EVALUATION AND PREDICTION OF SOME AGRICULTURAL MACHINERY OPERATIONS' COSTS UNDER IRRIGATED CONDITIONS

BY

ISMAEL ABDELAH M. ALLA
B.Sc. (Agric.) 1980
University of Al Mansoura (Egypt)

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SUMMARY

This study was carried out at irrigated schemes in Geniva, Bahad and New Nolfa which represent large, medium and small schemes in the Sudan, respectively, with the objective of evaluating and determining the costs of disc plowing, harrowing, dry ridging and harvest operations for wheat and dura under irrigation conditions in the Sudan.

The calculated costs were compared with the current charges for these operations in each scheme.

The machines studied were 3-bottom (Parariler) standard disc plows, 22 blades (Tower - Stemigal International) off-set disc harrows and (H50, Hardy 157 70) 4 body ridges.

The power units used for the above machines were 200 wheeled tractors (65-85 hp) which included 185-205-290, International 745-8 Case International 605 and Ford 6610 tractors.

Combine harvesters investigated were Claas D. 63 and H. 75 (103-105 hp) which are used for both direct combining of wheat and stationary threshing of dura in the Sudan.

The operations costs were obtained by determining ownership costs, operating costs, total costs and effective field capacity of each machine.

The results showed that in the three schemes disc plowing was the most expensive operation, followed by harrowing and then dry ridging which was found to be the least operation in cost. This result agrees with current charges for these operations in the schemes.
It was found that there were marginal differences in costs for the same tillage operation from one scheme to another. The results also showed that there were variations between the operations' costs calculated in this study and the existing charges for these operations in the three schemes. The pattern of variation is not systematic.

The results showed that the cost of direct combining of wheat was higher than stationary threshing of durra. The results also showed that calculated costs of direct combining of wheat and stationary threshing of durra were both lower than the existing estimated charges for these operations in the schemes.
التعليمية

نظرة على هذه الدراسة: تحدثت هذه الدراسة عن العلاقات العرقي - العرقية في السودان، وهي تتناول بعض الدراسات المتميزة والتحليلات المعمقة.

وبدأت الدراسة بتحليل الصور الصادرة عن السودان، وذاتي بتحقيق تحليلات علمية، وتقييم تحليلات علمية. تناولت الدراسة النماذج المختلفة، ووضعت الجداول النهائية لدراسة تحليلات النواحي المختلفة.

التعليمية والأدبية: أثبتت هذه الدراسة أن العلاقات العرقي - العرقية في السودان، تشعر بالعديد من التحديات.

التعليمات النهائية: لكي يتمكن التحليلات العلمية في هذا المجال، فإن العوامل النفسية، والتعليمية، والتعليمية被判 فعليًا.
صل كلفة 500 هذا الترقيم يتماشى مع الأسماء العملية لهذه التعليقات في هذه الملاحظ.

وجعلت النماذج وضوحية في الكتلة في النص المقطع حيث أن هذه الكتلة ضيوف للنحو كما أن النشاط الناجح أو هدفه يشير بين التكاليف المجمعة والتنقيح الناجح لعوامل التعليقات في المشاريع التالية.

وأظهرت النماذج أن عملية إعداد المنشور الناجح أكثر كفاءة من النشاط الناجح للنحو كما أن المنشور الناجح أو النشاط المجمعة للعوامل الناجحة للنحو والتحديات الناجحة للنحو كما أن النشاط الناجح أو النشاط الناجح للنحو.
Chapter I

Landscape preparation and harvest operations are supposed to consume more energy and described as the most costly operations in agricultural production.

Cost determination for different agricultural machines' operations in all schemes in the country are based on assumptions for many parameters contributing to the total cost of a machine, e.g. interest, taxes, insurance, housing, repair rates... etc.

The data used currently for estimating machine operation cost are mainly established abroad and may not be applicable in the Sudan. There are variations between different countries in the standard of knowledge, experience gained, agricultural policy and level of machinery and petrol prices.

Managers and decision-makers in the Sudan always find difficulties in determining the cost of farm machinery operation, because of the rapid changes in the local prices of machines, spare parts, fuel and labour costs. The costs are often of historical interest in only few years.

Therefore, the costs should be checked and revised every now and then in accordance with the experience gained and to up-date available data. etc.

The objectives of this study (1) to investigate the present data used in determining the cost of different agricultural operations and (2) to compare the current charges adopted by different agricultural firms and what had been reported in the literature with costs calculated in this
study using the standard methods widely used in the world. The suitability of the application of foreign data for parameters affecting the cost of operation (insurance, taxes, housing, interest repair and maintenance ... etc.) in the country will also be evaluated.

