRI LANKA
B. KENYA
C. EGYPT
D. SIERRA LEONE
E. PAKISTAN
F. SWAZILAND
G. SUDAN
H. UGANDA
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CASE STUDY A: SRI LANKA

Introduction: Background to Mechanisation in Sri Lanka

There were very few tractors in Sri Lanka before World War 2. The War provided a stimulus to mechanisation through the need to increase food production rapidly and the import of tractors by the military authorities. In the years following Independence there was continued emphasis on raising food output via Dry Zone colonisation schemes ie large-scale land development schemes in the relatively unexploited Dry Zone which covers about two-thirds of Sri Lanka. Mechanisation is closely linked to the development of the Dry Zone as the densely populated Wet Zone is characterised by paddy production on very small terraced fields and so is not well suited to mechanical cultivation.

1. Physical Background

The Dry Zone is mainly gently undulating with average slopes of 1.5% to 2%. Although the area was cultivated centuries ago, the population shifted away from the Dry Zone as a result of malaria and repeated attacks from the north. Thus most of the region reverted to jungle, large areas of which have been cleared again over the last few decades.

The climate is tropical with mean monthly temperatures around 75°F to 85°F and is suitable for year-round cropping. The Dry Zone covers those areas of Sri Lanka with rainfall of less than 1500 mm. Although this diminishes progressively towards the north of the island, rainfall is not low in absolute terms. It falls in the two monsoon seasons: maha (Oct - Jan), which receives about two-thirds of total rain, and yala (Mar - June), the smaller rains. The amount of rain and the dates of the monsoons are unreliable, varying considerably year to year. Cultivation during yala depends almost entirely on irrigation, and even in maha much use is made of irrigation water.

Broadly speaking there are two major soil categories. On the higher lands soils are reddish-brown, moderately coarse, and highly permeable, and on the lower land they are brown to grey-brown, finer, and poorly drained soils well suited to paddy cultivation.
2 Human Background

The Dry Zone is an area of relatively low population density (precise figures not known). There has been a large migration of settlers from the Wet Zone to the colonisation schemes in the Dry Zone, and there are also major seasonal migrations especially for land preparation and planting, and later for harvesting and threshing. There are shortages of locally available labour at these times, especially in the more recently settled areas. The population is predominantly agricultural and rural-urban migration has not been pronounced in Sri Lanka.

3 Farming Systems

The traditional farming system of the Dry Zone included "chena" or slash-and-burn cultivation; irrigated paddy cultivation based on small village tanks; and permanent "homestead" cultivation of mainly tree and vegetable crops. Typical cultivated area was less than 3 acres per family, and production levels were low. On the more recent settlement schemes where most tractor cultivation is concentrated, colonists have been allocated plots of unirrigated highlands and irrigated paddy land, the size of the allocation varying from 5 acres and 3 acres respectively in the early schemes to around 2 acres of paddy and 1 acre of highland in some recent schemes. The size of individual plots in irrigated land is commonly very small for water distribution purposes.

Paddy is the dominant crop on irrigated land, being grown on all land during maha and, in spite of official efforts to diversify production, on most of the cultivated area in yala. The extent of yala cultivation is often severely limited by water shortages. Other cereal, pulse, and vegetable crops are grown in smaller amounts, and tree crops are common on the highland plots.

4 Draught Power

Manual land preparation is still common among small Wet Zone farmers, but the dominant method is the use of buffaloes, either with traditional ploughs or simply driven around the field to churn the soil. Bullocks
are more common than buffaloes in the north of the island. Tractors have become widespread especially in the Dry Zone, where they are used for tillage and threshing as well as transport. Few other farm operations are mechanised. Four wheel tractors are almost universally fitted with 9-tine tillers, and single-axle tractors with rotavator- or mouldboard ploughs.

Cultivation is usually performed on wet land, which in the Dry Zone means after the release of irrigation water. At least two tillings are made, separated by 10 days or more to allow the decomposition of weeds. Great care is taken to level the field so as to permit good water control.

Because cultivation is delayed until water is issued from the tank, land preparation should be performed as quickly as possible so as to minimise water use. In fact it often extends over 6 weeks or so which means that water issues are unnecessarily high, limiting the amount available for yala cultivation. It has been argued that tractors will permit faster cultivation and could also cultivate dryland, but this has not been widely practiced so far. Greater use could be made of rain-water, but farmers tend to wait until they know that the stored water is adequate to irrigate the whole crop before cultivating their land.

5 Background to Machinery Hire Schemes

This section traces the history of public sector machinery hire schemes in Sri Lanka. From their initiation in the immediate post-war years until about 1956, tractor hire schemes were operated by three organisations: Department of Agriculture, Food Production Department, and the Cooperative Agricultural Production and Sales Societies (or Unions of these Societies).

i Department of Agriculture. The DoA opened its first tractor hire unit in 1944, offering a ploughing and harrowing service to farmers. The number of tractors operated by the Department increased from 50 in 1948 to 191 in 1951, most of the additional machines having been transferred from the departing military authorities. Demand was very
high and the quality of work is reported to have been good. Modest profits were made though no details are available. From 1952 the number of tractors declined as other organisations took over, until in 1956/7 the DoA took the leading role again.

ii Co-operative Tractor Pools. These grew up in 1952/3 when they took delivery of 241 tractors and associated implements from the UK. They were financed by the Food Production Fund, which transferred resources from the estate sector into the development of small farms. The Fund made loans to Co-ops and Unions which were to be repaid from profits. The Co-ops hired tractors to their members at rates fixed by the Government. DoA units were cut down or closed in the area where Co-op tractors operated so as to reduce competition. Tractor utilisation was low at only 96.6 acres per tractor in 1953. This seems to have been partly a result of surplus capacity as most of the 9 pools had idle tractors even at peak times. In 1953 the Co-op pools lost money, even without taking into account loan repayments, interest charges, and other capital costs. In 1954 the Government agreed to take over some of the tractors, and many of the Co-op Unions withdrew from tractor hire all together. In 1955 the Co-op Unions still running tractor hire services made a small operating surplus (excluding interest and depreciation), but only 58 out of 94 tractors were operating as a result of breakdowns or lack of work. In 1956 the remaining tractors were transferred to the DoA.

iii Food Production Department. In 1953 the DoA tractor unit at Anuradhapura was handed over to the Food Production Department (FPD), together with 112 tractors received under Australian Aid. The FPD took over services in various areas from the Co-op Unions in 1954, and also various operations from the DoA. By 1955 there were 9 units which ploughed over 18,000 acres, including some tractors in the Wet Zone to serve the coconut estates. However, losses were high: in 1956 expenditure came to Rs.1,054,010, and income to Rs.245,420 ie income was only 23% of the level of expenditure. Many tractors were underutilised, and it was therefore decided in 1956 to hand all the tractors over to the DoA to run a unified and enlarged service.
After the amalgamation of the different organisations, the fleet contained many broken-down and cannibalised machines. Spares were in short supply, and many of the machines never worked again. In 1957 there were 8 tractor hire units and by 1963 - 64 this had expanded to 21, with the acquisition of new tractors expanding the service. At its peak in 1965 the Government-operated hire fleet is said to have consisted of about 400 4-wheel tractors, but the proportion of these in operating condition is not known. The rate charged per acre had remained at its original level of Rs.24 until 1960 when it was raised to Rs.27.50. This was about half the private sector charge, and represents an increasing level of Government subsidy.

The UNP Government of 1966 - 70 wanted the DoA to withdraw from its tractor hire activities. The DoA Agricultural Engineering Unit was accused of neglect and corruption, and there is evidence that spares were being sold off to the private sector and that Government drivers were carrying out work with DoA machines for private customers. Losses were in the region of Rs 1.5m per annum in the late 1960s. In 1969 the Government announced its intention of closing down the remaining DoA tractor hire units which were doing little work anyway by this stage. Attempts had already been made to try and establish a private sector alternative to the Government pools by encouraging tractor importers to set up pools. It was hoped that this would avoid shortages of draught power and excessive increases in hire rates when the DoA service was withdrawn. Rates were fixed at a level between the former DoA rate and the higher private contractor rate. Sixteen such pools were established in 1967/68. However, farmers felt that the rates were too high and the tractor importers felt that they were not high enough to provide them with a profit. Browns, the Massey-Ferguson importers who ran the largest pools, reported difficulties in getting payment from farmers and high costs resulting from the short cultivation season in most locations. Thus by 1970 all these pools were wound up.

After the election of 1970 when the United Front were put into power, there was pressure to restore the Government pools. However, this was resisted and the remaining DoA pools received little additional support. In 1975 the DoA had tractor hire units in 12 Districts, with a total of
226 tractors of which about 120 were in working order. Many of the remainder were getting very old, and some had been out of commission for a long period. The total area cultivated in 1974/5 was 11,000 acres for private farmers in addition to about 5,000 acres on Government farms. The hire charge was about a third that of private contractors. The decision was taken in 1975 to withdraw the DoA tractor hire service, although the final closure was delayed by the need to redeploy staff.

The liberalisation of trade policies in 1978 made supplies of tractors to the private sector more readily available, and so reduced the need for a Government hire service. Most imports of tractors under aid agreements were sold off to private farmers and entrepreneurs eg under the Tank Improvement and Modernisation Project, and under the Mahaweli Ganga Development Project. Some small hire schemes have been set up. For example, the Mahaweli Development Board has provided a cultivation service to farmers in some newly colonised areas, though the need for such services and the inability of the private sector to provide them has not been fully demonstrated. Hire charges have again been below those of private contractors, so the schemes may have acted as a disincentive to the development of private sector hire services.

6 Equipment

Most of the tractors operated by the government hire schemes have been medium horsepower (40 to 70 hp) two-wheel drive machines of British manufacture (mainly Massey-Ferguson and Ford). Similar machines have been received from other countries, including some from Eastern Europe. Single-axle tractors have also been allocated to the project (numbers not known). Most work has been with tined harrows and trailers: efforts to introduce other implements have met with limited success. However, DoA units have often held a wider variety of implements than would be available in the private sector, so may have helped to inform farmers of what is available.

7 Staffing and Management

Little information has been found on the internal structure and staffing of the different types of hire organisation which have existed in Sri
Lanka, though some references mention problems which have resulted from the management. For example, under the DoA, machinery hire units were not free to purchase spares or get repairs done outside the organisation, though sometimes they could have got jobs done much more quickly in the private sector. Also overheads were raised as a result of Government employment conditions - drivers had to be paid all year round, though for at least 6 months there was little or no work. Units were allocated to particular districts in which they were permanently based, so missing out on the chance to travel from area to area to follow the work as done by some private contractors.

Machine allocation was supposedly on a first come first served basis, but farmers have complained that long delays and queue jumping were common, managers often giving preference to their friends or more influential farmers. There were also complaints about managers misappropriating funds by not issuing receipts.

8 Financial Aspects

Figures quoted in section 5 make it clear that rarely has the revenue earned by the schemes covered their operating costs, and never (except possibly in the very early years of the DoA scheme) has it covered this capital costs. The Co-operative Unions incurred heavy debts operating the tractors, and could not repay the purchase price. Some Unions put pressure on the importers to take back the tractors (which they refused to do). Eventually the Government was persuaded to step in, and in 1957 Parliament made an allocation to reimburse the Co-op Unions for the cost of the tractors and the losses they had built up operating them.

The DoA units made large losses each year in the late 1950s and 1960s, partly because of high overheads and poor work output, and partly because prices were kept down to well below those in the private sector. For example, in 1972 the rate charged for harrowing by the DoA was Rs35 per acre compared to around Rs60 charged by private operators. Governments seem always to have wanted the hire schemes to keep down their charges in order to lower the costs of cultivation to small farmers, and to keep down the rates charged by private operators. But they have not appreciated the financial drain on central government
funds which this policy implies, or the disincentive effect on private hire services which is a likely consequence. In fact it seems to have been pressure from the Ministry of Finance over the costs of the schemes which led to the closure of the DoA service in the late 1970s. However, lessons have not been fully learnt - even in 1982 the hire rates charged by the Mahaweli Development Board in System H were considered to be unrealistically low, and to discourage hire of private tractors and buffaloes within the area, and the movement of tractors into the area.

9 **Performance**

Detailed performance data are also lacking, though all indications are that in most periods the proportion of the tractor fleet in operating condition and the amount of work carried out per tractor have been very low.

For example in 1953 the average area cultivated per tractor under the Co-op scheme was 96.6 acres, and in 1955 the proportion of Co-op tractors working was only 62% (58 out of 94) though they were at most 3 years old. Results are similar for the DoA in 1975, when 53% of the tractors were operating (120 out of 226), and the average area cultivated was 71 acres per tractor or 133 acres per working tractor. Assuming (conservatively) that it would take 4 hours per acre to harrow twice (the normal practice), this puts the average annual work output at 280 - 530 hours.

Average working life also appears to have been low, with reports of tractors only a few years old breaking down and never working again. No precise figures are available.

10 **Alternative Machinery Services**

The number of tractors in the hands of private farmers and entrepreneurs increased gradually over the time that the various government schemes were operating. The ownership of tractors in Sri Lanka in 1956 is estimated to have been:
By 1962 the number of tractors registered on the island had increased to 2080, and by 1976 to 12,873, largely as a result of increased private ownership. Many small farmers preferred to hire from private owners even though charges were higher, because it was less bureaucratic, credit was more likely to be offered, and payment in kind might be accepted. Throughout much of the period tractor imports were allowed into Sri Lanka on quite generous terms. For example duty on tractors was only 1% until 1967 when it was increased to 10% on tractors and implements and 5% on spares. In 1968 a system of foreign exchange premiums was introduced, but tractor imports were still available more readily and at lower cost than most other imported capital goods until the adoption of a floating exchange rate in 1977. There have been generous tax allowances and credit arrangements for tractor purchase. Together with continued cheap access to spares and subsidised diesel prices, these have acted as additional incentives to wealthier farmers and rural businessmen to invest in tractors. Recent research has shown that the private returns to investment in tractors have been very high.

Conclusions

Experience in Sri Lanka with public sector tractor hire schemes of a variety of different organisational forms over the last 40 years has shown that they almost always suffer from high costs and low work output. Rarely has revenue covered the operating costs of the service, and never has it covered the capital costs of machine purchase. There is evidence that political pressures have influenced tractor acquisition and the regional distribution of machines, and have also prevented increases in hire charges to bring them more nearly in line with the costs of operation. The main motivation for the continuation of Government cultivation services in the face of these difficulties has been the rapid expansion of the cultivated area in the Dry Zone, and the alleged failure of private sources of animal draught and tractors to meet the increased demand. This has been coupled with the need for speedy cultivation so as to avoid excessive use of irrigation water in
land preparation. However, the demand for custom services is in itself a reflection of Government colonisation policy, especially the allocation in the early days of such schemes of larger holdings than could be farmed by the individual farm family with a single buffalo pair. More careful planning of draught requirements and build-up of supplies in step with the extension of colonisation schemes would have reduced or removed the need for Government hire services. The very existence of a Government service, especially with highly subsidised rates, must have acted as a disincentive to the establishment of private contract hire services. Furthermore, the need for cultivation to be completed in a short period and the limited range of operations mechanised made it difficult to achieve high utilisation of the tractors.
Introduction: Background to mechanisation in Kenya

Kenyan agriculture is characterised by the coexistence of a large-farm sector dating from the period of European colonisation and a peasant farming sector with small land holdings. Peasant farms are traditionally cultivated by hand, using a jembe. In 1981 84% of the land on such farms was still tilled in this way. The first tractors were introduced on a few large farms in the 1920s, and they were more widely adopted after World War 2. By 1960 the numbers of tractors and combines in use in Kenya had risen to 6400 and 1000 respectively. They were owned almost entirely by large farmers, and contractors working in the large farm sector. Following independence, mechanised cultivation services were made available to small farmers on several settlement and irrigation schemes. The tractor hire service now operated by the Agricultural Mechanisation Services Branch of the Department of Agriculture (AMSB) is the only large-scale public sector operation and its development and activities will be described below.

1 Physical Background

The AMSB operates tractor hire services over large areas of Kenya which have varied climatic and topographical conditions. These range from high rainfall forest zones in the Highlands to very high temperature virtually desert conditions in Eastern and Northern districts. Much of the variety is a result of altitude differences, and in consequence farm operations take place at different times in different areas making it possible in theory to move machines to follow the work. Because of these major variations across the country it is difficult to make generalisations about the physical background of the scheme. The scheme originated in the wheat growing area in the southern part of the Rift Valley where the land was flat and large areas were available for cultivation. However, as attempts were made to spread the benefits of mechanical cultivation to smallholder farmers in other parts of the country machines were allocated to districts which were much less suited to tractor ploughing. Most recently the organisation has moved into the
more arid regions, for example in Eastern Province, where the returns to arable farming are unlikely to make mechanisation viable.

2 Human Background

The population of Kenya is one of the fastest growing in the world with an estimated increase of 3.9% per annum. The areas of highest population density are the Lake Victoria region, the south-western highlands, and the coastal belt, where densities reach 700 people per square km. Employment opportunities have failed to keep up with the increasing population, both in rural and urban areas. There has been a considerable drift of people towards the towns and cities, particularly Nairobi and Mombasa, and an increase in rural landlessness. This has been alleviated by the subdivision of large farms and estates, but at the expense of reducing the marketed surplus of some crops. Further subdivisions to increase employment opportunities are likely in the future.

3 Farming Systems

Farming systems in the areas of AMSB operation are naturally as diversified as the climatic and topographical conditions. Non-irrigated annual cropping is the norm, as irrigated projects are fairly limited in extent and in some cases served by their own tractor services. Some districts have scope for further land development to extend the cropped area, e.g., South Nyanza, Western Baringo, Transmara, and Eastern Narok. With increasing population pressure in the higher potential districts, problems of soil erosion are becoming severe. The principal food crops are maize and wheat, and cash crops include coffee, tea, sugar cane, sisal, pyrethrum, and cotton.

The small farm or "family farm" sector makes up about 50% of the total cultivated area. In 1978, 58.8% of family farms were less than 2 ha in size, and 90% were less than 5 ha. In contrast some of the larger farms go up to several thousand ha (especially the ranches in the lower rainfall areas), though such enterprises are not likely to use Government machinery hire services.
Draught Power

Mechanisation of tillage, planting, and harvesting has been regarded as essential for the expansion of the cultivated area in the wheat growing districts of the Rift Valley. Similar arguments are used to justify the introduction of the tractors into the districts of new land development. The expansion of tractor cultivation before Independence was closely tied to the development of the expatriate farming sector, where labour was less plentiful than on peasant farms and where the problems of organising and managing more labour intensive technologies over large areas were great. The increase in the use of tractors since the Second World War has been partly a result of the relative lack of animal draught in Kenya. Oxen use shows marked regional concentration, resulting from historical differences, tribal attitudes, and the distribution of diseases. Use of draught oxen is highest in south west Kenya where it is traditional among the Luo, Kamba and Luya tribes, and among some Kikuyu in a band around, and to the south of, Mt. Kenya. One of the key questions relating to the economics of animal draught is the opportunity cost of land used for grazing or fodder production, and researchers have disagreed on whether this makes animal draught more or less expensive than tractor cultivation.

There has in the past been no clear Government policy towards farm mechanisation in Kenya. The Government has in recent years given greater attention to the development of animal draught as it has recognised the need to avoid technologies which lead to rural unemployment. However, it has previously tended to favour tractor mechanisation via an overvalued exchange rate, absence of import duty on farm tractors, and continued subsidies to the Department of Agriculture tractor hire service.

Background to the Machinery Hire Scheme

The Government tractor hire service (THS) in Kenya originated in 1966-67 when 50 tractors were introduced to provide a cultivation service primarily for areas under the Masai Wheat Scheme. Operating in mobile units with no permanent bases, the tractors could be moved from area to area to follow the work. With Kenya's diverse ecology and agriculture,
virtually year-round utilisation of machinery was possible. Fields on newly developed land were large and regularly shaped so high work rates could be achieved.

The original objectives of the scheme were:

i To open new areas for agricultural production.
ii To introduce modern agricultural techniques and to stimulate private ownership of agricultural machinery.
iii To supplement land preparation where private contractors are not sufficiently operative.
iv To increase agricultural production, especially cash crops.

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. In 1980 THS was amalgamated with the former Soil Conservation Service (SCS) Machinery Unit to form the AMSB, and its tractors and implements were assigned to 15 of the 19 stations which fall under the new organisation. The rapid expansion of THS, the increased emphasis on small farm cultivation, and the geographical dispersion of the machines, has led to a serious fall in efficiency.

Most of the stations also operate heavy plant from the former SCS units. This consists of bulldozers, scrapers and graders which are used for land development work in agriculture eg dam building, bush clearing, soil conservation work, and access road construction. Prior to 1980 the plant hire service concentrated on implementing government programmes for central and provincial authorities, but is now mainly involved in revenue earning activities for private farmers.
6 Equipment

In 1983 the THS had 196 tractors including 9 different models from 6 different manufacturers. They were relatively new, with 60% of the fleet between 3 and 5 years old and only 22% over 5 years old. The average power rating was 73 hp (54 kw), and about 60% were four-wheel drive.

The most widely used implements are three and four furrow disc ploughs which are well suited to the cultivation of new land where some soil inversion is required and the risk of obstructions from buried rocks or tree roots is high. Chisel and mouldboard ploughs are also available but not much used. Disc harrows are popular for secondary tillage. More sophisticated implements, including European seed-drills, are available at some stations but are little used.

The plant hire service operates mainly crawlers fitted with angle dozer blades and in some cases rippers. These are backed up by motor graders, self-propelled scrapers, and smaller plant such as towed scrapers, terracers, rollers, etc. There are machines from 9 different manufacturers creating problems over spares supply and dealer service. Much of the fleet is too large for the work normally carried out. The total number of heavy machines was about 120 in 1983, though a large proportion is out of action through breakdowns at any time.

7 Staffing and Management

The AMSB is part of the Land Resources Development Division of the Ministry of Agriculture. In common with other Ministry activities the organisation is decentralised. In effect, its administration is in the hands of Provincial Directors of Agriculture, while technical and professional matters are the responsibility of the headquarters staff of AMSB. As a result chains of authority and responsibility are frequently unclear. The 19 stations operate more-or-less independently of each other, each with its own area of activity.

The total staff of AMSB was 1450 in December 1982, with between 30 and 150 employees at each individual station. However, there are shortages of trained manpower such as mechanics, and many station managers are
inexperienced or lacking in engineering and management training. Staff pay is on Government grades and is well below private sector levels, so it is difficult to keep good staff. There is no provision for the payment of performance-related incentives, or even overtime payments.

Management and control is a serious weakness of AMSB. Scheduling of machine work programmes is made difficult by unreliable equipment and lack of finance for running costs, and there is clearly some pressure on station management to favour those with political influence. Many farmers have to wait long periods for tractors. Basic recording such as machine logs, job cards, stock records, and application forms, is not fully and properly completed. Station reports are not standardised and some contain much insignificant information while leaving out what is important for management purposes.

8 Financial

The AMSB receives an allocation of funds from the treasury in the annual budget. This is based on theoretical work output and costs which bear little resemblance to the actual situation. Stations are not permitted to retain revenue from their operations, which are paid directly into government accounts. This might not matter if accounting procedures and disbursement to stations were satisfactory. However, government financial arrangements are not adapted to the requirements of a commercially orientated organisation. For example, in 1983 funds were allocated on a six-monthly basis and monthly spending was limited to one sixth of that allocation. This disregards the highly seasonal nature of AMSB work. In addition, suppliers accounts are settled by provincial accounting officers which has resulted in long delays and sometimes the closing of accounts.

Foreign aid inputs have been substantial, much of the fleet of tractors and plant having been financed from this source. The mixture of donors has resulted in a mixture of equipment which exacerbates management and maintenance problems.

Hire charges are fixed within the Ministry at a level which is intended to cover costs at projected levels of utilisation. However, these are so far
out of line with actual work levels that revenue from hire covers only a small proportion of total costs. The AMSB appears to cover about 50% of operating costs from revenue received, making no contribution to capital costs. When all costs, including an estimate of depreciation, are included the total cost per acre ploughed is almost ten times the revenue received. AMSB is clearly a large drain on Government resources.

9 Performance

The performance of the tractor hire service is summarised in Table B1. Some of the figures are derived rather than actual eg for several years the number of productive hours was obtained by multiplying reported hectareage figures by average reported work rates for each operation. Although the size of the tractor fleet has increased rapidly, the number of productive hours worked per tractor has gone down. The levels of recorded work output per tractor per year are low, averaging only 154 productive hours per year over the whole period. There has been a downward trend in most of the years for which figures are available. Recent performance is far worse than in the early years of the scheme. For example, in 1967/68 over 1000 hours per tractor were recorded with an average of 772 productive hours per machine. The proportion of productive hours in total running hours is satisfactory at about 70%.

Ploughing was the most important operation, with between 61% and 87% of the total area cultivated consisting of ploughing. The other operations which the THS performs are harrowing (between 10% and 30% of total cultivated area), and planting (up to 9.5%). Average rates of work for the different operations were:

<table>
<thead>
<tr>
<th>Hours per ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ploughing new land</td>
</tr>
<tr>
<td>Ploughing old land</td>
</tr>
<tr>
<td>Harrowing</td>
</tr>
<tr>
<td>Planting</td>
</tr>
</tbody>
</table>

These figures represent quite satisfactory levels of field performance, especially in view of the difficult conditions.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of tractors (at end of period)</td>
<td>57</td>
<td>104</td>
<td>109</td>
<td>159</td>
<td>173</td>
<td>197</td>
<td>196</td>
</tr>
<tr>
<td>Total ha ploughed</td>
<td>2291</td>
<td>5167</td>
<td>4707</td>
<td>4985</td>
<td>7271</td>
<td>6880</td>
<td>5550</td>
</tr>
<tr>
<td>Total ha harrowed</td>
<td>1110</td>
<td>587</td>
<td>652</td>
<td>853</td>
<td>2211</td>
<td>2407</td>
<td>1278</td>
</tr>
<tr>
<td>Total ha planted</td>
<td>356</td>
<td>183</td>
<td>96</td>
<td>165</td>
<td>202</td>
<td>30</td>
<td>260</td>
</tr>
<tr>
<td>Total running hours</td>
<td>14150</td>
<td>20471</td>
<td>26422</td>
<td>31105</td>
<td>41416</td>
<td>39752</td>
<td>30782</td>
</tr>
<tr>
<td>Productive Hours</td>
<td>9062</td>
<td>19819</td>
<td>17605</td>
<td>21386</td>
<td>28866</td>
<td>27706</td>
<td>21454</td>
</tr>
<tr>
<td>Non-productive hours</td>
<td>4288</td>
<td>8652</td>
<td>8817</td>
<td>9719</td>
<td>12550</td>
<td>12046</td>
<td>9328</td>
</tr>
<tr>
<td>Running hours per tractor</td>
<td>248</td>
<td>274</td>
<td>242</td>
<td>196</td>
<td>239</td>
<td>202</td>
<td>157</td>
</tr>
<tr>
<td>Productive hours per tractor</td>
<td>173</td>
<td>191</td>
<td>162</td>
<td>135</td>
<td>167</td>
<td>141</td>
<td>109</td>
</tr>
<tr>
<td>Area ploughed per tractor (ha)</td>
<td>40</td>
<td>50</td>
<td>43</td>
<td>31</td>
<td>42</td>
<td>35</td>
<td>28</td>
</tr>
</tbody>
</table>

i From 1976 to 1980 figures are for financial year (July-June) and from 1980 for calendar year.

ii For 1976-77 and 1980, 1981, and 1982 these figures are calculated from ha cultivated and rates of work figures.

iii These figures are biased downwards as end of year figures on tractor numbers used.

Source: THS and Station Annual and Half-yearly Reports.
Examination of 1982 figures for individual stations shows that some stations were practically inoperative. Three of them carried out less than 100 ha in total and less than 10 ha per tractor, mainly as a result of poor management. The four best stations all achieved over 40 ha per tractor (maximum 83 ha per tractor), apparently because they were located in areas with scope for new land development where demand is high. There was a tendency for stations with newer tractors to perform better than those with older machines, but poor performance is not just a result of machine age as very few tractors had reached 2000 hours and 70% were less than 5 years old.

It is difficult to give specific reasons for poor performance and high downtime. When a station does little work for many months the reasons are often complex: machines may be broken down, but there is no incentive to try and repair them if there is no money for fuel, no spare parts, and little demand anyway because of seasonality. However, the following reasons are clearly important.

i Seasonality Tractor hire units are now based at specific locations and work mainly in the district within which they are located. This usually limits their busy season to between 3 and 6 months per annum. It is in contrast to the earlier mobility of THS units which shifted from district to district so could find work over most of the year.

ii Lack of Fuel. This was commonly given as a reason for down-time. There have occasionally been national shortages of diesel fuel, but these are less serious than lack of finance to pay for fuel, lack of storage at stations, and inadequate transport facilities.

iii Breakdowns. It is common for more than half the tractors at a station to be broken down, because of poor maintenance, improper use and the harsh working conditions. Machines are out of action for long periods waiting for even relatively simple components, and as a result may suffer further deterioration and cannibalisation. Sometimes machines grounded with quite minor faults are ultimately
written off for these reasons.

iv Inadequate or delayed budget allocations leave stations starved of funds. All revenue is returned to central government funds and there is not even provision, officially, for the purchase of fuel from hire revenue.

v Incentives. There are no incentives for operators or managers to achieve high rates of work, so even when tractors are in demand operating hours are low. Overtime payments are not made.

10 Repairs and Maintenance

There is a central THS workshop and stores at Nakuru, and each station should have its own workshop, offices and stores. However, the standard of facilities varies widely from station to station. Some have good modern workshops and offices, satisfactory stores and staff housing and reasonable fuel storage, etc. Other newly established stations have virtually no facilities, mechanics having to work in the open, making contamination of components by dust and dirt almost inevitable.

Long delays in repairing tractors are common, either because spare parts are not available in Kenya or because AMSB does not have the funds to purchase the parts it requires. Foreign Aid donors are partly to blame for supplying machines for which there is no adequate dealer support in Kenya.

Some stations have low-loaders and mobile workshops, as well as smaller pickups and trucks. However, the transport fleet is as badly affected by breakdowns as the tractors and similarly hit by lack of fuel.

11 Alternative Machinery Hire Services

AMSB is the only significant government machinery hire service, but there is an active private tractor hire sector. It is estimated that around 1500 tractors are engaged wholly or mainly in contracting work. At one extreme there are specialist contractors with 10 or more tractors undertaking mainly big jobs in the large-farm sector. They
employ high horsepower tractors (often 4 wheel drive) and so achieve fast work rates on large and well cleared fields. However, most such contractors are reducing the scale of their activities because of increasing costs of operation, and the greater profitability of other agricultural activities. As large estates are further subdivided the demand for large-scale contracting seems bound to decline.

At the other extreme is the operator with just one tractor who cultivates his own farm first and then carries out additional work for his neighbours or further afield. Most contract work in the family farm sector is performed by such men, who usually operate small to medium horsepower tractors.

Some contractors reported achieving very high rates of machine utilisation, working long hours at peak periods including night work with drivers working in shifts. It is common to travel long distances to find work. Annual running hours in excess of 1000 hours appear common, some operators achieving more than 2000 hours per year. The larger contractors replace their tractors every 2 or 3 years so as to avoid major repair problems. However, shortages of foreign exchange are making this more difficult, and are also affecting spares acquisition.

Contractors charges were (in 1983) typically 15-30% above those of AMSB. There is some evidence that contractors keep their rates down as a result of competition from THS. Some contractors would not undertake work on previously uncultivated land because of the danger of damage to machinery from tree stumps, boulders, etc. So THS probably gets a disproportionate share of cultivation of new land.

Though some AMSB station managers avoid sending their tractors to areas where private contractors are active, elsewhere THS had clearly acted as a disincentive to the establishment of a private contract market, an effect quite opposite to that intended.

There is no clear preference among farmers for THS or private contractors. The contractors are more dependable but are sometimes criticised for rushing the work.
Conclusions

Almost 20 years of experience with public sector tractor hire in Kenya has demonstrated the difficulty of operating a semi-commercial activity as part of a Government ministry. The scheme was quite successful in its early days when it concentrated on areas which were most amenable to mechanisation and benefited from good management. However, the expansion and geographical dispersion of the scheme have made it much harder to operate efficiently, and there are many aspects of government administration and finance which seem incompatible with effective management of such a service.

The main motivation behind the scheme was the expansion of the cultivated area, and the provision of mechanised cultivation for small farmers. However, there is now only limited potential for additional expansion of cultivation, and the mechanisation needs of the small farm sector could be met by private farmer-contractors who achieve much higher machine utilisation than the AMSB. If the Government wishes to continue subsidising mechanisation (eg in newly developed areas where private contractors are not yet established) it could do so more efficiently via direct subsidies to contractors rather than via an expensive public sector hire service.
1. **Physical Background**

Farming in Egypt is practically all concentrated in the Nile river valley and Nile delta. The exception is an area in the north western coastal area. Farming is fully irrigated; again apart from the north western strip. The soils are fertile alluviums, which with the year round supply of water allows for a high cropping intensity close to 2.0. It also allows for an extremely high rural population density of about 5.7/ha. With farming being restricted to the close proximity of the Nile, only 3.5% of the total land area of Egypt is cultivated.