Different sites in Gezira, Bahada and New Halfa schemes were chosen for this study. Three tillage operations were studied namely, plowing, harrowing and dry ridging while two harvesting operations were chosen namely, stationary threshing of durra and direct combining of wheat. Parameters investigated were ownership costs, operating costs, total hourly costs and field capacity in feddan per hour or ton per hour for each machine.

The data were collected from record, personal contact and interviews with responsible personnel.

The data collected were machine make, model, age, price, annual use, economic life, scrap value, field capacity per hour, ownership costs (interest, taxes, insurance and housing) and operating costs (annual repair cost, labour charge, fuel, oil and lubricant consumption).

In each scheme and for each operation machines were divided into groups according to age. The hourly average ownership cost, operating cost and total cost of each group were calculated. The overall average hourly total costs for all groups were obtained. The average field capacity in feddan per hour or ton per hour for each operation was calculated and then each operation cost was determined.
CHAPTER II
LITERATURE REVIEW

2.1 Background

S.P. Fothergill (1965) reported that steam tuggers were in fact introduced into the Gezira from 1930's and later were replaced by diesel engines to operate wheeled and crawler tractors.

Kashim et al. (1986) reported that wheeled tractors were first introduced in Sudan in 1944, with limited number of tractors to grow data for soldiers consumption during WWII.

N.W. Scott (1967) found that 38% of the private tractor owners in the Gezira were possessing tool bars, while in the rain-fed areas every tractor equipped with a wide level disc with a seed box. Also, he found that disc plows were used at Basem al Gish in to break up virgin soil and were used for weed control in the Northern provinces.

Mahmoud et al. (1965) stated that determination of the best size and type of field equipment for any operation involves consideration of such factors as the total area, the total time available, the capacity of the machine, climatic fluctuations, scheduling efficiency, and the over all cost of performing the operation.

N.W. Scott (1967) reported that in 1964 four manufacturers of combines harvester employed 20 combines for harvesting 21,000 feddans of tenants' wheat in the Gezira Scheme.

Gezira Board reported in 1983 that 250 combines of different makes were contributing in wheat harvesting of 250,000 feddans in the scheme.
Kepner et al (1972) stated that the four basic operations performed by a combine in recovering the seed are:

1. Cutting or picking from the row and conveying the material to the threshing mechanism.

2. Threshing (detachment of individual seeds from the supporting parts of the plant).

3. Separating the seed and chaff from the straw.

4. Cleaning the chaff and other debris from the seed.

Mahmoud et al (1976) reported that the possibility of using combine harvester for the stationary threshing of dura had been investigated and tried by both the village farming experience and the Beards' Agricultural Engineering department who recommended that, under controlled supervision and management wheat combines can be quite profitable for stationary threshing of dura.

Stapleton and Hixson (1974) established information to help in costs' estimation, management and selection of farm machinery. They provided lists of fixed and repair costs for agricultural machinery used in Arizona.

2.2 Machine Life

Hunt (1979) defined the economic life of the machine as the length of time from the purchase of the machine to that point where it is more economic to replace by a new machine than to continue with
repairing the first. At this time the machine still have considerable service life but will become uneconomic because of high rate of repair costs, technological obsolescence or change in the farm enterprise.

J.B. Alchey (1961) reported that the useful life of a machine depends on:

1. Mechanical deterioration or wear as affected by:
   (a) amount of use (b) operating conditions (c) care by the operator.

2. Obsolescence as affected by:
   (a) Increased efficiency of new machines (b) Development of new method to carry out the job.

Jalpiss (1975) stated that the useful life of a machine can be determined approximately by means of broadly based surveys covering machines recently scrapped or partly worn out. Such surveys must be reasonably up to date, since machines are being continuously improved. He reported that a study in the United States showed that the annual use of machinery in the late 1950’s had become appreciably less than it had been for similar machines ten or fifteen years earlier.

Lonnemark (1967) reported that in developing countries there are some conditions which tend to prolong the useful life of machinery. Lack of capital, and perhaps foreign currency for the purchase of new machines and low wages of labour in repairing and maintaining machines
are reasons for continuing to repair and use machines beyond their economic lives.