2. **Farming Systems**

Table C1 gives the size distribution of Egyptian farms in 1961 and 1977.

<table>
<thead>
<tr>
<th>Farm Size (ha)</th>
<th>1961 Census (% of total)</th>
<th>Estimated 1977 (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>less than .42</td>
<td>26 (84%)</td>
<td>28 (91%)</td>
</tr>
<tr>
<td>.42 - .84</td>
<td>24 (16%)</td>
<td>19 (9%)</td>
</tr>
<tr>
<td>.84 - 1.26</td>
<td>17 (84%)</td>
<td>24 (91%)</td>
</tr>
<tr>
<td>1.26 - 1.68</td>
<td>11 (16%)</td>
<td>16 (9%)</td>
</tr>
<tr>
<td>1.68 - 2.10</td>
<td>6 (4%)</td>
<td>4 (9%)</td>
</tr>
<tr>
<td>2.10 - 4.20</td>
<td>10 (6%)</td>
<td>6 (9%)</td>
</tr>
<tr>
<td>4.20 - 8.40</td>
<td>3 (2%)</td>
<td>2 (9%)</td>
</tr>
<tr>
<td>8.40 - 21.</td>
<td>1 (1%)</td>
<td>*</td>
</tr>
<tr>
<td>21. - 42.</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>42. +</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

**TABLE C.1** Size distribution of Egyptian Farms in 1961 and 1977

* Less than 1 per cent

1961 - total cultivatable area
1977 - total cultivated area

The 0-2.10 ha (0-10 feddan) size of farm accounted for 91% of the farms in 1977 and about 80% of agricultural production. The 0-1.26 ha (0-3 feddan) category accounts for 71% of the farmers. The impact of
mechanization on these more numerous small family size farms is of prime consideration in the analysis of mechanization effects. The predominant farming system is of small family farms using some hired labour at peak periods. The main crops are: berseem (fodder) (27% cropped area), cotton (14%), maize (17%), wheat (12%) and rice (10%). Some of the minor crops are: sorghum (4%), sugarcane (2%), vegetables (9%), and flax (½%). November is considered the start of the agricultural year. The winter crops include wheat, barley, Egyptian clover (berseem) and various pulses. Harvesting takes place from April to June. The summer crops are planted from March to June and include cotton, rice, maize, sorghum, sesame. Two crops per year are produced on most of Egypt’s farms. From 1972-1974, the cropping intensity was estimated to be 1.89. In fact, the intensity is higher on the smaller farms than large farms, the latter being more dependent on hired labour. Table C.2 shows the extent of mechanization in Egyptian farming.

<table>
<thead>
<tr>
<th>% of total done by machine</th>
<th>Ploughing</th>
<th>Threshing: Wheat</th>
<th>Threshing: Rice</th>
<th>Irrigation</th>
</tr>
</thead>
</table>

**TABLE C.2** Extent of Mechanisation

There is no significant difference in machine usage between farms of different sizes:

**TABLE C.3** gives the inputs of labour, machinery and animals for the 5 main crops.

<table>
<thead>
<tr>
<th>Crop</th>
<th>In-Put: Days/ha</th>
<th>Man Days</th>
<th>Boy Days</th>
<th>Animal Days</th>
<th>Machine Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td></td>
<td>132</td>
<td>236</td>
<td>82</td>
<td>0.95</td>
</tr>
<tr>
<td>Rice</td>
<td></td>
<td>86</td>
<td>123</td>
<td>113</td>
<td>1.9</td>
</tr>
<tr>
<td>Wheat</td>
<td></td>
<td>62</td>
<td>28</td>
<td>70</td>
<td>1.19</td>
</tr>
<tr>
<td>Maize</td>
<td></td>
<td>94</td>
<td>104</td>
<td>108</td>
<td>0.83</td>
</tr>
<tr>
<td>Berseem</td>
<td></td>
<td>90</td>
<td>64</td>
<td>97</td>
<td>1.43</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td>123</td>
<td>170</td>
<td>94</td>
<td>1.67</td>
</tr>
</tbody>
</table>

**TABLE C.3** Labour and Machine Inputs for the Main Crops

*This includes a high proportion of non tractor time. Electric and diesel pumps for irrigation*
Irrigation uses the highest number of animal days and machine days. Berseem, for example, requires 14 irrigations, cotton 12, wheat 6, and maize 11.

3. Draught Systems and Equipment

As already shown, the tractorized operations are almost entirely limited to ploughing and the powering of threshing machinery. The ploughing is carried out by a chisel plough. 70% of all farmers use custom-hired tractors for some ploughing. All further seed-bed preparation is done using animal draught. Harvesting is done by hand, using sickles. About half of all farm operators use tractor-powered drum threshers. Another 10-40%, depending on the crop, use a tractor-drawn variant of the traditional animal-drawn "norag".

400,000 water wheels (sakias) are used to lift water from the channels to field level, for irrigation. Sakias, along with man-powered "tambours" provide water for 70% of farms. Sakias account for about 80% of all the draught work done by animals. 20% of farms are irrigated by electric or diesel pump sets. A farm management survey in 1978 for a cross section of Egyptian farms gave the following statistics. Tables C.4 and C.5 give statistics on method of irrigation and method of access.

<table>
<thead>
<tr>
<th>Method</th>
<th>Delta Areas</th>
<th>Middle and Upper Areas</th>
<th>Total</th>
<th>Adjusted Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakia</td>
<td>87</td>
<td>25</td>
<td>52</td>
<td>63</td>
</tr>
<tr>
<td>Tambour</td>
<td>-</td>
<td>13</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Pumpset</td>
<td>13</td>
<td>25</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Gravity</td>
<td>-</td>
<td>37</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

TABLE C.4 Method of Irrigation by Region

<table>
<thead>
<tr>
<th>Method</th>
<th>Delta Areas</th>
<th>Middle and Upper Areas</th>
<th>Total</th>
<th>Adjusted Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sakia</td>
<td>87</td>
<td>25</td>
<td>52</td>
<td>63</td>
</tr>
<tr>
<td>Tambour</td>
<td>-</td>
<td>13</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Pumpset</td>
<td>13</td>
<td>25</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>Gravity</td>
<td>-</td>
<td>37</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

It is thought that there was too much weighting given to the middle and upper areas biasing the total to an over representation of gravity irrigation, and under-representation of sakias. A representative figure is shown under "adjusted total". The majority of pumps are used on the small farms, and as the table C.5 shows, many are rented.
The replacement of sakias by pumpsets is a central part of the government's mechanisation policy. This is seen as a promising method of increasing agricultural production, either through an increase in livestock products due to them being worked less, or an increase in other agricultural products due to less animals being required for draught, less berseem grown, and more cereal or other agricultural products being grown.

4. Background to Machinery Hire

Table C.6 gives the tractor numbers in Egypt in 1978. These are divided into cooperatively owned and privately owned. The total number is 24,680 of which 17% (4,190) are cooperatively owned.

At the time of this particular study (1978) the numbers of cooperative tractors were declining in absolute and percentage terms. The cooperatives tended to be suppliers of last resort. Even so, they still have a restraining influence in the tractor hire market to the extent of keeping charges at very marginal, or even unprofitable levels, so far as primary tillage is concerned.

Prior to land reforms in 1952 and 1961, any mechanisation was on the whim of the large land-owners. Government decided that the only way to include the small farmers was through cooperative based custom
<table>
<thead>
<tr>
<th>Governorate</th>
<th>Co-op Owned</th>
<th>% of total</th>
<th>Privately Owned Number</th>
<th>% of total</th>
<th>Total</th>
<th>Cultivated Area per Tractor in Feddans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alexandria</td>
<td>10</td>
<td>4.4</td>
<td>216</td>
<td>95.6</td>
<td>226</td>
<td>297</td>
</tr>
<tr>
<td>Beheira</td>
<td>421</td>
<td>18.1</td>
<td>1917</td>
<td>82.0</td>
<td>2338</td>
<td>296</td>
</tr>
<tr>
<td>Gharbia</td>
<td>353</td>
<td>15.1</td>
<td>2000</td>
<td>85.0</td>
<td>2353</td>
<td>186</td>
</tr>
<tr>
<td>Dakahlia</td>
<td>141</td>
<td>3.8</td>
<td>3555</td>
<td>96.2</td>
<td>3696</td>
<td>167</td>
</tr>
<tr>
<td>Kafir El Sheikh</td>
<td>463</td>
<td>18.1</td>
<td>2112</td>
<td>82.0</td>
<td>2575</td>
<td>191</td>
</tr>
<tr>
<td>Danuetta</td>
<td>46</td>
<td>10.7</td>
<td>382</td>
<td>89.3</td>
<td>428</td>
<td>220</td>
</tr>
<tr>
<td>Menoufia</td>
<td>320</td>
<td>23.1</td>
<td>1072</td>
<td>77.0</td>
<td>1392</td>
<td>246</td>
</tr>
<tr>
<td>Kalubya</td>
<td>158</td>
<td>19.0</td>
<td>673</td>
<td>81.0</td>
<td>831</td>
<td>246</td>
</tr>
<tr>
<td>Sharkia</td>
<td>606</td>
<td>20.0</td>
<td>2420</td>
<td>80.0</td>
<td>3026</td>
<td>223</td>
</tr>
<tr>
<td>Ismailia</td>
<td>17</td>
<td>14.0</td>
<td>104</td>
<td>86.0</td>
<td>121</td>
<td>356</td>
</tr>
<tr>
<td>Suez</td>
<td>8</td>
<td>42.1</td>
<td>11</td>
<td>57.9</td>
<td>19</td>
<td>200</td>
</tr>
<tr>
<td>Giza</td>
<td>112</td>
<td>19.9</td>
<td>450</td>
<td>81.1</td>
<td>562</td>
<td>302</td>
</tr>
<tr>
<td>Beni Suef</td>
<td>379</td>
<td>27.0</td>
<td>1022</td>
<td>73.0</td>
<td>1401</td>
<td>201</td>
</tr>
<tr>
<td>Fayoum</td>
<td>240</td>
<td>22.0</td>
<td>849</td>
<td>78.0</td>
<td>1089</td>
<td>280</td>
</tr>
<tr>
<td>Minyeh</td>
<td>409</td>
<td>28.0</td>
<td>1051</td>
<td>72.0</td>
<td>1460</td>
<td>329</td>
</tr>
<tr>
<td>Assiut</td>
<td>158</td>
<td>15.0</td>
<td>895</td>
<td>85.0</td>
<td>1053</td>
<td>341</td>
</tr>
<tr>
<td>Sohag</td>
<td>167</td>
<td>15.0</td>
<td>949</td>
<td>85.0</td>
<td>1116</td>
<td>287</td>
</tr>
<tr>
<td>Kena</td>
<td>142</td>
<td>19.9</td>
<td>571</td>
<td>81.1</td>
<td>714</td>
<td>490</td>
</tr>
<tr>
<td>Aswan</td>
<td>42</td>
<td>14.8</td>
<td>241</td>
<td>85.2</td>
<td>283</td>
<td>361</td>
</tr>
<tr>
<td></td>
<td>4190</td>
<td>179.0</td>
<td>20490</td>
<td>83.0</td>
<td>24680</td>
<td>249</td>
</tr>
</tbody>
</table>

**TABLE C.6 Estimated Number of Farm Tractors, by Governorate, 1978**

* Based on 2-part Farm Machinery Survey, 1978 with cross-check reference to Ministry of Agriculture data supplied by respective Governorates. In addition to above tractors serving private farmers MOA 1978 data indicate an additional 5,336 are on the state farms reclaiming New Lands. Of these only 55 per cent were reported to be in operating condition.
services. These efforts were quite successful and the cooperatives were well established by 1973. At this point, the government adopted "open door" economic policies which started a new wave of mechanization, and private operators starting buying their own tractors and entering the tractor hire market. The majority of these private operators use the tractors on their own farms but hire out to other farmers as well. In 1979, it was estimated that there were twice as many privately owned tractors for hire as cooperatively owned ones.

5. **Performance**

Table C.7 gives some of the performance parameters for cooperative and private tractors; the main difference is in the total hours of annual use, 557 for cooperative versus 908 for private. Seed-bed preparation involves ploughing, levelling twice, ditching and harrowing. The charge is LE 6.42/feddan (US $18.50/ha) by machinery custom service against LE 14.8/feddan (US $41.54) for the same operations using animal draught. Low utilization of farm machinery and equipment, and uneconomic charges (especially for primary tillage), have led to substantial losses in many cooperatives.

Table C.8 shows that 22% of all the cooperatively owned tractors surveyed were inoperative, compared with 3% of privately owned ones. 49% were in fair condition compared to 39% of privately owned ones.

Table C.9 gives the results of a comparative survey of costs for tractors from Cooperatives, Government enterprises, Private entrepreneurs and Associations. The Private and Associations operate at a profit, whereas the Cooperatives and Government enterprises have to operate with subsidies, 70% and 57% respectively.

The Associations are a promising new development. The Ministry of Agriculture started a programme establishing contract service stations in association with groups of private farmers. Government assist in training managers, operators and mechanics, as well as providing land. The objective is to have a phased hand-over during a 5 year period.

6. **Alternative Machinery Sources**

77% of all tractor hours are hired. Table C.7 shows the following division of tractor hours worked per year between cooperative and private.
<table>
<thead>
<tr>
<th>Ownership</th>
<th>Type 'of Use</th>
<th>Ploughing</th>
<th>Irrigation</th>
<th>Threshing</th>
<th>Transportation</th>
<th>Other</th>
<th>All uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperatives</td>
<td>Percent of all uses</td>
<td>52</td>
<td>2</td>
<td>29</td>
<td>17</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>Private</td>
<td>Own farm</td>
<td>36</td>
<td>16</td>
<td>25</td>
<td>19</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Custom work</td>
<td>40</td>
<td>4</td>
<td>39</td>
<td>15</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Total private</td>
<td>39</td>
<td>7</td>
<td>36</td>
<td>16</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>All tractors</td>
<td>41</td>
<td>7</td>
<td>34</td>
<td>16</td>
<td>2</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ownership</th>
<th>Percent of total hours</th>
<th>16</th>
<th>3</th>
<th>10</th>
<th>13</th>
<th>-</th>
<th>12 (Total hrs 557)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooperatives</td>
<td>Own farm</td>
<td>20</td>
<td>55</td>
<td>16</td>
<td>27</td>
<td>38</td>
<td>23 (235)</td>
</tr>
<tr>
<td></td>
<td>Custom work</td>
<td>64</td>
<td>42</td>
<td>74</td>
<td>60</td>
<td>62</td>
<td>65 (673)</td>
</tr>
<tr>
<td></td>
<td>Total private</td>
<td>84</td>
<td>97</td>
<td>90</td>
<td>87</td>
<td>100</td>
<td>88 (908)</td>
</tr>
<tr>
<td></td>
<td>All tractors</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>

TABLE C.7 Hours of Tractor Use, by type and ownership
Farm Machinery Survey, 1978
Privately Owned

<table>
<thead>
<tr>
<th>Age</th>
<th>Condition</th>
<th>All Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years</td>
<td>Percent of total reported</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>24.9</td>
<td>1.5</td>
</tr>
<tr>
<td>2</td>
<td>19.9</td>
<td>3.0</td>
</tr>
<tr>
<td>3</td>
<td>12.2</td>
<td>4.1</td>
</tr>
<tr>
<td>4</td>
<td>6.7</td>
<td>6.5</td>
</tr>
<tr>
<td>5</td>
<td>7.8</td>
<td>6.5</td>
</tr>
<tr>
<td>6</td>
<td>3.3</td>
<td>4.2</td>
</tr>
<tr>
<td>7</td>
<td>2.5</td>
<td>3.9</td>
</tr>
<tr>
<td>8</td>
<td>3.4</td>
<td>5.1</td>
</tr>
<tr>
<td>9</td>
<td>.9</td>
<td>1.9</td>
</tr>
<tr>
<td>Over 10 1/</td>
<td>14.1</td>
<td>53.1</td>
</tr>
<tr>
<td>All ages</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total No.</td>
<td>2637</td>
<td>1781</td>
</tr>
</tbody>
</table>

Co-op Owned

<table>
<thead>
<tr>
<th>Age</th>
<th>Condition</th>
<th>All Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Good</td>
<td>Fair</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>16.4</td>
<td>1.0</td>
</tr>
<tr>
<td>2</td>
<td>21.2</td>
<td>1.9</td>
</tr>
<tr>
<td>3</td>
<td>5.9</td>
<td>1.7</td>
</tr>
<tr>
<td>4</td>
<td>5.1</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>10.5</td>
<td>6.0</td>
</tr>
<tr>
<td>6</td>
<td>4.2</td>
<td>2.6</td>
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<tr>
<td>7</td>
<td>3.6</td>
<td>2.4</td>
</tr>
<tr>
<td>8</td>
<td>5.4</td>
<td>2.0</td>
</tr>
<tr>
<td>9</td>
<td>.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Over 10 1/</td>
<td>22.9</td>
<td>70.8</td>
</tr>
<tr>
<td>All ages</td>
<td>100.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total No.</td>
<td>354</td>
<td>588</td>
</tr>
</tbody>
</table>

TABLE C.8 Age of Farm Tractors by condition and ownership

1/ Of all privately owned tractors in this age group 66 per cent were reported to be 10-15 years of age; 22 percent 15-20 years and 12 percent 20 or more years. Comparable data for cooperative-owned tractors are: 89 percent 10-15 years, 8 percent 15-20 years and 3 percent 20 or more years.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of tractors</td>
<td>30</td>
<td>320</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>Average working hours/year</td>
<td>410</td>
<td>690</td>
<td>1534</td>
<td>1414</td>
</tr>
<tr>
<td>Cost per working hour</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depreciation</td>
<td>2.43</td>
<td>1.04</td>
<td>0.65</td>
<td>0.70</td>
</tr>
<tr>
<td>Fuel and oil</td>
<td>0.40</td>
<td>0.71</td>
<td>0.62</td>
<td>0.65</td>
</tr>
<tr>
<td>Repairs &amp; Maintenance</td>
<td>2.16</td>
<td>1.62</td>
<td>0.65</td>
<td>0.63</td>
</tr>
<tr>
<td>Operators</td>
<td>0.20</td>
<td>0.20</td>
<td>0.42</td>
<td>0.50</td>
</tr>
<tr>
<td>Overheads</td>
<td>1.21</td>
<td>1.04</td>
<td>-</td>
<td>0.36</td>
</tr>
<tr>
<td>Total cost</td>
<td>6.40</td>
<td>4.61</td>
<td>2.34</td>
<td>2.83</td>
</tr>
<tr>
<td>Actual hire rate</td>
<td>2.00</td>
<td>2.00</td>
<td>3.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Amount of subsidy</td>
<td>4.40</td>
<td>2.61</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Profit</td>
<td>-</td>
<td>-</td>
<td>0.66</td>
<td>0.17</td>
</tr>
</tbody>
</table>

**TABLE C.9 Cost of Tractor Work by Different Enterprises compared with Actual Hire Rate.**
The balance in the hire market between cooperative and private has been changing radically since 1973, the start of the open-door economic policy. By 1973, it had been demonstrated that there was a good market for tractor hire, and the more open policies allowed private operators into that market. The structure of Egyptian agriculture lends itself to a custom service, in that the vast majority of farms are too small to justify the sole use of a tractor, but there are well established systems for the sharing and hiring of equipment and animals. This made it relatively easy for the more enterprising individuals to buy tractors for use on their own farms and for custom work.

7. Overall Objectives and Consequences of Mechanisation for Egypt

The initial conception of introducing and encouraging mechanization in Egypt was that the production of food crops would be increased at the same time as maintaining the level of cotton production for export. This is within the context of a limited and quite rigidly fixed area of land. 55-60% of the population are urban, so there is strong political pressure to ensure adequate food supplies at a low cost. It was hoped that mechanisation would increase food production in two ways:

1) Increased yields and increased cropping intensity.
   This should occur through more timely operations and improved seed-bed preparation. Increase in intensity could occur through quicker turn around between crops.

2) Machines would displace animals which would mean a decrease in the fodder (berseem) area, and a parallel increase in the area of grain and pulse crops.

Mechanization has been adopted quickly and enthusiastically, indicating that it is benefiting the farmers in some way. From the national point of view, the real objective of increased food production has not been met. Since 1965, the agricultural sector has faltered. Crop yields
have levelled off, and in the face of a continued population increase of 2-2.5%, food imports have increased.

The only real increase in agricultural production has been beef and milk. This points to the real effects of the uptake of mechanization so far. Cattle numbers have continued to increase at 1-2%. Animals have not been phased out as a consequence of mechanization. What has happened is the work-load of the cattle has decreased, and so milk and meat production has increased with the fodder area remaining constant at about 25% of the total cropped area. The price for these products is high, and there is little incentive for the farmer to change from fodder crops to grain crops.

So far as future mechanization and national policy are concerned, the implications of the effects so far are important. The fact that most farmers have retained their animals indicates the problems of trying to increase grain production by the replacement of animals by machines, and substitution of fodder area to grain crops. Farmers have retained their animals for secondary tillage operations and sakia (water wheel) operation. Another important factor is that with his own animal, the farmer has flexibility as to when the job is done. If government were to provide pumpsets for hire or provide more credit and service back-up specifically for pumpsets, this may have the effect of reducing animal numbers. Animals will probably be retained for the secondary tillage operations since it is likely to be unprofitable for custom services to carry out such quick operations on small fields.

The other strategy is to aim for large yield increases without actually trying to displace draught animals. Provision of more pumpsets may, in fact, help with this if it means water can be delivered more quickly, therefore taking advantage of the, sometimes limited, period it is available. Other possibilities are; improved seed-bed preparation, more timely planting, and land levelling. The best opportunity for government involvement is in land levelling. They are already involved in contract deep ploughing, ditching and levelling, on a subsidised service. This service could be expanded: the gains come from more efficient use of water within the field. Seed-bed preparation and timely planting are more a case of an extension input being needed, with perhaps some new equipment being introduced.
CASE STUDY D : SIERRA LEONE

1 Background to agriculture in Sierra Leone

Sierra Leone is a predominantly agricultural economy and rice is the most important crop. The average ambient temperature is around 26 C, and average rainfall of 2500 mm rising to over 3500 mm on the coast. The rains are concentrated into the period June to October, the rest of the year being quite dry.

The most common farming system is bush-fallow. Traditionally one or two years cropping were followed by 10-15 years fallow, but increasing population pressure has led to shorter fallow periods and reduced yields. Soils are severely leached and low in fertility so yields are low. Mixed cropping is commonly practiced as a hedge against complete crop failure. Most of the country's rice is grown under upland conditions, but the potential for mechanisation is limited by the presence of rocks and stumps in poorly cleared land.

There are also large areas of deepwater rice grown in swamplands but these too are difficult to mechanise. However, mechanised rice production is feasible on the extensive riverain grasslands, consisting of flat and unobstructed flood plains along the sides of major rivers, and the "bolis", large saucer-shaped depressions of up to 5000 acres which are subject to seasonal flooding. Soils in the riverain and boli lands are generally light and easily cultivated, though heavy weed growth can be a problem. Soil in the bolis is not particularly fertile, and yields in the riverain areas are dependent on the rate and depth of flooding each year.

Traditional land tenure prevails in Sierra Leone, which makes it possible to plough large areas by arrangement with the chief rather than with all the individual farmers involved. This should make the scheduling of tractor work programmes more straightforward. But on the other hand it reduces the incentive for the farmer to invest in land improvements if he does not have guaranteed tenure over a particular plot.

Labour is in relatively short supply in some of the rice growing areas.
Cultivation is mainly manual (though animal draught is expanding in a few districts), and harvesting is also almost entirely by hand. So labour shortages are experienced during these operations, and migratory labour, including some from the cities, is used in the boli and riverain lands. Indeed there is the risk that expansion of the cultivated area through mechanisation of land preparation would result in more acute labour shortages at harvest.

2 The Mechanised Cultivation Scheme

Government tractor hire in Sierra Leone began in about 1950, and a service has been operated by the Ministry of Agriculture and Natural Resources since then (apart from short periods when it has been transferred to other authorities e.g. the Rice Corporation, 1965 to 1968). In addition to the main scheme which operates over much of the country, there have been separate projects in some of the higher potential locations e.g. Torma Bum. The main objective of mechanised cultivation has been the expansion of rice production. Rice is the main food crop in Sierra Leone but domestic production is inadequate and imports represent a major drain on foreign exchange. Self-sufficiency has therefore been pursued. The relatively unexploited riverain grasslands and boli lands appeared amenable to mechanisation, though over the years the tractor hire service has also been used in upland rice cultivation. In fact there has been considerable pressure to provide mechanical cultivation to influential farmers in areas which are not well suited to it, and once such people have benefitted from the service they expect it to be continued.

The area cultivated mechanically each year is given in Table D1: most of the mechanically cultivated land is ploughed and then harrowed by tractor drawn implements, with subsequent operations carried out manually. In most years since 1955 at least 10,000 acres of rice have been grown on land cultivated mechanically, and at the peak of the scheme in 1974 and 1975 the acreage exceeded 50,000 with between 250 and 300 tractors in operation. The total area under rice in 1975 was about 850,000 acres, so at its height mechanical cultivation represented about 6% of rice cultivation.
The ploughing season is constrained by the water level, as the riverain grasslands and bolis are flooded throughout the growing period. Ploughing can commence once the land is dry enough (about February-March) until the rains begin and the water table rises again (about June-July). Care must be taken to avoid machines being cut off by rising water levels, and in the past machines have been lost as a result of flooding.

3 **Equipment**

The mechanised cultivation scheme has operated a variety of medium horsepower wheeled and tracked tractors. Most have been British though other West European and East European machines have been imported under aid or barter agreements. The East European tractors proved most unreliable, some of them suffering serious engine problems after doing very little work in the field. Tracked tractors have the advantage of lower ground pressure and better traction in wet conditions.

The normal cultivation has been disc or mouldboard ploughing followed by one or two harrowings. Proposals have been made to evaluate wide disc implements which would be faster and more economical than ploughing. Other implements such as seed-drills and combine harvesters have also been introduced, though the latter have not been successful.

4 **Staffing and Management**

The mechanical cultivation scheme has a base workshop near Freetown and three regional workshops, each with a number of sub-stations. There is a Regional Agricultural Engineer for each of the 3 regions, and the workshops are staffed by mechanics, fitters, drivers etc. with very mixed standards of experience and competence. All staff are employees of the Ministry of Agriculture and Natural Resources and so are paid on government salary scales and have considerable security of employment. At all levels of the organisation there are large numbers of underemployed staff, reflecting patronage and nepotism in the allocation of government jobs. This reduces the discipline and incentive to work, and in
consequence time-keeping and attendance are very poor.

There is a general shortage of good managers and administrators in Sierra Leone, so management problems are not unique to the scheme. However, managers appear to be insensitive to the problems of field operation and unwilling to visit field sites regularly, and field-level staff do not have the authority to make simple purchases such as of fuel and spares without reference to senior staff.

One of the biggest organisational problems of the scheme is the division of responsibility between scheme staff (drivers, fitters and engineers under the Regional Agricultural Engineer), and agricultural staff (Agricultural Instructors, Agricultural Officers, under the Principal Agricultural Officers). The RAE is responsible for the maintenance and repair of the tractor fleet, but its actual deployment is under the control of the PAO. Thus recommended work schedules have been drawn up by agricultural engineers e.g. concentrating on sites which are at least 100 acres, flat, free of obstructions such as trees and termite hills, and which have good access and potential yield. But these are not subsequently adhered to as a result of strong political pressure from individuals wishing to obtain tractors. As a result work is done on sites which are too small, inaccessible or badly prepared to be economic.

At the site level, the Agricultural Instructor is in charge of the deployment of the tractor though the driver and the fitter have to take responsibility for the condition of the machine. Thus they may be instructed to use it in an unsuitable area, and yet have to accept responsibility if damage occurs. There is probably corruption at the lower levels too, AIs failing to record work which has been carried out and paid for.
5 Finance

The operating costs of mechanised cultivation are met from the Ministry budget, and capital costs are covered partly by foreign aid and partly from Government funds (special allocations have been made for tractor purchase as there is no programme to replace tractors on a systematic basis). Not only are the total costs to the government high, but there is also a large foreign exchange element. The acceptance of machines under aid (or at highly concessionary prices) has meant that machine selection is not always based on suitability or quality of dealer support.

The scheme has been very highly subsidised for many years as a result of inefficiency of operation, poor recovery of revenue and extremely low charges. It has taken up a large share of the Ministry's budget (reportedly about 1/3 in some years) and has been demanding of staff time.

It was estimated that the rate of subsidy in 1982, with arbitrary but reasonable assumptions on machine life and the allocation of capital costs, was about 94% i.e. farmers paid only 6% of the actual cost per acre of providing the service. In fact it appeared that the total costs of cultivation might well have exceeded the gross returns from rice production on the tractor-cultivated land!

Charges are fixed at Cabinet level and are levied on a per acre basis. They cover only a fraction of actual operating costs and are far less than the costs per acre of even an efficiently operating cultivation scheme. However, it is a measure of the political pressure to continue the subsidy that increases in charges have continued to be small and usually inadequate to cover increases in costs, let alone reduce the degree of subsidy.

Figures on debt recovery are not available for the scheme as a whole but are reported to be about 65% on the Torma Bum Project.

There were plans for many years to operate a "revolving fund" whereby revenue could be used for the purchase of fuel and minor spares (thus reducing loss of work due to delays in funding such purchases). Though such a scheme was eventually initiated it never operated as envisaged, and has now been dropped as unworkable.
6 Performance

In addition to figures on the total acreage cultivated, Table D1 gives the number of operational tractors for 7 of the last 10 years. Tractor numbers in other years, and tractor hours per year are not known. The average number of acres per working tractor is 144 for the years for which it can be calculated. Assuming that this land is ploughed at a rate of 1.5 hours per acre, and harrowed at a rate of 0.75 hours per acre, then the number of working hours per operational tractor is 324 hours p.a. Clearly this is a low level, and one which would be further depressed if the average number of hours of all tractors were calculated, including those which were broken down.

The proportion of tractors out of action at any time and the average life of tractors are not known precisely. However they are apparently at very poor levels. For example, 207 new tractors were obtained in 1980 but by 1982 the operational fleet was only 106 (and this included some older machines). Admittedly the Universal tractors were particularly unreliable so the loss of half the fleet in 2 years is probably exceptional.

7 Repairs and maintenance

There has been a long-term input of British aid (capital and personnel) into improving the workshop facilities and repair and maintenance standards of the mechanical cultivations scheme, but many serious deficiencies remain. The main workshop at Kissy near Freetown has a modern workshop building and adequate stores and office facilities. While it lacks certain machine tools and some specialist equipment (e.g. for the repair of diesel injectors and electrical components) it is more-or-less capable of coping with major repairs and overhauls for the tractor fleet. The regional workshops vary in quality. That at Bo is fairly well equipped for most routine repairs and maintenance jobs, but those at Makeni and Port Loko lack much of the equipment needed for effective support of the fleet. The sub-stations have only basic tools, but should not really be needed if tractor deployment is well organised with effective backup from the regional workshops.
Under the British aid agreement considerable improvements were made in stores records, workshop procedures and training of mechanics. A system of service exchange units was introduced though its effectiveness was restricted by lack of spare parts. Mobile service trucks were provided which improved the standard of field servicing and repairs.

Serious delays have resulted from failure to plan in advance the requirements for spare parts, fuel and lubricants and to make sure that they are available when needed. Spares orders are delayed due to lack of funds, and, because dealers keep minimal stocks of parts, long delays are experienced once the finance is available for their purchase. Tractors are often inoperable because a small part is not available, and then suffer further deterioration because they are out of action for so long.

Lack of fuel has been to blame for much of the down-time. There have been national fuel shortages at times, but these do not explain the frequent shortages experienced by the scheme. These are mainly due to problems in obtaining fuel in Freetown and supplying the regional workshops, resulting partly from lack of funds and partly from the long-winded procedures for securing payment. Delivery of fuel from workshop to field site causes some difficulties in remoter locations.

Provision has been made for farmers to pay a lower rate and to provide fuel and lubricants themselves (this is probably done informally more than is officially recorded). However, it has resulted in the use of contaminated diesel, and it has proved difficult to persuade farmers of the need for regular oil changes.

8 Alternative Machinery Services

Ownership of tractors by private farmers is very limited in Siera Leone, though there are a few who carry out cultivation work for themselves and neighbouring farmers. Some cooperatives and estates also have tractors. The development of the private sector has been hampered by shortages of foreign exchange, and by the lack of well developed machinery agencies and repair services. There is no doubt that the continued existence of such a highly subsidised government service has retarded the growth of private sector tractor hire, as it would be impossible for the private owner to
make a profit charging government hire rates and yet farmers would be unwilling to pay a rate substantially higher than they have become used to.

Recently, the Ministry of Agriculture and Natural Resources has attempted to reverse this situation by preparing for sale, to individual farmers or entrepreneurs, many of the tractors currently operated by the mechanised cultivation scheme. The remaining equipment and the existing workshops would be run as a joint venture operation between the government and a private-sector company, and a service would be provided to both government and private operators. Whether this handover of much of the operation of tractors and workshops to commercial interests is allowed to proceed and in fact succeeds remains to be seen.