Hust (1979) reported that the USA year book gives expected wear-out lives to be as follows:

- Tractors: 12000 hrs
- Tillage machines: 5000 hrs
- Harvester: 2000 hrs
- Seeders: 1200 hrs

Naumou et al. (1976) estimated the economic lives and annual use of machines in the Sena Scheme as follows:

<table>
<thead>
<tr>
<th>Economic life (hrs)</th>
<th>Annual use (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Durra and wheat combines</td>
<td>8</td>
</tr>
<tr>
<td>Wheel tractors</td>
<td>8</td>
</tr>
<tr>
<td>Ridge s</td>
<td>6</td>
</tr>
<tr>
<td>Disc plow</td>
<td>3</td>
</tr>
<tr>
<td>Disc harrow</td>
<td>8</td>
</tr>
</tbody>
</table>

### 2.3 Cost Factors

Machinery costs are divided into two categories, ownership costs and operating costs. The cost of owning and operating farm machinery continue to gain importance because of higher machinery prices, higher rates of interest, higher costs of repair and maintenance and difficulty in forecasting prices of agricultural products.

#### 2.3.1 Ownership Costs

Ownership costs are fixed costs which are independent of the amount of use of the machines. They cover items such as depreciation
interest, taxes, insurance and shelter or housing.

2.3.1.1 Depreciation

Kopner et al (1972) and Hunt (1979) defined depreciation as a loss in the value of the machine with the passage of time whether the machine is used or not and attributed to wear, excessive repair costs, low capacity or obsolescence.

Hunt (1979) mentioned the following methods that are commonly used to determine the annual amount of depreciation.

1. **An estimated value method**

This method is commonly known as market value method. It is more realistic method of estimating depreciation. At the end of each year the value of the machine is compared with its value at the start of the year. The difference is the amount of depreciation.

The reliability of this method depends very much on how responsible the machine is evaluated at the end of each year. The estimated values of second hand farm machines are determined at specialized machinery auctions or by farm machinery dealers.

2. **Straight line Method**

This is the simplest and more common method. It charges an equal amount of depreciation each year as shown by this equation.

\[ D = \frac{(F - S) \times L}{2} \]

where

- \( D \) = depreciation amount \$/yr
- \( F \) = purchase price
\[ S = \text{salvage value} \]
\[ L = \text{life of machine yrs} \]

3. Declining - Balance Method

It is the simplest of all, a constant percentage is applied each year to the remaining value of the machine at the beginning of the year.

4. Sum-of-the-Years-Digits Method

This method is more accurate than straight line but more complicated, it depreciates the machine to zero at the end of the economic life. The digits of the estimated number of the year life are added together. The sum of the years of life remaining (including the year under consideration) is divided by the sum of years digits. This fractional part is multiplied by the difference between purchase price and the salvage value. The result is the amount of depreciation charged each year. This can be shown by this equation

\[ D = \frac{L - n}{y^d} (P - S) \]

where
- \( D \) = Annual depreciation
- \( y^d \) = Sum of years digits
- \( n \) = Age of the machine at the beginning of the year
- \( L \) = Economic life of the machine in years
- \( P-S \) = The difference between the purchase price and the scrap value of the machine.

Lonnemark (1967) stated that when the value of money is decreasing, the price of new machines are increasing and therefore the funds set aside by writing off on the basis of the original value will be insufficient for the replacement.
Consequently as the prices of new machines rise, the depreciation on the existing machines should be recalculated accordingly.

Falbarnes et al. (1971) found that depreciation comprised a major item of cost among ownership costs of combine harvesters, supporting the previous findings of Larson and Panton (1965).

2.3.1.2 Interest, Taxes, Housing and Insurance

These items of ownership costs are proportional to the remaining value of various machines. They are determined by multiplying rates as percentages for interest, taxes, housing and insurance by the value of the machine at the beginning of each year.

The official rate of interest varies from one country to another.

Lonnemark (1967) states that in developed countries with stable national economy, it may be possible to borrow money for financing the purchase of farm machinery at an interest rate 6%-8%. He reported that in developing countries with scarcity of capital and less credit facilities, the rate may be as high as 15 percent or more. The Agricultural Bank of Sudan charged 12 percent as interest rate for agricultural purposes in 1988.

Bowers (1975) estimated a charge of 1-2 percent of the remaining value of the machine for shelter, and 0.25-0.5 percent as an annual charge for insurance.
Kepner et al (1972) suggested a charge of 0.5-1.0 percent of the new cost for shelter.

Fenton et al (1969) combined the costs of depreciation, interest, taxes, shelter and insurance into a single percentage of the purchase price and suggested 16 percent of the purchase price for the annual ownership costs.

2.3.2 Operating Costs

These are costs that vary with use and more or less directly proportional to the amount of use. Variable costs include repair and maintenance, labour, fuel, oil and lubricants costs.

2.3.2.1 Repair and Maintenance Cost

Repair and maintenance cost has received greater attention than other items of cost because it is difficult to estimate and it is one of the largest items of total cost.

Repair and maintenance cost includes maintenance, adjustment for wear out parts and daily service as well as the cost of all spare parts and the labour to install them.

Hunt (1979) stated that repair and maintenance costs are expected to vary from one part of the country to another, because of differences in soils, weather and crop conditions. He mentioned that some variations are due to differences in the skill of machine operator and the value of machines.
Kepsar et al. (1972) attributed the variations in repair and maintenance costs to the differences in operating conditions, management, maintenance programs and local cost. He stated that tillage implements and other machines that require frequent sharpening or replacement of cutting elements have relatively high repair costs.

Larsen and Bowers (1965) reported information on farm machinery repair costs and published by the ASAE in their year book (1979). Also Bower and Hunt (1970) developed mathematical formulas for computing repair costs.

Buckwal (1982) found that the older tractors had higher repair and maintenance cost per hour than new ones.

Culkin (1975) estimated the annual cost of spares and repairs as a percentage of purchase price at various levels of use of farm machinery as shown in table 1.

2.3.2.2 Fuel and Lubricant Costs

Fuel and lubricant vary with the use of the machine when accurate records are lacking, the costs of fuel and lubricants can be satisfactorily estimated. Bowers (1975) suggested 20-30 percent of the total machine annual costs for fuel and lubricants. Fuel consumption can be approximated from the Nebraska tractor test data established by the Department of Agricultural Engineering University of Nebraska (1975).
<table>
<thead>
<tr>
<th></th>
<th>Approx. Annual Use (hours)</th>
<th>Additional Use per 100 hrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tractors</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>750</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Harvesting machinery</td>
<td></td>
<td></td>
</tr>
<tr>
<td>combine harvester-self prop.</td>
<td>1.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Pick up baler, potato harvester and sugar cane harvester</td>
<td>3.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Other implement and machines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 4 normal coils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 4 normal coils</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 5 disc harrows, fertilizers, combine drill spreaders, sprayers</td>
<td>3.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Group 5 disc harrows, fertilizers, combine drill spreaders, sprayers</td>
<td>3.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Group 5 disc harrows, fertilizers, combine drill spreaders, sprayers</td>
<td>3.0</td>
<td>5.3</td>
</tr>
<tr>
<td>Group 6 corn drills, milking machines, hydraulic loaders, simple potato planters, planters</td>
<td>2.0</td>
<td>4.0</td>
</tr>
<tr>
<td>Group 6 grain drills and grain cleaners</td>
<td>1.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>
Lawrence (1967) cited that surveys in United States indicated that the average consumption of oil in tractors is 2.5-3 percent of fuel consumption and that the cost of oil and filters can be taken as 15 percent of the cost of fuel used.

Lawrence (1967) reported that the cost of oil and greasing is a small item of cost but should be considered for tractors and self-propelled machines. Data on oil consumption can be obtained from the manufacturer's instructions for changing the engine oil. However all consumption can be estimated by practical experience specially for old machines.

2.3.2.3 Labour Cost

Fairbanks and et al. (1971) found that variable costs for tractors were about 64% of all costs, with the greatest single cost being for labour.

Aghamiri (1969) attributed high depreciation and operating costs of tractors in Sudan to high purchase price and high spare parts prices resulting from custom duties, unreasonably high profit margins and a chronic shortage of spare parts.

2.4 Field Capacity of Farm Machinery

Field capacity of agricultural machine is the rate at which farm operations are accomplished. Field capacity can be expressed in terms of area/time (acres/hr, ha/ha/hr) or bushels, tonnes or balers per hour.
Hunt (1979) proposed the following time fractions to be considered when computing the capacities or costs of machinery.

2. Travel time to and from the field.
3. Machine preparation time in the field and before and after operations.
4. Theoretical field time (the time, the machine is operating in the field at an optimum forward speed and performing over its full width of action).
5. Turning time.
6. Time to load and unload the machine.
8. Maintenance time (refueling, lubrication, chain tightening etc.).
9. Repair time (the time spent in the field to replace or renew parts that have become inoperative).
10. Operator's personal time.

He stated that not all the above time elements are commonly charged against machine operations.

The operator's personal time, machine preparation and travel time to and from the field are highly variable quantities and are usually unrelated to the operating efficiency of the machine.