9 Conclusions

The Government tractor hire service in Sierra Leone has existed for so long that many farmers have become reliant on it and there is strong political pressure from those who benefit from its continuation. The recipients obtain an extremely highly subsidised, if unreliable, service, and for many of them rice production would be quite uneconomic if they had to meet the full costs of tractors, or alternative methods of cultivation. The scheme is inefficient because of political pressures on the deployment of tractors, inadequate finance preventing timely purchase of spares and fuel, and geographical factors which make high utilisation and effective field servicing difficult to achieve. Mechanised cultivation has placed a heavy burden on the finances and personnel of the Ministry and on the foreign exchange availability of the country. The money could almost certainly have been spent in more productive ways. Furthermore, the high degree of subsidy has stifled the emergence of a private tractor hire sector which could not operate profitably in the face of such low government charges.
<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated acreage of rice mechanically cultivated</th>
<th>Number of operational tractors in fleet</th>
</tr>
</thead>
<tbody>
<tr>
<td>1951</td>
<td>394</td>
<td>-</td>
</tr>
<tr>
<td>1952</td>
<td>2097</td>
<td>-</td>
</tr>
<tr>
<td>1953</td>
<td>3957</td>
<td>-</td>
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<td>1954</td>
<td>6267</td>
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<td>1955</td>
<td>10,001</td>
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</tr>
<tr>
<td>1956</td>
<td>12,066</td>
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<td>1957</td>
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<td>-</td>
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<td>1958</td>
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<td>-</td>
</tr>
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<td>1959</td>
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<td>1960</td>
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<tr>
<td>1961</td>
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<tr>
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<tr>
<td>1963</td>
<td>15,750</td>
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</tr>
<tr>
<td>1964</td>
<td>18,250</td>
<td>-</td>
</tr>
<tr>
<td>1965</td>
<td>21,619</td>
<td>-</td>
</tr>
<tr>
<td>1966</td>
<td>13,434</td>
<td>-</td>
</tr>
<tr>
<td>1967</td>
<td>20,459</td>
<td>-</td>
</tr>
<tr>
<td>1968</td>
<td>21,604</td>
<td>-</td>
</tr>
<tr>
<td>1969</td>
<td>24,276</td>
<td>-</td>
</tr>
<tr>
<td>1970</td>
<td>21,208</td>
<td>-</td>
</tr>
<tr>
<td>1971</td>
<td>27,788</td>
<td>-</td>
</tr>
<tr>
<td>1972</td>
<td>24,358</td>
<td>-</td>
</tr>
<tr>
<td>1973</td>
<td>17,291</td>
<td>143</td>
</tr>
<tr>
<td>1974</td>
<td>51,450</td>
<td>288</td>
</tr>
<tr>
<td>1975</td>
<td>54,770</td>
<td>256</td>
</tr>
<tr>
<td>1976</td>
<td>25,175</td>
<td>170</td>
</tr>
<tr>
<td>1977</td>
<td>18,530</td>
<td>144</td>
</tr>
<tr>
<td>1978</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1979</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1980</td>
<td>-</td>
<td>(207 new tractors delivered)</td>
</tr>
<tr>
<td>1981</td>
<td>14,900</td>
<td>-</td>
</tr>
<tr>
<td>1982</td>
<td>Approx 10,000</td>
<td>106</td>
</tr>
<tr>
<td>1983</td>
<td>&quot; 10,000</td>
<td>91</td>
</tr>
</tbody>
</table>

- = information not available
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Introduction

Mechanization of field operations in Pakistan is mainly via purchase of tractors by individual farmers, but the Provincial Governments operate fleets of bulldozers and associated equipment for land development work. Information is available for the scheme in Sind which is operated by the Directorate of Agricultural Engineering, most of it relating to the last 10 years, and this is outlined below.

1. Physical Background

The Province of Sind covers the lower part of the Indus Plain. It has fertile alluvial soils, but receives negligible rainfall, so the availability of irrigation water is the key determinant of agricultural production. There is some irrigation from groundwater, but most of the cultivated area is dependent on water from the Indus. This is diverted from the three major barrages across the river in Sind, at Gudu, Sukkur, and Kotri, and there is a well developed network of irrigation canals. No provision for drainage was made when the irrigation works were laid out, and over the last 50 or 60 years the water table has gradually risen until waterlogging and salinity have become severe problems:

Table E.1: Land Availability in Sind, 1978, million acres

<table>
<thead>
<tr>
<th>Description</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cultivable command area</td>
<td>13.25</td>
</tr>
<tr>
<td>Too saline or alkaline for economic crop production</td>
<td>4.75</td>
</tr>
<tr>
<td>Currently cultivable, of which</td>
<td></td>
</tr>
<tr>
<td>- severe salinity</td>
<td>4.50</td>
</tr>
<tr>
<td>- non saline</td>
<td>4.00</td>
</tr>
</tbody>
</table>

Land is continuing to go out of production as a result of salinity at a rate estimated at 20,000 acres per year. However, there is still the potential to bring additional land under cultivation. There is a limited amount of undeveloped land within the canal command areas (especially under Kotri barrage which is the most recently completed). However, there is a shortage of additional water for the cultivation of such land,
because the storage capacity and the canal system are fully stretched with no spare capacity. Further undeveloped land, extending to more than 0.5 million acres, exists in the riverain or "kutcha" areas, and much of this is underlain by fresh groundwater, and so can be irrigated via tubewells. Such areas are relatively inaccessible and subject to flooding in some years, and so the incentive to invest in their development is reduced.

2. **Human Background**

The most common form of land tenure in Sind is private ownership of land by landlords (zamindars) who allocate plots to tenants (haris) but retain most management functions which they exercise either personally or through managers (kamdars). The costs of inputs are normally shared equally between zamindar and hari, the hari provides all labour and draught power, and the gross output is divided equally. Casual labour, including seasonally migrant workers, is sometimes used at peak times.

Land development work is financed by the zamindar, but the hari is expected to contribute labour and animal draught as required.

The effects of land reform appear to have been minimal in Sind, and many zamindars still own large acreages (perhaps distributed between several family members). However, in more recently settled areas traditional land tenure is not so dominant, and private ownership and operation of individual farms is more common.

3. **Farming Systems**

There are two dominant cropping patterns in Sind: rice-wheat in Upper Sind, much of which receives irrigation water only in Kharif season so the rabi wheat crop is grown on residual moisture, and cotton-wheat in the less saline areas of Central and Lower Sind. Sugarcane cultivation is also expanding rapidly in the central and southern parts of the State, and various other cereals, pulses, and vegetables are also grown. Average cropping intensities are only 110% to 120%.

The average land holding per zamindar is not known. One survey of 32 zamindars found the average holding size to be 334 acres, but this was not necessarily all owned by one person and the sample may not have been typical. The area allocated to each hari family varies according
to family size and farming skill, averaging around 10 to 12 acres. Plot sizes are small for irrigation purposes, usually about 0.5 acres.

4. **Draught Power**

Tractor cultivation is becoming common in Sind, and the tined cultivator is the standard implement used. Tractors are usually owned by zamindars who cultivate the land for their haris, and some work is done on hire to other farmers. However, some land is cultivated entirely by animal power, and even where tractors are used, there may be additional ploughings using ox-drawn ploughs. Tractors clearly reduce the workload of the hari, and also reduce the need for draught animals, and therefore for land to be devoted to fodder crops. They may also enable the zamindar to retain a larger share of the crop than under traditional cultivation arrangements.

5. **Background to Machinery Hire Scheme**

The scheme is run by the Directorate of Agricultural Engineering of the Government of Sind, which took over the formerly separate land development services of the 3 barage commands in 1972. It carries out work in response to requests from zamindars, and does not try to influence the type of work which is done or to give priority to particular areas or operations. The objectives of the scheme were to raise agricultural output by:

i) New land development, either in the riverain areas or the canal command areas. This includes the clearing of bushes and small trees, the flattening of sand dunes and minor surface irregularities, and the construction of bunds, water courses and roads. The type of land ranges from thick jungle interspersed with sand dunes, to more-or-less flat areas with very little vegetation.

ii) Levelling already cultivated land: This is usually carried out in canal command areas with the object of reducing variations in the depth of watering (improving yields and reducing water consumption), and amalgamating fields and removing bunds. This form of levelling may be surveyed using instruments, or more commonly, judged by eye.
(iii) Lowering the level: Previously cultivated or newly cleared land is sometimes lowered by removing soil from the surface and pushing it into bunds around the sides. Thus fields are brought under the canal command, and the need for pumping water into them removed.

(iv) Salinity control: Bulldozers are used for the removal of saline top-soil by skimming it off, or alternatively, unaffected soil (e.g. from bunds or dunes) may be spread over the surface. These operations may be combined with (ii) or (iii).

New land development work makes up about 50% of DAE's total work, an increase from about 30% in earlier years of its operation. The largest areas of undeveloped land in canal command areas are under Gudu and Kotri barages, and the DAE machines in these areas carry out a high proportion of their work on new lands. Development of land in riverain areas has not turned out to be so important as initially planned, though it remains significant in some locations (e.g. Khairpur and Hyderabad Districts).

In all parts of Sind, land levelling operations are markedly seasonal, with the slack and peak seasons occurring at more-or-less the same time throughout the Province, thus offering little scope for transfer of machines between Districts in order to raise utilisation. The peak season runs from December through to May or June, but little work can be carried out during the kharif (summer) season when fields are inundated. In rice growing areas of Upper Sind there is virtually no work during the summer months as land is waterlogged and movement of machines impossible.

6. **Equipment**

When the DAE took over the amalgamated service in 1972, there were 296 bulldozers, of which 224 were Russian T-100s, 45 Fiat AD-7s, plus smaller numbers of Caterpillar and I.H. machines. Many of these were already quite old, 38% of them having covered over 8,000 hours of work.

In 1977, 160 Track Marshall 75C bulldozers were supplied under British aid, and a further batch of 90 T.M. 75Ds in 1981. In 1982, the fleet was increased with the receipt of 85 Japanese Komatsus. By this time all the original fleet had been retired.
Most bulldozers have been in the range of 75-125 hp, the smaller ones being suitable for lighter levelling and the larger ones for operations such as jungle clearing or flattening of sand-dunes. Some machines are fitted with rippers, and scrapers are available, but most work is carried out with the dozer blade. For the lighter operations bulldozers are competing against wheeled tractors with front-mounted blades, and their popularity for such jobs is no doubt enhanced by the subsidised level of charges.

7. Staffing and Management

The DAE is administered by the Director and headquarters staff based at Hyderabad. There are five Divisions, each headed by an Agricultural Engineer, and there are ten field units headed by Assistant Agricultural Engineers. The total staff of the organisation was just over 1,000 in 1975, and has been reduced slightly since then, but precise numbers are not known. Staff are paid at flat rates according to Government pay scales, but is is usual for customers to make an additional payment per hour to drivers. Thus there is an incentive to achieve high rates of work, even if it is not recognised officially. In addition, awards are made to drivers and mechanics of machines which achieve the best performance. Most machine operators are experienced and skilful, and some of the mechanics are also highly experienced and capable.

The DAE allocates machines in response to requests from zamindars, who must apply in writing to the Assistant Agricultural Engineer for the district in which their land lies. The AAE completes the appropriate forms including the number of hours required and the total cost. This has to be paid in full at any branch of the National Bank before the work is started, though additional hours can be purchased later if required. The zamindar is also charged the cost of transporting the bulldozer to his farm, and of any time lost which is his fault (e.g. because of delays in depositing money for additional work).

All revenue deposited at the bank goes directly to the Treasury and is not available to the Department.

There is a maximum limit of 250 hours on the amount of work which is done for any individual zamindar within a year. If machines would otherwise be idle this limit can be, and often is, exceeded, and it appears that some influential Zamindars are able to obtain the services of bulldozers for as long as they desire.
Delays in supplying bulldozers after receipt of an order are normally small, even during the busy season, machines normally being available within 1-2 weeks.

Daily work sheets are maintained for each bulldozer, recording meter-hours worked, and these are aggregated into monthly statements of work performance at the district level. Although good records of hours worked are available, there is no systematic recording of the type of work undertaken. Information is collected on spares and fuel consumption, and on reasons for down-time, so availability of management information is satisfactory. However, the information has not been used fully e.g. to assist with planning machine deployment, or forecasting spares requirements.

8. Financial

The bulldozers themselves, together with much of the ancillary equipment, have been provided under foreign aid agreements between Pakistan and several donor countries. Finance for salaries, fuel, locally purchased spares; workshop equipment, etc. is by annual allocation of funds from the Government of Sind to the Directorate of Agricultural Engineering. Revenue from bulldozer hire is not paid into DAE accounts. There are sometimes administrative problems which delay the release of finance (this has, for example, held up imports of spare parts), but lack of finance has not normally been a major problem for the organization.

The low level of hire charges for the bulldozers has meant that the scheme has been a heavy drain on the Government budget. For many years there has been a 50% subsidy on bulldozer hire for agricultural purposes, including land development, but because of delays in raising charges and underestimates of the full cost of the operation, the actual rate of subsidy has sometimes been higher. Such a level of subsidy is difficult to justify, as the financial returns to levelling appear attractive even at the full cost. The beneficiaries are predominately wealthy landlords, and the existence of a highly subsidised service acts as a disincentive to potential competitors. In particular, it biases the choice between wheeled tractors and bulldozers for lighter work. Rates in Sind have been at levels comparable with those in neighbouring Provinces (Punjab and Baluchistan). There has been some resistance against efforts to reduce the subsidy in the past, but in view of the high benefits it should not be politically impossible to
to remove the subsidy. It appears to continue mainly because it has existed in the past, rather than for any clear reason of policy.

9. Performance

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>T.M.75C</td>
<td>1745</td>
<td>1358</td>
<td>1356</td>
<td>933</td>
<td>603</td>
</tr>
<tr>
<td>T.M.75D</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1851</td>
<td>1554</td>
</tr>
<tr>
<td>Komatsu D50A</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1948</td>
</tr>
</tbody>
</table>

The annual work output for the Track Marshall and Komatsu bulldozers shows that quite good performance is achieved in the early years of a machine's life, but the figures for the 75Cs suggest that this tails off rapidly as the tractors get older. This is partly a result of increasing breakdowns and lack of spare parts, and partly because as the service acquires newer (and, in the case of the Komatsus, higher hp) machines, these are used in preference to the older ones. By 1982-83 the DAE probably had surplus capacity and so did not need to utilise its older machines fully.

The average life of the TM machines looks like being about 8,000 hours. Previous bulldozers are said to have achieved between 10,000 hours and 13,000 hours. Such levels of performance could be exceeded if maintenance and spares availability improved, but are nevertheless satisfactory in a harsh working environment.

Figures on the actual area of land development work achieved are not available. However, they have been devised from the figures on hours worked, on the assumption (borne out from past experience in Sind) that it takes 5 hours per acre to level previously cultivated land, and 7 hours per acre on average for new land development. On this basis, the area levelled each year in the late 1970s and early 1980s was between 35,000 and 50,000 acres.
10. Repairs and Maintenance

The five Divisions have well equipped main workshops where major overhauls are carried out and some components can be manufactured. In response to shortages of replacement parts, mechanics have developed expertise in the repair and rebuilding of components which would normally be replaced. The sub-workshops of the Field Units are more variable in standards, and contain more limited facilities for routine repair and maintenance operations.

A system of sub-assembly exchange is in operation, so that, for example, an engine can be exchanged in the field and so save considerable tractor downtime. The very dusty working conditions have led to excessive engine wear in some cases where air filtering has been inadequate. In some areas machines are working in sandy soils which has led to abrasion of the running gear and the more exposed components such as radiators.

Spares stores are adequate but stocks are small, and analysis of future requirements and ordering in advance are areas of weakness. Many components (such as bulldozer chassis parts) have a fairly predictable working life and so replacements should be purchased in anticipation of overhauls.

Fuel is supplied to the bulldozers from the district workshops by tanker which fills storage drums, or alternatively, the fuel is transported in drums directly. Contamination of diesel is a danger when it is transferred from drum to tractor using a bucket and funnel.

11 Alternative Machinery Hire Services

The DAE has a virtual monopoly on the provision of bulldozer services to agriculture in Sind. There are very high taxes on bulldozer purchase (they are not classified as agricultural machinery like wheeled tractors), and so only a handful of machines are operated by private farmers or contractors in Sind (mainly old machines sold off by DAE).

In a recent study of land levelling work in Sind, zamindars who had used the services of DAE were asked to compare the costs of using bulldozers with those of using tractors, and all but one thought the bulldozers to be much cheaper. Likewise, the use of animal implements and manual labour was regarded as less attractive than bulldozer hire on grounds of cost and organisational requirements. Of course, the
charges which zamindars pay for bulldozers cover only about 50% of the total costs of their operation.