Theoretical field capacities of farm machine can be calculated by this equation:
\[ O_r = \frac{S \times W}{c} \]

where \( O_r \) = Theoretical field capacity ha/hr (a/hr)  
\( S \) = Speed km/hr (mi/hr)  
\( W \) = Rate width of implement, m(ft)  
\( c \) = Constant, 10 (3.25)

Hunt (1979) stated that it is impossible to operate machines continuously or at their rated width of action, therefore actual capacities will be substantially less than their theoretical capacities.

He mentioned the following equation for the effective field capacity

\[ C = \frac{S \times W}{c} \]

where \( C \) = effective field capacity ha/hr (a/hr)  
\( S \) = speed km/hr (mi/hr)  
\( W \) = rate width of implement m(ft)  
\( c \) = Field efficiency as a decimal  
\( c \) = constant, 10(3.25).

Lounsbury (1967) mentioned two main methods by which field capacity of farm machinery can be obtained.

The first method is to collect data by recording the time taken to cover a given area. The second method is to calculate the time taken according to the working width of the machine and its working speed. He stated that the first method can be used both for obtaining rough averages and for detailed and accurate studies. The rough average figures are closely related to the conditions under which they have been obtained and can easily be collected.
He reported that for the purpose of calculating costs and establishing rates, however, this method is very useful and sufficiently accurate in most cases.

Yahmoud et al (1976) reported that field operation capacities in the Gezira scheme were 3.8 faddans per hour for direct combining of wheat when using a 4.75 combine harvester (14-16 ft) 2.5 faddans per hour for dry ridging when four shanks ridger is used, and one fadshan per hour when using the three body standard disc plough.

Gezira Board's Agricultural Engineering Department (1983) reported that field capacity of Class combines (No 75, Dom.63 - 14-16 ft) was 4 faddans per hour when used in direct combining of wheat, and estimated 2.5 faddans per hour for dry ridging and disc harrowing when using four shanks ridgers and offset disc harrows (24 units).

2.4 Field Operation Cost

Reynar et al (1972) suggested the following factors for determining the total cost per unit of work:

1. Annual use of implement in hours or hectares.
2. Effective field capacity of implement in hectares per hour.
3. Annual rental costs for implement.
4. Total operating costs per hour (repairs, fuel and lubricant) for the implement.
5. Cost per hour or per hectare for tractor power required by the implements that are not self-propelled.
6. Labour cost per hour.
Hunt (1979) derived an equation that expresses the total cost per year for a field machine as follows:

$$AC = \frac{P + \frac{d}{2}}{100} + \frac{\pi M}{4} \left[ (A + M)F + L + 0.5 F + T \right]$$

where

- $AC = $Annual cost of operating machine $\$/year
- $P = $Annual fixed costs percentage
- $M = $Purchase price of machine $\$
- $C = $Constant 10(8.25)
- $A = $Annual use in ha(a)
- $S = $Forward speed km/hr (MPH)
- $W = $Effective width of action of machine m(ft)
- $e = $Field efficiency, decimal
- $R&M = $Repair and maintenance costs decimal of purchase price per hour.
- $L = $Labour rate $\$/hr
- $U = $Oil cost $\$/hr
- $F = $Fuel cost $\$/hr
- $T = $Cost of tractor used by machine $\$/hr

In Nigeria Igeka (1985) found that the cost of plowing was highest while that of ridging was marginally higher than harrowing. He stated that it is not possible to compare costs of operations for different countries because there are many factors such as labour, fuel, lubricant costs and purchase prices which vary from one country to another.
Hunt (1979) reported that for the significant differences in machine use, price level, energy requirements, fuel costs and labour cost, farm machinery managers have to develop individual standard costs and use the average costs obtained by others only for comparison purposes.

Agricultural Engineering Departments in Gedira, Sahed and New Halfa schemes estimated the costs of farm machinery operations per feddan for season 1988/89 as follows

<table>
<thead>
<tr>
<th></th>
<th>Disc Flailing La/Fed</th>
<th>Disc Harrowing La/Fed</th>
<th>Dry Ridging La/Fed</th>
<th>Wheat Direct Combining La/Fed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gedira Scheme</td>
<td>60</td>
<td>18.5</td>
<td>12.0</td>
<td>72</td>
</tr>
<tr>
<td>Sahed Scheme</td>
<td>37</td>
<td>20</td>
<td>13.7</td>
<td>-</td>
</tr>
<tr>
<td>New Halfa Scheme</td>
<td>35</td>
<td>17</td>
<td>12.0</td>
<td>-</td>
</tr>
</tbody>
</table>

2.6 **Main Factors Affecting the Cost per Hour**

Lonnemark (1967) mentioned that the costs of tractor were high up to 900 hours annual use, but reduced rapidly beyond this up to 1000 hours.

Sahhari (1988) found that there was a reduction in total cost with increasing annual use in hours. This agreed with the views of Kitsopoulos and Hattrix (1969), and Rahim et al (1979).

Kolwoli (1974) reported that low annual use resulted in high cost per hour.
Moeses and Proct (1965) reported that the annual use and age were both important factors in explaining cost per hour of operating tractors.
CHAPTER III

MATERIALS AND METHODS

3.1 Data Collection

The data of cost evaluation of some farm machinery operations under irrigation conditions were collected in a survey conducted during the period between October 1987 and April 1989 at different sites in Gezira, Rahad and New Halsa Schemes.

The data were collected using questionnaire, records, personal contacts with managers, agricultural engineers, mechanic, operators, individual private-owners of machinery, store keepers, farm machinery dealers and government local authorities.

Machines investigated in this study were the popular sizes (65-82 hp) tractors, (102-105 hp) combine harvesters, disc plows, disc harrows and ridgers.

The data gathered were the following:

3. Interest rate.
4. Taxes, insurance and shelter charges.
5. Expected life.
6. Type and annual use in cedestas or in hours.
7. Field capacity per hour.
8. Fuel consumption per hour.
9. Oil and lubricant consumption per hour.
10. Annual repair and maintenance costs.
12. Custom rate.

Each observation was recorded in a questionnaire data sheet. The data sheet used by the interviewer is attached in Appendix (A).

3.2 Data Analysis Procedures for Dura and Wheat Combine Harvester

Combines investigated in this study were Class Neroster 75 and Dominator 66 which represent the major types of combine harvesters used in dura and wheat harvest in the Sudan specially in Sefara and New Halfa schemes. (Specifications of the two types of combine harvesters were shown in table 2). The average density of the wheat was 0.6 ton per feddan.

Combines harvesters used in dura are used as stationary threshers, the crop is cut by manual labours collected in large heaps and fed to the combine for threshing, separation, cleaning and bagging in sacks. However, in combine varieties of dura and wheat the machine is used for direct cutting and threshing of the crop. Fig. 1.

Analysis procedure adopted in each operation was as follows:

1. The combines were divided into four groups according to their ages as in table (3).

2. The average working hours for each age group in each operation was determined.

3. The ownership cost per hour for each age group was calculated by using the following parameters, the average working hours for
Figure 1. Class Combine Harvester.
Table 2: Specifications of combine harvesters.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td>Germany</td>
<td>Germany</td>
</tr>
<tr>
<td>Class</td>
<td>Class</td>
<td>Class</td>
</tr>
<tr>
<td>Models</td>
<td>Nr. 72</td>
<td>Dom. 63</td>
</tr>
<tr>
<td>Power</td>
<td>105 hp</td>
<td>132 hp</td>
</tr>
<tr>
<td>Width of cut</td>
<td>4.5 m (15 ft)</td>
<td>4.2 m (14 ft)</td>
</tr>
<tr>
<td>Weight approx.</td>
<td>6270 kg.</td>
<td>6770 kg.</td>
</tr>
<tr>
<td>Group</td>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>---------</td>
<td>----------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>1st. group</td>
<td>Combines purchased in the period between 1987 and 1988 or 1-2 years old combines.</td>
<td></td>
</tr>
<tr>
<td>2nd. group</td>
<td>Combines purchased in the period between 1985 and 1986 or 3-4 years old combines.</td>
<td></td>
</tr>
<tr>
<td>3rd. group</td>
<td>Combines purchased in the period between 1983 and 1984 or 5-6 years old combines.</td>
<td></td>
</tr>
<tr>
<td>4th. group</td>
<td>Combines purchased in the period between 1981 and 1982 or 7-8 years old combines.</td>
<td></td>
</tr>
</tbody>
</table>
the two operations, depreciation using the straight line method, 14 percent interest rate (normally charged for agricultural purposes estimated by the Agricultural Bank), 8 years economic life, and annual charge of LE 1175 for taxes and insurance.

4. The operating cost per hour for each age group was computed, using the average hourly repair and maintenance cost, fuel cost, oil and lubricant cost and labour cost.