12. Conclusions

The bulldozer hire operations of the Sind Directorate of Agricultural Engineering represent a well established and generally well-run scheme. There is scope for improvement in standards of machinery maintenance and spare parts provision, which would help extend the working life of machines. But repair work is of quite a high standard, and annual machine utilisation is satisfactory given the limited working season. This is helped by the incentive effect of unofficial payments to operators by zamindars.

The financial returns to landowners who have their land levelled are clearly very high. Economic returns are probably satisfactory, although they are dependent on the cost of providing irrigation water which are difficult to quantify.

In view of this, it is difficult to see why hire rates should be so heavily subsidised, especially at this leads to a heavy demand for Government finance for what might otherwise be a self-supporting project. It also distorts the choice between using bulldozers and wheeled tractors.

As private tractor ownership is very widespread, there is no clear reason why private bulldozer ownership could not also be encouraged. Government control over land development might be preferable in view of the limited availability of water: increasing the area cultivated in one part of the canal command system may give financial benefits to the farmer concerned, but at the expense of farmers elsewhere in the system, particularly tailenders. However, the DAE does not at present exercise such control over the deployment of the government-owned machines, so this advantage is theoretical rather than practical.
CASE STUDY F: SWAZILAND

1. Physical Background

The kingdom of Swaziland is one of the smallest political entities in Africa. It has an area of 17,363 sq km (6,782 sq miles) and straddles the broken and dissected edge of the South African plateau lying 26° south of the Equator. Swaziland has four regions aligned north-south. To the west is the high veld averaging 1,100m, moving East is the Middle Veld (500 m) then the Low Veld (200 m), lastly there is the Hbombo Range, an undulating plateau between 450 and 825 m. The eastward descent is accompanied by a rise in temperature and be a decrease in mean annual rainfall from between 1,150 and 1,900 mm in the High Veld to between 500 and 750 mm in the Low Veld, increasing again to about 850 mm in the Hbombo Range. The higher regions with more than 1,000 mm support temperate grassland, dry woodland savanna is characteristic of the lower areas. Drainage is by four main river systems running eastwards across the four regions. Soils are highly variable and so far as mechanical cultivation is concerned the important factors are slope and stoniness. Tractorisation will occur where there has been animal cultivation. The highest concentration of fertile soils occurs in the middle veld.

2. Human Background

The population is estimated at 580,000, with about 80% generating a living from Agriculture. 67% of the population are engaged in subsistence farming. 98% of the population are Africans (mostly Swazi tribe). They own 53% of the land which is held under communal land tenure and is administered by 200 chiefs. The average homestead size varies from 7 to 10 people depending on the region. About 1/4 of the adult homestead population are reported to be absent either working in the Swazi towns or, the mines in South Africa. There are about 10,000 Europeans (2.0%) who own about 44% of the land. Population density is variable, depending on the region. The highest densities live in the Middle Veld with an average of 40/km², but exceeding 200/km² in some areas. The Middle Veld has some of the country's best soils and Manzini, its main industrial and commercial centre.
3. **Farming Systems**

There are two distinct Agricultural sectors in Swaziland. The foreign dominated sector who have freehold to their land and the Swazi Nation Lands (SNL) who have communally owned lands administered by their chiefs.

The foreign sector accounts for about 2% of the total population and they own 44% of the land. Some of the land is underutilised, but there are also many successful highly mechanised estates producing sugar and/or citrus. There are also large cattle ranches and large commercial forest areas producing for pulp. Many of these areas are owned by foreign institutions and there is increasing financial and managerial influence from Swazi concerns.

The SNL accounts for about 75% of the country's population (97% of the rural population) and 53% of the land area. They account for 40% of agricultural production and 12% of GDP. It is predominantly subsistence farming. The main crop is maize, grown by 94% of farmers and occupies 3/4 of the arable land. Pumpkins are usually intercropped with the maize, other important crops are; Beans, Sweet Potatoes and Groundnuts. The average size of homestead arable holdings is 2.75 ha, but there is a large variation depending on the region. For instance in the low Veld where it is less fertile the holdings are twice the average size. Holdings are fragmented, the average being 3 or 4 plots per homestead but fragmentation increases with higher population densities.

The predominant source of draught power is oxen. Women and children (under 14 years) provide 55% of farm labour, carrying out most of the routine and time consuming jobs. Males tend to be involved with the more specific and arduous jobs such as ploughing. There are sharp labour peaks coinciding with land preparation and harvest. 95% of homesteads grow crops for one season of the year only. A quarter of homesteads will have one or more adults involved in off-farm employment throughout the year. This does not seem to create a labour shortage but does have important implications so far as disposable cash is concerned.
67% of homesteads own cattle, 95% own chicken, 33% goats and 25% pigs. The cattle and goats use the communal land. There is overgrazing which is difficult to curtail since cattle are seen as a vital means of saving and accumulating capital.

About 1/2 of homesteads have at some time used tractors. This is closely linked to those areas designated as Rural Development Areas (RDAs). Ten of these have tractor pools. Tractors are hired for primary cultivation and transporting. A high proportion of those using tractors have access to non-farm earnings, 40%, compared to 25% for non-tractors users.

4. **Draught Power**

Animal draught is the traditional method of cultivation in Swaziland. The highly commercial foreign dominated sector have used tractors for many years. This machinery is privately owned and therefore not of direct relevance to this report, other than the fact that the traditional farmers will have seen tractors in use in this sector.

The main uses of draught power in the Swazi National Lands (SNL) are for land preparation and transport. Harvesting and threshing in the SNL is practically all carried out by hand. Combine harvesters are used only by the large commercial farms.

Transport is an important use for both animal and tractor draught. Carts are used for the transporting of crops when possible as well as the transporting of building materials, firewood and water.

The RDA machinery pools report that the operations carried out, in decreasing order of important are:

- **Primary Cultivation** - Mouldboard plough. Disc plough if conditions are rough.

- **Secondary Cultivation** - Off-set disc harrows, spike harrows, mouldboard ridgers. Becoming increasingly important.
Transport - 14 trailers for 27 tractors 3 1/2 - 5 tonne capacity. Used for building materials, firewood, crops and water.

Further indication of the uses of tractors is given by a survey of Private tractor owners (1979). Of those that hired out their tractors they did so for the following jobs.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ploughing</td>
<td>More than 90% of hirers</td>
</tr>
<tr>
<td>Planting</td>
<td>25%</td>
</tr>
<tr>
<td>Ridging</td>
<td>25%</td>
</tr>
<tr>
<td>Others</td>
<td>Rarely</td>
</tr>
</tbody>
</table>

The equipment owned by the Private tractor owners also gives a good indication of tractor use:

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mouldboard Plough</td>
<td>70%</td>
</tr>
<tr>
<td>Disc Plough</td>
<td>40%</td>
</tr>
<tr>
<td>Harrows</td>
<td>23%</td>
</tr>
<tr>
<td>Planter</td>
<td>33%</td>
</tr>
<tr>
<td>Cultivator</td>
<td>8%</td>
</tr>
<tr>
<td>Ridger</td>
<td>13%</td>
</tr>
</tbody>
</table>

The evidence is that tractor use is increasing. So far as the THPs are concerned these were started in 1974, with a pilot project in one area. In 1979 THPs were established in 5 areas with 27 tractors in total. In 1982 there were reported to be 34 tractors in 10 pools.

Private tractor ownership seems to be concentrated in the areas where the THPs operate, though they do also exist outside supposedly in lesser numbers. The five Rural Development Areas with THPs were surveyed in 1979. There were a total of 97 privately owned tractors, representing from 1.3% to 2.3% of homesteads owning them. The owners do, in general, represent a more progressive group of farmers, growing more than average areas of hybrid maize, less traditional crops and more having
irrigation. Two thirds of all private tractors in the 5 areas were bought since the start of tractor pools in 1974.

There is no written evidence that yields or areas have increased as a consequence of mechanisation. Attempts to increase the utilisation of existing tractors through early ploughing with chisel ploughs has not yet shown any success. In theory this would extend the ploughing season since chisel ploughs can be used when the ground is still too hard for mouldboard ploughs.

The explanation for the expansion in tractor use is that the opportunity costs for labour, especially at ploughing time has always been high, has probably been increasing, and now that there is an alternative to ox ploughing farmers are able to put a value to that opportunity cost. In 1979 it was calculated that the cost of ploughing using the Tractor Hire Pool (THP) was 1/2 the cost of ox-ploughing. In recognition of this it is now quite common for the absentee adult to send back the money to the homestead for a tractor to be hired rather than return to do the ox-ploughing themselves.

5. Background to Machinery Hire Scheme

The pools were primarily established as an extension exercise, they were planned to operate within the boundaries of the RDAs' and only to undertake primary cultivation and transportation. The intention was to curtail supply so as to encourage private tractorisation. It was also intended that each pool continue only for the economic life of the tractors, predicted to be about 6 years. After that the hope was that private tractorisation would take over. Demand for tractor services is not yet being met by private tractorisation which has forced the Swazi Government into a shift in emphasis of objectives for the THP. Having created the demand there is, probably, political pressure to fulfil it. With the shortfall in private tractorisation the THPs have had to replace the first batch of tractors and embark on another phase.

The THPs have, to an extent, been successful. There is now a strong demand for the services, and the Pools have been run efficiently. The problem arises from the charges being too low. The THP charges set the
going rate for all tractor hire operations and at THP rates, not many private operators are encouraged to enter the market.

Table F1 shows that peak utilisation of the tractors is in October and November. These are the two months when most of the primary cultivation is carried out. The cultivation period is linked closely to the onset of the rains. The start of the rains may vary between regions, but not by many weeks as the THP are specifically set up to operate within a 10 mile radius of the centre to minimise logistical problems. It is noticeable from the table that during cultivation time that productive (revenue) hours as a percentage of total hours is at a maximum. The rest of the year the tractors do less hours in absolute terms, and of this time a greater percentage is spent on departmental work such as transporting building materials or grading roads.

An attempt has been made to expand the primary cultivation period by using chisel ploughs following the very first rains. Although technically viable the reception from the farmers has been very unenthusiastic. If the idea was adopted ploughing could be started in September or even the end of August thus increasing the area and number of farmers that could be served by a given number of tractors.

6. **Types of Tractors**

The THPs have used two makes of tractor; the Massey Ferguson 165 and the Leyland 255. In 1982 with 10 pools and 34 tractors 3 of the pools were equipped entirely with the Leyland tractors, and Leyland tractors have tended to be used to replace the ageing MF165. Thus in 1982 45% of the fleet were Leyland tractors, and some of the "retired" MF165s are used as backups in case of breakdowns.

7. **Equipment**

The majority of the work remained **primary cultivation** with mouldboard ploughs and, transport throughout the year. **Secondary tillage operations** are on the increase but remain a relatively minor part of the work. **Forage maize chopping** was introduced as a farmer service in 1981 and met with "some success". **Grass seeding** and **haymaking** equipment (2 sets) were
TABLE F.1  Histogram showing tractor utilization on a monthly basis throughout the year.
(Based on performance of nine MF 165 tractors in three RDAs [excluding central RDA], for which records were complete 1978/79).

Prodctive Hours P.A.  730  
Total Hours P.A.  1011  
% Productive Time  73%
brought in 1982, to be introduced in two RDAs. These were to be expanded if successful as these occupy a slack time for the THPs in mid/late summer.

8. **Staffing and Management**

Table 2 shows the Management Structure for the Tractor Hire Pools. The system has, by and large, worked efficiently. Responsibilities are well defined, operators and mechanics are reasonably well trained and the objectives are set at realistic levels, ensuring a good workload but not over stretching the resources. After 1979 when the THPs were expanded from 5 to 10 overall efficiency dropped sharply. A clear indication of this drop was a fall in average effective tractor hours per year from 738 in 1979 to 366 in 1981. The % of productive time dropped by 6%, there are several management and staffing lessons to be learnt from this drop.

- **Incentive problems.** Up to 1979 the operators were kept on all year but given generous overtime allowances at peak periods. These allowances were stopped and the operators performance dropped.

- **Diversification of Machines.** Some new pools were equipped with Leyland tractors. These are less reliable than the original MF165 and spares are harder to obtain.

- **Revolving Fund.** THP revenue goes back into a Central Government fund which left them fighting for funds at a time when the first batch of machinery was starting to wear out. There were particular problems with the service vehicles wearing out and resultant falls in maintenance standards of the tractors.

- **Coordinating Management.** Highly competent individuals are needed who are not going to be overstratched. Up to 1979 the efficient Mechanisation Officer and overall RDA Co-Ordinator were able to keep up with events. After 1979 when the number of THP was doubled the Coordinating Management became too rushed to fulfil their roles to full efficiency. Until 1984 the Mechanisation Officer was an
**TABLE F.2**

**THE THP SUBSIDY – RECORDED AND REALISED (EMALANGENI)**

<table>
<thead>
<tr>
<th>Year</th>
<th>Useful Hours</th>
<th>Revenue P.A.</th>
<th>Cost P.A.</th>
<th>Recorded</th>
<th>Realised (1)</th>
<th>Hourly ploughing hire charges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Annual (Cumulative and [%] Subsidy -)</td>
<td>(less depreciation and interest)</td>
<td>Actual (3)</td>
</tr>
<tr>
<td>1974/75</td>
<td>1758</td>
<td>6,154</td>
<td>15,466(2)</td>
<td>- 9,312</td>
<td>8,971</td>
<td>6,495 - 341</td>
</tr>
<tr>
<td>1975/76</td>
<td>4706</td>
<td>20,167</td>
<td>31,372</td>
<td>- 11,205</td>
<td>16,899</td>
<td>14,483 + 5,684 + (5,343) [39%]</td>
</tr>
<tr>
<td>1976/77</td>
<td>6802</td>
<td>39,796</td>
<td>57,461</td>
<td>- 17,665</td>
<td>23,120</td>
<td>34,341 + 5,455 + (10,798) [16%]</td>
</tr>
<tr>
<td>1977/78</td>
<td>8735</td>
<td>52,833</td>
<td>73,679</td>
<td>- 20,846</td>
<td>24,934</td>
<td>48,745 + 4,088 + (14,826) [8%]</td>
</tr>
<tr>
<td>1978/79(7)</td>
<td>9493</td>
<td>66,848</td>
<td>89,559</td>
<td>- 22,711</td>
<td>25,354(6)</td>
<td>64,205 + 2,643 + (17,529) [4%]</td>
</tr>
</tbody>
</table>

(1) i.e. cost to S.G. (omitting donor financing) and assuming the THPs to be a consumptive rather than a continuing service.

(2) Adjusted to allow for the change in the method of accounting for depreciation.

(3) Ploughing only.

(4) Lower hire charge for a hire of 2 or more hours.

(5) Total cost divided by total useful hours.

(6) Approximate figure only.

(7) 17 tractors

(8) 1978/79 increased charges applied for but rejected by Government
expatriate. Swazi nationals had received overseas training in preparation for taking over this role. It is too early to say how they are going to cope with this position.

Record keeping and reporting in general is carried out efficiently throughout the system. Operators record meter hours and the type of job. Detailed individual annual tractor record cards are kept in the THP workshop. On these are recorded the hours of work done, what jobs, fuel and lube costs, maintenance and repair costs (including labour). Monthly reports are sent to the Mechanisation Officer who also makes regular visits to all the pools and has overall responsibility for the operation of the THPs.

Requests for work either came from the farmer going to the THP workshop and making a formal contract, or by contacting the Extension Officer whilst making their rounds.

9. Financial

The THPs are financed by the Swazi Government and all revenues go back into the central government funds. According to Table F.2 the THPs have received a large subsidy. Omitting the first year of operation, this represents a subsidy of 25% - 36% of total costs. If depreciation and interest charges are subtracted from the total costs the THP ran at a profit of between 40% and 4%. In financial terms this might appear quite attractive, especially since much of the capital financing came from foreign aid and it was thought that the THP would only run for the life of the tractors, and so replacement costs did not need to be considered.

In economic terms the THP have not been a success. All costs should be accounted, and when this is done there is a large subsidy. In the short term the farmers gain, paying low hire rates. Ultimately they

1 Relative to public tractor hire schemes in other countries they have been successful in economic terms.
will lose out because Private contractors will not have entered the hire market, and the Government will probably withdraw the THPs when the subsidy becomes too much of a burden.

The last two columns (actual and break even hire charges) in Table F.2 show how the hourly hire rates reflect the overall subsidy. There were repeated recommendations to raise hire rates to economic levels but it was reported (1982) that all requests had been turned down by the Government. This implies there is political pressure to maintain the low subsidised prices which bodes ill for the future of private tractor hire.