5. The total cost per hour of each age group was obtained by adding up ownership and operating costs.

6. The overall average ownership, operating and total costs were computed for all combines. The former two were expressed as percentages of the later. For the two operations each item contributing to the ownership and operating costs was calculated as a percentage to the total cost and presented in charts.

7. The overall average field capacity in feddans or tonnes per hour was calculated.

8. The overall average cost per feddan or per ton was found by dividing the overall average total cost per hour by the overall average field capacity per hour for each operation.

9. The overall average cost per feddan or ton was compared with custom rates and the break even point was calculated using the standard method.
A. (carse) = Annual operating cost  
Costs rate/fed - Operating cost/fed

B. (hours) = Annual ownership cost  
Costs charge/hr - Operating cost/hr

A sample of the analysis is attached in Appendix (B).

3.3 Data Analysis Procedure for Tillage Operations

3.3.1 Data Analysis Procedure for 20-WD Tractors

Tractors investigated in this study were 20-WD, 25-WD, 50-WD, International 740-4, Case International 685 and Zero 660.

(Specification shown in Table 4). All these were small tractors (65-82 hp) which are currently used extensively in tillage operations in Qasrira, Alshad and New Nalta Schemes.

The following steps were followed in analyzing the costs of using the above tractors in each scheme:

1. Tractors were divided into groups according to their age and subgroup according to their make as shown in Table 5.

2. The average working hours for each age group was calculated.

3. The ownership cost per hour of each age group and subgroup was calculated, using straight line method of depreciation, 14 percent interest rate, 8 years economic life of the Qasrira tractor and ten years economic life for Alshad and New Nalta tractors. Annual charges of 2.5% for taxes and insurance in Qasrira and Alshad but zero for New Nalta. 5% of the purchase price is the charge for housing in Alshad and New Nalta, and zero percent for Qasrira tractor.
Table 4: Tractors specifications.

<table>
<thead>
<tr>
<th>Tractor</th>
<th>N.P.</th>
<th>M.F.</th>
<th>N.P.</th>
<th>Inter</th>
<th>Case - Inter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>N.P.</td>
<td>M.F.</td>
<td>N.P.</td>
<td>IH</td>
<td>Case - IH</td>
</tr>
<tr>
<td>Model</td>
<td>185</td>
<td>265</td>
<td>290</td>
<td>745-8</td>
<td>685</td>
</tr>
<tr>
<td>Power hp</td>
<td>71</td>
<td>65</td>
<td>82</td>
<td>72</td>
<td>69</td>
</tr>
<tr>
<td>P.T.O.</td>
<td>66.5</td>
<td>58.6</td>
<td>65.7</td>
<td>65.9</td>
<td>59.3</td>
</tr>
<tr>
<td>Weight</td>
<td>2230</td>
<td>2588</td>
<td>2585</td>
<td>3050</td>
<td>2436</td>
</tr>
</tbody>
</table>
Table 5: Tractors Age-groups.

<table>
<thead>
<tr>
<th>Wearsa</th>
<th>Yamasu</th>
<th>New Walesa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st.</td>
<td>Tractors purchased</td>
<td>Tractors purchased</td>
</tr>
<tr>
<td>group</td>
<td>in 1984 or one year</td>
<td>in 1983 or 6 years</td>
</tr>
<tr>
<td>old tractor</td>
<td>old tractor</td>
<td>old tractor</td>
</tr>
<tr>
<td>2nd.</td>
<td>Tractors purchased</td>
<td>Tractors purchased</td>
</tr>
<tr>
<td>group</td>
<td>in 1983 or 6 years</td>
<td>in 1975 or ten years</td>
</tr>
<tr>
<td>old tractor</td>
<td>old tractor</td>
<td></td>
</tr>
<tr>
<td>3rd.</td>
<td>Tractors purchased</td>
<td></td>
</tr>
<tr>
<td>group</td>
<td>in 1981 or 8 years</td>
<td></td>
</tr>
<tr>
<td>old tractor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4. The operating cost per hour for each age group and make group was computed, using the average hourly repair cost, fuel cost, oil and lubricant costs and labour charges.

5. The average cost per hour for the make groups was calculated to represent one age group.

6. The total cost per hour of each age group was calculated by adding the ownership cost to the operating cost.

7. The overall average ownership, operating and total costs for all groups were computed. The former two were expressed as percentages of the latter.

Each item contributing to the ownership and operating costs was calculated as a percentage to the total cost and presented in charts.

A sample of cost analysis is attached in appendix (B).

3.3. Cost analysis procedure for tillage implements

The soils in the schemes are between brown and dark grey cracking clays, and tillage operations are usually carried out in the dry season (November to May), so the soils are considered to be dry.