10. Economic

In economic terms it is calculated that THP ploughing is less than half the cost of ox ploughing. It may also yield further benefits through increased farm production due to more timely and better cultivations and/or more time for planting. The freed labour should also benefit by finding more productive employment elsewhere in Swaziland or in South Africa.

THP will have a lower economic rate of return than Privately contracted hire services and of farmers using their own tractors. This is because farmers with their own tractors will have a higher annual utilisation, also they do not have to bear the overhead costs of management and administration.

Economic analysis shows that ox power is much cheaper than tractors for all other forms of farm operation other than ploughing. The use of oxen for the non-ploughing tasks should be continued and there may well be scope for refinements that would make their use even more efficient.

11. Performance

An analysis of the 1978/79 figures (see Table F.1) for the three THP's with good records shows the average productive hours per tractor per year as 738. Total hours per tractor were 1,011, giving a figure for % productive time of 73%. This reflects well on the running of the THPs
### TABLE F.3

**THE RDA TRACTOR HIRE POOLS - SOME BASIC INFORMATION (DEMAND)**

<table>
<thead>
<tr>
<th>RDA</th>
<th>THP Started</th>
<th>No.</th>
<th>Type</th>
<th>Revenue Hours Each Year (No. of Tractors)</th>
<th>RDA</th>
<th>No. of Private Tractors</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1979 Tractor Distribution</strong></td>
<td></td>
<td></td>
<td></td>
<td>[Revenue Hours per Tractor]</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>74/75</td>
<td>75/76</td>
<td>76/77</td>
</tr>
<tr>
<td>SOUTHERN</td>
<td>1974</td>
<td>3</td>
<td>MF 165</td>
<td>141 (2)</td>
<td>637 (2)</td>
<td>917 (3)</td>
</tr>
<tr>
<td>NORTHERN</td>
<td>1974</td>
<td>3</td>
<td>MF 165</td>
<td>811 (4)</td>
<td>2042 (4)</td>
<td>1339 (3)</td>
</tr>
<tr>
<td>MAIALANG-ATSIAHA</td>
<td>1974</td>
<td>3</td>
<td>MF 165</td>
<td>399 (3)</td>
<td>695 (3)</td>
<td>776 (3)</td>
</tr>
<tr>
<td>CENTRAL</td>
<td>1976</td>
<td>4</td>
<td>MF 165</td>
<td>- - -</td>
<td>1497 (4)</td>
<td>2038 (4)</td>
</tr>
<tr>
<td>NGWEMPISI</td>
<td>1978</td>
<td>4</td>
<td>LEYLAND 255</td>
<td>- - -</td>
<td>- - -</td>
<td>- - -</td>
</tr>
<tr>
<td><strong>TOTALS:</strong></td>
<td></td>
<td>17</td>
<td></td>
<td>1351</td>
<td>3374</td>
<td>4529</td>
</tr>
</tbody>
</table>

(9) (9) (13) (13) (17)
but a closer look at the same table and also at Table F.3 shows that a large % of this "productive" time is spent on the Rural Development Area's Departmental work. This includes; grading of roads, transporting building materials for infrastructural projects and for demonstration purposes. Table F.3 gives a figure of 438 revenue hours, i.e. directly for farmers. About 210 of these hours (48%) occur in two months, October and November. This demonstrates how much a tractor hire service depends on primary cultivation for its work. It should be remembered that this is the job tractors were originally designed for, and they probably enjoy the greatest comparative advantage in, over other methods of cultivation. Data indicates that tractors are running "light" for part of their working time. This suggests that either operators are not working the machines as hard as they should or that the implements are not well matched to the tractors. Table F.4 gives expected fuel consumption (assuming tractors work an average 40% of maximum rated power) and actual consumption. The practical implication of this is, work rates are probably slightly lower than they should be.

Table F.4: Fuel Consumption
(an indication of efficiency of utilisation)

<table>
<thead>
<tr>
<th></th>
<th>Expected Consumption</th>
<th>Actual Consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>MF 165 (62 HP = 46.2 kW)</td>
<td>46.2</td>
<td>7.5 = 6.16 l/hr</td>
</tr>
<tr>
<td>Leyland 255 (55 HP = 41 kW)</td>
<td>41</td>
<td>7.5 = 5.47 l/hr</td>
</tr>
</tbody>
</table>

1 For the same 3 THP analysed in Table F.1, Southern, Northern and Mahalang-Atsla.
Repair aspects of the organisation are effective. In 1979 all 13 of the original MF165s were still working and in reasonably good conditions after 3 to 5 years. Costs of repairs are about 27% per year of replacement costs of the tractor. Figure F.5 gives a graphic representation of THP cost items per tractor over 5 years. The second graph gives the same breakdown of items as percentage of total costs.

Generally the THPs in Swaziland are fortunate from the point of view of maintenance and repairs. There was a good Mechanisation Officer co-ordinating efforts, mechanics are competent and spares especially for the MF 165 tractors are readily available from South Africa.

From the farmers point of view the technical service provided by the THP is considered to be good but in short supply. This is especially marked in areas where the THP have been established for longer. This implies that the THP have been effective in stimulating demand for hire services but, as yet, unsuccessful in stimulating enough Private contractors to enter the market.

12. Lessons so far and the Future

The THPs have been successful from a technical point of view. Annual utilisation is high, the life of the tractor is long, the economic cost of the main operations (primary cultivation) is cheaper than alternatives, and the technical and managerial staff are good. The high economic subsidy (including depreciation of capital) and the fact that demand for hire services is not being met by private services shows that the primary objectives have not been met. These were; to run THP for about 6 years (the expected life of a tractor), to demonstrate the potential of tractorised operations, create surplus demand and stimulate private hire services. The main lesson to be learnt from this is that if a service is intended to be economically viable then realistic charges should be introduced from an early stage. The longer the subsidised rates are maintained the harder it is to lift the subsidy due to political pressures from the farmers.
TABLE F.5: THP Costs 1974/75 to 1978/79
Low charges are not the only reason that demand for the services exceeds supply. There are valid explanations for this response from the farmers. The economic rate of ploughing by tractor is about half that of ox-ploughing. Ploughing is a job done, for the most part, by the males. There are good off-farm employment opportunities and the opportunity to hire tractors for ploughing allows more males to take these jobs and send money back to the homesteads for the ploughing.

Annual utilisation of the tractors has been high but 40% of this time is on department work. It is doubtful if a private tractor owner would be able to find this much extra work to keep his machine busy over the year. The economic viability of tractors is closely linked to annual utilisation. It would be helpful if more work outside of the Oct/Nov ploughing period could be found. Possibilities that have been suggested are earlier ploughing using chisel ploughs, hay making, forage harvesting of maize and more secondary cultivation.

Finally, the THP's have shown the wisdom of having small pools with a restricted physical area of operations. It makes life easier for both the farmers and the tractor pools to rationalise operations.
Introduction

With large areas of potentially cultivable land and low population densities Sudan appears to offer good scope for agricultural mechanization. Furthermore, most of the best soils are heavy clays, so a high power input is needed if cultivation is to be extended. There is an established history of mechanization. For example, the Sudan Gezira Board (established in 1950), has provided a cultivation service through its "Ploughs Section" to tenant farmers on the scheme. It has achieved high annual machine utilization, made possible by large geometrically shaped fields, firm central management, and good tractor maintenance. Various other government or parastatal organisations have provided tractor hire services, commonly as part of land settlement schemes aimed at expanding the area of cultivation and, following the Gezira pattern, retaining strong central control over farming practices and cropping patterns. This case study examines one such scheme - that run by the Nuba Mountains Agricultural Production Corporation.

1. Physical Background

The Nuba Mountains Region covers about 5.8 million ha. of which about 50%, the predominantly clay plains, is suitable for extensive mechanized cultivation. Less than 10% is mechanized at present. The area consists of gently undulating or almost flat plains with outcrops of granite hills. The natural vegetation is open tree or shrub savannah with sparser trees where land has been cultivated.

The predominant soils are dark, cracking clays or Vertisols. These develop deep vertical fissures when they dry out, but when it rains these soon fill up, and the soils become sticky and virtually impermeable. Cultivation has to be performed within a very limited period. Before the initial rains the soils are too dry, and after much rainfall they become so wet that machines get bogged down.

Almost all the annual rainfall comes in the khareef season (June to September, peaking in August), and annual totals range from about 500 to 800 mm. The start of the rains varies between years by several weeks.
2. **Human Background**

Precise population figures are not known, but the area is clearly very sparsely populated. It is mainly rural, but with out-migration to the towns and to other parts of Sudan. A relatively small proportion of the rural population consists of nomadic pastoralists, but most are cultivators, practicing shifting cultivation, and achieving very poor yields with low input systems. The average holding among traditional farmers is 3 to 5 acres per family, limited by the area that can be cultivated and weeded manually.

3. **Farming Systems**

The main traditional farming system is rainfed bush-fallow. Cultivation normally occurs for 3 to 5 years before land is left fallow, but no particular crop rotation is followed. Sorghum, sesame, and cotton are the most commonly grown crops. Traditionally sorghum has been the subsistence crop and cotton has been grown as a cash crop, but increasingly, sorghum is also marketed as a cash crop. Some intercropping is practical as a hedge against crop failure.

For the first year that newly cleared or fallowed land is cultivated, dead grasses, timber, etc. are burnt off when the first flush of weeds has appeared, so as to kill off the weed growth. In subsequent years little land preparation work is carried out other than light weeding.

4. **Draught Power**

Ox cultivation is not traditional in the area, though some research work is now being carried out into the possibility of expanding it. There are obvious attractions to the use of mechanised cultivation in a land abundant/labour scarce situation, so as to increase the area cultivated and the output per person. The short period within which cultivation must be performed is a further spur to mechanization. This is especially true if cotton is grown, as the time of planting is critical.

5. **Background to the Machinery Hire Scheme**

The Nuba Mountains Agricultural Production Corporation was established as a public corporation in 1970, and is responsible to the Minister of
Agriculture. Its objectives are to administer aspects of agricultural production in the Nuba Mountain Region, and encourage the mechanization of the traditional smallholder sector by introducing mechanization and other new technologies. One of its main aims is to raise cotton production, and it provides seed, pest control, and processing and marketing facilities. To try and achieve this, it started "Smallholder Tenant Schemes" in 1970-71, under which blocks of land of 500 to 1000 acres were to be developed by mechanized cultivation and allocated to smallholders in plots of 5 to 10 acres each. The NMAPC provided the cultivation service, determined the crops to be grown and practices to be followed, and supplied the necessary inputs, subtracting payment from the money due to the farmer when the crop was marketed, so a tractor hire service was initiated to perform cultivations on the newly established schemes.

The objectives of the THS were therefore:

1) To increase the area under cultivation, especially of cotton, beyond that which could be prepared by hand.

2) To raise yields through better land preparation

3) To consolidate scattered holdings, and so improve the provision of agricultural and social services

The area cultivated and the number of schemes operating from 1970-71 to 1980-81 are shown in Table G1. The typical scheme consists of 1500 to 2000 acres of cleared land, of which 900 to 1400 acres are cultivated each season. The number of participants ranges from about 150 to 200.

Farmers from a village or area may decide they want a scheme in the area, and after obtaining the agreement of NMAPC they have to select a committee from participating farmers. The committee then organises the clearing of an area (usually at least 1500 acres) and allocates land within the scheme according to labour inputs for clearing, and bearing in mind historic land rights. The standard allocation is 10 acres: 5 acres of cotton and 5 acres of sorghum. In practice, there is a wide range of holding sizes, and farmers vary the proportions of the two main crops.
TABLE G.1 : NMA PC Smallholder Tenant Schemes and Areas Cultivated (acres)

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Schemes</th>
<th>Area of Cotton</th>
<th>Area of Sorghum</th>
<th>Total Area Cultivated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>18</td>
<td>12553</td>
<td>15420</td>
<td>27973</td>
</tr>
<tr>
<td>1971-72</td>
<td>23</td>
<td>19497</td>
<td>20312</td>
<td>39809</td>
</tr>
<tr>
<td>1972-73</td>
<td>22</td>
<td>19596</td>
<td>20609</td>
<td>40205</td>
</tr>
<tr>
<td>1973-74</td>
<td>21</td>
<td>12973</td>
<td>11021</td>
<td>23994</td>
</tr>
<tr>
<td>1974-75</td>
<td>3</td>
<td>5931</td>
<td>2249</td>
<td>8179</td>
</tr>
<tr>
<td>1975-76</td>
<td>19</td>
<td>22957</td>
<td>21128</td>
<td>44084</td>
</tr>
<tr>
<td>1976-77</td>
<td>47</td>
<td>41119</td>
<td>11540</td>
<td>52659</td>
</tr>
<tr>
<td>1977-78</td>
<td>63</td>
<td>57552</td>
<td>22981</td>
<td>80533</td>
</tr>
<tr>
<td>1978-79</td>
<td>61</td>
<td>56539</td>
<td>29801</td>
<td>86340</td>
</tr>
<tr>
<td>1979-80</td>
<td>62</td>
<td>32446</td>
<td>31556</td>
<td>64001</td>
</tr>
<tr>
<td>1980-81</td>
<td>62</td>
<td>55921</td>
<td>35831</td>
<td>91752</td>
</tr>
</tbody>
</table>
NMAPC inspect the clearing of the site and appoint a site supervisor who acts as the Corporation's representative within the scheme. He agrees to the cultivation programme with the Committee, and should enforce the cultivation programme laid down by NMAPC. In exchange for free cotton seeds, pesticides, ginning and marketing, and very low cost cultivation, the farmer agrees to:

1) sow cotton and sorghum on the plots designated
2) weed plots as necessary
3) assist in spraying for cotton pests
4) pick and harvest crops when mature
5) transport seed cotton to nearest buying centre
6) eradicate cotton stalks.

In practice, these conditions cannot be enforced, and farmers frequently neglect their crop allocation. Many of them live far from the scheme, and have cultivated land in their home area, and this may take priority over the scheme land.

6. Equipment and Operations

The mechanization service uses 70-80 hp wheeled tractors with wide level discs. These consist of four independently mounted gangs of 6 discs each, with an overall width of about 4 m, and are the standard cultivation implement on the clay plains of Sudan. They are simple and robust, relatively unaffected by stumps and roots, and capable of quick cultivation. Seeder attachments are also available, and some trailers are used for transport work. The number of tractors operated by the scheme in different years is shown in Table G2.
### TABLE G.2: Numbers of Operational Tractors

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Tractors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>62</td>
</tr>
<tr>
<td>1971-72</td>
<td>56</td>
</tr>
<tr>
<td>1972-73</td>
<td>39</td>
</tr>
<tr>
<td>1973-74</td>
<td>26</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1975-76</td>
<td>49</td>
</tr>
<tr>
<td>1976-77</td>
<td>89</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1980-81</td>
<td>154</td>
</tr>
<tr>
<td>1981-82</td>
<td>149</td>
</tr>
</tbody>
</table>

There are 5 different makes of tractors in use, and 3 makes of disc harrow. Attempts have been made to keep machines of one particular make based in the same area so as to facilitate repairs and spares provision.

The normal pattern of cultivation is one pass with the wide-level discs, and then usually hand seeding. (Alternatively, seeding can be done by a seeder attachment to the discs). A second discing may be carried out to cover over the seeds. Weeding and harvesting are performed manually except for thrashing which is occasionally mechanized.

The suitability of wide-level discs has been debated, as it is feared that continued shallow cultivation may lead to the development of a pan, and to weed build-up which reduces yields. They are also difficult to transport on poor country roads, maybe needing to be dismantled and moved by truck if they are damaged and require repair. However, no completely satisfactory alternative has emerged.

### 7. Staffing and Management

The mechanized cultivation operations form a separate department of NMAPC under the management of a Senior Agricultural Engineer. The staff was about 220 in 1980, excluding the workshop staff who came under a different department. There were about 70 workshop staff who were
responsible for maintenance and repair of the transport fleet as well as tractors. Salary scales are slightly higher than those in central government, and overtime payments are available to field staff, but the difficult working environment results in a high staff turnover.

Some of the mechanics are experienced and well able to carry out repairs with limited facilities, but their numbers are inadequate. About 70% of the tractor operators are only hired seasonally, and have very poor driving and mechanical skills. They are usually recruited too late to be given adequate training before the season starts. The better ones may be kept on and given basic mechanical training so they can work as fitters. More commonly, however, operators do more harm than good when they try to repair their machines.

There is a main workshop at Kadugli, and three other service stations where minor repairs can be carried out. Tractors are dispatched to the cultivation schemes at the start of the season, but cultivation is commonly delayed until well after the optimum date because of poor organisation. Cultivation schedules are not agreed in advance between the NMAPC supervisor and the farmer committees, and the discs (which are left at the schemes) may require repairs before work can start. Thus valuable days are lost during the short cultivation season. Farmers are informed at least 2 days in advance when cultivation of their land will occur, but most of them are not present at the time. It seems that work is often done first on the plots of scheme committee members and their relatives and friends, and this means that the sequence of discing may be extremely haphazard.

8. Financial

No separate accounts are maintained for the different activities of the NMAPC, so it is not possible to examine the financial performance of the tractor hire scheme. The Corporation as a whole makes large losses: revenue in 1980/81 was anticipated to be only about 15% of budgeted expenditure.

Calculations have been made of the cost of providing the mechanized cultivation service, and have shown that they are at a similar level to those of private large-scale farmers and similar to the charges made by private contractors. However, the level of charges for the NMAPC service is about 1/3 of the costs per acre cultivated. This might not be
important if the Corporation can recoup its costs through the purchase at fixed prices of the cotton crop, but it nevertheless reduces the incentive for the farmer to attend to his crop and try to ensure good yields (e.g. by careful weeding).

9. Performance

**TABLE G.3: Acres cultivated per operational tractor, 1970-81**

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres disced</th>
<th>No. of operational tractors</th>
<th>Acres disced per tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970-71</td>
<td>27973</td>
<td>62</td>
<td>451</td>
</tr>
<tr>
<td>1971-72</td>
<td>39809</td>
<td>56</td>
<td>711</td>
</tr>
<tr>
<td>1972-73</td>
<td>40205</td>
<td>39</td>
<td>1031</td>
</tr>
<tr>
<td>1973-74</td>
<td>23994</td>
<td>26</td>
<td>923</td>
</tr>
<tr>
<td>1975-76</td>
<td>44084</td>
<td>49</td>
<td>900</td>
</tr>
<tr>
<td>1976-77</td>
<td>52659</td>
<td>89</td>
<td>592</td>
</tr>
<tr>
<td>1979-80</td>
<td>-</td>
<td>-</td>
<td>1014</td>
</tr>
<tr>
<td>1980-81</td>
<td>91752</td>
<td>154</td>
<td>596</td>
</tr>
</tbody>
</table>

Average 629

Discing should be a very quick operation, and two operators are allocated to each tractor so that high daily work rates (including night-time working) can be achieved. With large blocks of consolidated cultivation, down-time should be minimised. Most tractor hour meters are broken, but supervisor's records show levels of performance which are far below what should be attainable. The average number of working hours per tractor in 1979/80 was reported to be only 171, plus 221 unproductive hours per tractor (travelling time etc.). The average rate of work was about 6 acres per hour. Assuming a working season of 8 weeks and a 6-day week, this represents only about 3.6 hours per day on average. Table G.3 shows that the average area discing per operational tractor since 1970 has been only 629 acres. If machines achieved 6 acres per hour and 10 hours per day, this would be only about 10 days work!
The reasons for poor performance include poor driver ability, (some tractors are driven, unofficially, by young boys), poor field clearance, small plots (5-10 acres), and, in some cases, small over-all scheme size.

However, the main reason for the poor annual utilisation is that the potential working season is short and there are commonly serious delays at the start of the season before tractors actually start work. These are mainly due to poor organisation and planning of tractor allocations, including protracted discussions between scheme committees and the NMAPC supervisors. Machines may be late arriving due to breakdowns and delays in repairing them. With a maximum cultivation season of only 8 to 10 weeks, it is clearly important that machines are ready to start work as soon as conditions permit, yet delays of a month or so are reportedly common.

10. Repairs and Maintenance

Major repairs are carried out at the main NMAPC workshop in Kadugli, and smaller jobs at the 3 service centres which have their own small workshops and stores. Routine maintenance and minor repairs can be undertaken in the field by service teams, consisting of mechanic, assistant mechanic and fitter, each of which is responsible for about 14 tractors. Tractors should not be more than about 1 hour's drive from a service team. Though teams appear to work conscientiously, it has been suggested that they spend too long on minor repair jobs during the season when tractors ought to continue working.

The Kadugli workshop has been extended and re-equipped under a British Aid project, and now has the facilities required to support and overhaul the tractor fleet. In addition to improving the hardware, considerable improvements have been made to stores and workshop procedures and recording. Tractor service schedules have been introduced (systematic servicing based on machine hours or months). Improvements have been made in the planning of spares purchases, but shortages of spare parts continue to cause problems. This is partly because Government tractor purchases are commonly made direct from the manufacturer, by-passing the local dealer who is then reluctant to provide a good spares backup.
As a result of improved repair facilities and reasonable levels of mechanical competence, tractor breakdowns have been less of a problem than in some other schemes. Breakdowns of the wide-level discs have, however, caused serious delays, partly because of the rough conditions in which they work, partly because of inaccessibility and transport problems, and partly just because repair of the implements is neglected until the season begins.

11. Alternative Machinery Hire Services

There are many large private farms in Sudan which have their own tractors, and in some locations (notably the Gezira) private contracting services are well developed. However, in Nuba Mountains Region there are very few contractors, and the large-farm sector is small. There are large-scale tenant farms and State farms run by the Mechanized Farming Corporation, totalling about 350,000 acres. The MFC has also organised cooperative schemes, but it proved difficult to make the cooperative groups accountable for the tractors and implements and other advances made to them. Many of the tenants on MFC tenant farms are prosperous merchants who employ managers to run their farms. Holdings average around 1000 acres, and loans are available for machinery purchase. However, the problems experienced are similar to those faced on the NMAFP schemes: planting is often late, labour is scarce for weeding and harvesting, and there is a gradual build-up in the weed population.

Conclusions

The NMAFP smallholder tenant schemes offer the potential for high machine utilization and good returns to mechanization. With large and well laid out areas, it should be possible to cultivate across individual holding boundaries and achieve high work rates. The quality of workshop staff and repair facilities are quite good by the standards of developing countries.

On the other hand, there are physical constraints on efficient tractor use. Machines have to work considerable distances from the workshops, and travelling conditions are extremely difficult. The cultivation season is very short as a result of soil conditions and rainfall patterns.
However, it seems not to have been the physical problems which have been the main constraints on the efficiency of the scheme. Management has been poor, and so cultivation programmes have been delayed, and valuable working time lost. Preparation of tractors and implements in advance of the cultivation season has been inadequate. Scheduling of tractor operations within schemes has been poor. Finally, the schemes have been linked to encouraging the cultivation of cotton which has been less economically attractive to farmers than sorghum in recent years, and this has reduced the commitment of farmers to plant weed, and harvest their plots at the correct times.
1. Introduction

The first tractors were imported to Uganda in the 1920s, but it was only after World War II, when great efforts were made to raise crop production, that the government became involved in tractor cultivation. From 1948, the first small contract hire services were set up, initially around government farms. Mechanisation came under the "Special Development Section" of the MoA, and was seen as an educational and advisory service which was worthy of subsidy. Gradually, contract hire services were set up in new areas and on some settlement schemes. Other bodies were also involved in providing mechanisation services, e.g. the Cotton Corporation and the Tobacco Board.

The tractor hire service expanded rapidly, largely under the impetus of the Group Farming Project. This was designed to bring local farmers together into groups so that their contiguous individual plots could be cultivated as a single unit. The scheme seems to have been motivated by political pressures to "modernise" farming, and to have disregarded the inappropriateness and unpopularity of the method chosen. It was terminated in 1969.

It is not known what became of the tractors during the 1970s, but presumably with the political upheavals in the country the service was entirely run-down. In the last couple of years tractors have once again been provided through foreign aid. It is noticeable that one of the most successful of such projects has involved the sale of tractors to individual operators who have achieved much better rates of utilisation than obtained under government-run schemes in the past.

2. Equipment

Table H.1 gives the numbers of tractors hired out under the SDS and Group Farming schemes (most Group Farm tractors did much contract work outside the Group Farms). It shows clearly the acceleration in the scale of operations in the mid-1960s. Almost all were wheeled tractors, as early experience with tracked machines showed them to be insufficiently mobile for contract work. The fleet was mixed (11 models from 6 different manufacturers in 1968), and it was not possible to allocate just one make to each district because of differences in horsepower. In fact
TABLE H.1: Tractor Numbers and Performance, S.D.S. and Group Farm Tractors 1948-68

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of Tractors</th>
<th>Total Hours Worked</th>
<th>Total Acreage Cultivated</th>
<th>Hours per Tractor</th>
<th>Acres per Tractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1948</td>
<td>1</td>
<td>NA</td>
<td>NA</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1949</td>
<td>7</td>
<td>NA</td>
<td>NA</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1950</td>
<td>17</td>
<td>7,300</td>
<td>2,300</td>
<td>429</td>
<td>135</td>
</tr>
<tr>
<td>1951</td>
<td>29</td>
<td>9,900</td>
<td>4,500</td>
<td>340</td>
<td>154</td>
</tr>
<tr>
<td>1952</td>
<td>40</td>
<td>13,100</td>
<td>4,600</td>
<td>327</td>
<td>115</td>
</tr>
<tr>
<td>1953</td>
<td>79</td>
<td>20,100</td>
<td>6,900</td>
<td>254</td>
<td>87</td>
</tr>
<tr>
<td>1954</td>
<td>47</td>
<td>17,300</td>
<td>5,700</td>
<td>368</td>
<td>121</td>
</tr>
<tr>
<td>1955</td>
<td>41 (Est)</td>
<td>19,600</td>
<td>6,100</td>
<td>479</td>
<td>148</td>
</tr>
<tr>
<td>1956</td>
<td>35</td>
<td>17,300</td>
<td>5,500</td>
<td>494</td>
<td>158</td>
</tr>
<tr>
<td>1957</td>
<td>39</td>
<td>20,800</td>
<td>6,200</td>
<td>532</td>
<td>158</td>
</tr>
<tr>
<td>1958</td>
<td>44</td>
<td>21,500</td>
<td>7,700</td>
<td>490</td>
<td>176</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1962</td>
<td>35</td>
<td>12,600</td>
<td>6,400</td>
<td>361</td>
<td>183</td>
</tr>
<tr>
<td>1963</td>
<td>44</td>
<td>22,600</td>
<td>10,900</td>
<td>514</td>
<td>249</td>
</tr>
<tr>
<td>1964</td>
<td>245</td>
<td>56,800</td>
<td>35,000</td>
<td>232</td>
<td>141</td>
</tr>
<tr>
<td>1965</td>
<td>341</td>
<td>119,500</td>
<td>81,000</td>
<td>350</td>
<td>237</td>
</tr>
<tr>
<td>1966</td>
<td>489</td>
<td>151,400</td>
<td>103,800</td>
<td>310</td>
<td>212</td>
</tr>
<tr>
<td>1967</td>
<td>651</td>
<td>159,200</td>
<td>93,800</td>
<td>245</td>
<td>144</td>
</tr>
<tr>
<td>1968</td>
<td>703</td>
<td>180,000</td>
<td>99,000</td>
<td>256</td>
<td>149</td>
</tr>
</tbody>
</table>

1 Hours worked on hire
the projects had too many low horsepower tractors which were unsuitable for cultivation work. By the late 1960s there was clearly surplus tractor capacity.

TABLE H.2: Breakdown of THS work by operation (1968)

<table>
<thead>
<tr>
<th>Operation</th>
<th>% of acres worked</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Ploughing</td>
<td>41.9</td>
</tr>
<tr>
<td>Second Ploughing</td>
<td>29.5</td>
</tr>
<tr>
<td>Discing</td>
<td>9.4</td>
</tr>
<tr>
<td>Slashing</td>
<td>5.9</td>
</tr>
<tr>
<td>Planting</td>
<td>4.3</td>
</tr>
<tr>
<td>Spraying</td>
<td>2.8</td>
</tr>
<tr>
<td>Rotavating</td>
<td>2.4</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>3.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Ploughing makes up over 70% of the total work (by area). Although a variety of other implements are used they are not so well known by farmers, so advertising and demonstrations would be needed to raise utilisation. Average rates of work for the main operations were:

- First Ploughing: 1.7 hours per acre
- Second ploughing: 1.6 hours per acre
- Discing: 1.05 hours per acre

3. **Performance**

Hours worked and acres cultivated each year, for the whole fleet and per tractor, are given in Table H.1. The average number of actual revenue earning hours per tractor over the whole period was 374 p.a., and the average number of acres cultivated per tractor was 160 p.a. Figures for 1968 show that 65% of all meter hours were revenue earning, 22% were spent in travelling, preparing for work etc., and 13% were "departmental hours" i.e. carrying out work for the DoA including haulage, collection of spares and fuel etc.
Under Ugandan conditions, it should be possible to achieve much higher utilisation. In much of the country, tractors can work for two seasons as there are second rains. So the season varies from 5 to 9 months in different areas. The low output figures are partly a result of poor management: machines not ready to start work at the beginning of the season, delays in taking payment for work, poor scheduling of tractors. Also there is a high proportion of small plots, about 85% being less than 2 acres.

However, the main constraint on utilisation was probably the limited level of demand. Although farmers were initially enthusiastic to use tractor hire, it became clear that by mechanising cultivation and planting only, the major labour bottlenecks for weeding and harvesting became more pronounced. The effect of tractor hire was therefore to reduce the input of manual labour for cultivation, but with little increase in crop acreage or yields.

4. Financial

TABLE H.3 : Revenue and Expenditure figures for Mechanised Cultivation in Uganda ('000 U.Sh.)

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenue</th>
<th>Expenditure</th>
<th>Deficit</th>
<th>Revenue % of Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947-53</td>
<td>70</td>
<td>399</td>
<td>329</td>
<td>18</td>
</tr>
<tr>
<td>1954-63</td>
<td>305</td>
<td>688</td>
<td>389</td>
<td>44</td>
</tr>
<tr>
<td>1964</td>
<td>1460</td>
<td>2612</td>
<td>1152</td>
<td>56</td>
</tr>
<tr>
<td>1965</td>
<td>2028</td>
<td>6114</td>
<td>4086</td>
<td>33</td>
</tr>
<tr>
<td>1966</td>
<td>3004</td>
<td>9416</td>
<td>6412</td>
<td>32</td>
</tr>
<tr>
<td>1967</td>
<td>3820</td>
<td>13500</td>
<td>9680</td>
<td>28</td>
</tr>
<tr>
<td>1968</td>
<td>4240</td>
<td>13059</td>
<td>8819</td>
<td>32</td>
</tr>
</tbody>
</table>

The above figures show the extent of the subsidy on tractor hire. Attempts were made in the late 1950s and early 1960s to raise charges more nearly in line with costs, but this was later reversed. In 1966 and 1967 the mechanised cultivation schemes absorbed 75% of the DoA's development budget, as well as large amounts of foreign aid funds. Some further returns could have been obtained via government purchases of cotton at prices below world levels, but as no significant increase in acreage occurred this cannot be assumed.
Some work was done on credit, but about 90% was paid for in cash. The scheme probably had adverse distributional effects. In order to hire a tractor, a farmer needed either ready cash or proof of credit worthiness (collateral, such as land, cattle, house), and clearly this favoured the well off.

Government accounting procedures were inadequate for the management of such a large operation, e.g. vote heads were too general for budgeting purposes.

A breakdown of the costs of tractor operation is given in Table H.4

**TABLE H.4: Breakdown of Costs of Tractor Hire Service (1967)**

<table>
<thead>
<tr>
<th></th>
<th>% of total costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel and Oil</td>
<td>14.2</td>
</tr>
<tr>
<td>Mechanics and Workshop</td>
<td>10.3</td>
</tr>
<tr>
<td>Spares and Repairs</td>
<td>12.9</td>
</tr>
<tr>
<td>Drivers Wages</td>
<td>13.6</td>
</tr>
<tr>
<td>Supervision</td>
<td>18.2</td>
</tr>
<tr>
<td>Plot measurers</td>
<td>3.6</td>
</tr>
<tr>
<td>Clerical</td>
<td>5.7</td>
</tr>
<tr>
<td>Transport</td>
<td>3.8</td>
</tr>
<tr>
<td>Depreciation</td>
<td>17.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

5. **Conclusions**

The government hire service in Uganda in the 1960s was one of the largest in any developing country. In spite of reasonable levels of management, dealer backup and infrastructural support, and potentially fairly long working seasons, the average number of productive hours per tractor was still only around 250 hours at this time. The main reason for this was the concentration of mechanisation at the time of cultivation and planting, which appear not to have been the critical constraints on the acreage cropped. The expansion of the service seems to have arisen from the political objective of "modernising"
agriculture rather than an understanding of the needs of the farming system. The decision in the early stages of the service to subsidise it for demonstration and educational reasons was not reversed as the scale of the scheme expanded, so that the drain on government finances became unacceptably great.

A recent tractor project in which machines were sold on credit to farmers has resulted in much higher utilisation, most machines achieving between 800 and 1500 hours in their first year. This may reflect shortages of draught power and transport resulting from the disturbances as well as the better incentives of individual ownership.
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