The operations considered in this study were dry ridging, disc harrowing and disc plowing. (Fig. 3, 4)

 Implements investigated were ridgers, off set disc harrows and 3 bottom disc plows. The specifications of the aforementioned implements are shown in tables (6a, 6b, 6c).
Figure 3. Disc harrowing operation.

Figure 4. Disc plowing operation.
Table C6: Disc plow specification.

<table>
<thead>
<tr>
<th>Machine make</th>
<th>F.J. Harmer and Sons, L.F.D., England</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>DM13</td>
</tr>
<tr>
<td>Disc diameter</td>
<td>76.2 cm (30&quot;)</td>
</tr>
<tr>
<td>Width of cut</td>
<td>20 cm - 25 cm - 30 cm (8&quot; - 10&quot; - 12&quot;)</td>
</tr>
<tr>
<td>Maximum depth</td>
<td>25-30 cm (10-12&quot;)</td>
</tr>
<tr>
<td>No. of Furrow</td>
<td>3</td>
</tr>
<tr>
<td>Min. Hp Required</td>
<td>30 hp</td>
</tr>
</tbody>
</table>

Table C6: Ridgore specifications.

<table>
<thead>
<tr>
<th>M. Make</th>
<th>M.F. England</th>
<th>Nardi Italy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>M.F. 80</td>
<td>F.M. 70</td>
</tr>
<tr>
<td>No. bodies</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Working width</td>
<td>3.4 m</td>
<td>3.4 m</td>
</tr>
</tbody>
</table>

Table C6: Disc Harrows (off set) specifications.

<table>
<thead>
<tr>
<th>M. Make</th>
<th>U.S.A.</th>
<th>U.S.A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model</td>
<td>Towetr 510-222</td>
<td>Steermal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>International F.N. (2)</td>
</tr>
<tr>
<td>Units and</td>
<td>22 disc blades</td>
<td>22 disc blades</td>
</tr>
<tr>
<td>Disc diam.</td>
<td>60.96 cm</td>
<td>60.96 cm</td>
</tr>
<tr>
<td>Working width</td>
<td>260 cm</td>
<td>260 cm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>270 cm</td>
</tr>
</tbody>
</table>
The operations depths were 15-20 cm for dry ridging and
barrowing and 20-25 cm for plowing.

The average working speeds were 3 km/hr for dry ridging, barrowing
and 5 km/hr for plowing.

Data analysis procedure adapted in each scheme was as follows:

1. One age group of 5-8 implements from each type was chosen, making
three groups in each scheme and a total of 9 groups in the
three schemes.

2. The average working hours of each group was calculated.

3. The ownership cost per hour for each group was computed, using
the straight line method of depreciation, 1% percent interest
rate, and life time as in tablea (15, 16, 17).

4. The operating cost per hour for each group was calculated, using
the average hourly repair and maintenance cost.

5. The total cost per hour for each group was obtained by add
ownership and operating costs.

6. The average area covered per hour by each implement group was
determined.

3.3.3 Determination of Tillage operation Cost

1. In each scheme and for each operation the average total cost per
hour of the tractor was added to the implement average total cost
per hour. The operation hourly cost obtained was divided by the
average area covered by the implement in feddan per hour to
give the operation cost per feddan.

2. The costs of disc plowing, disc harrowing and dry ridging
per feddan computed in this study were compared with the
existing charges per feddan currently implemented in the
respective schemes.
4.1 Introduction

The results showed that there are some differences between the land preparation operations' costs calculated in this study and current costs estimated for these operations in the schemes. For example, disc plowing has the highest operation cost followed by the disc harrowing and then dry ridging which has the lowest operation cost. This sequence agrees with the general feature of estimated costs in the schemes, but there are marginal variations between calculated costs for each operation in the schemes.

The results showed that tractors and implements have high annual use which may be attributed to the ratio of machines to land area and to the long period of land preparations.

High annual use results in comparatively low operation cost. This was confirmed by Bakhari et al. (1988) and Kolivis (1974).

The annual use of combine harvester in the stationary threshing of grain is more than the direct combining of wheat due to the long period of grain harvest. The calculated costs for direct combining of wheat and stationary threshing of grain are lower than current charges for these operations.

4.2 Land Preparation Costs

4.2.1 Cost of Using Wheeled Tractors

Tables 7, 8, 9 show the costs of operating tractors of different ages within their economic lives in Gaclra, Sah and Nw Halfa Schemes.
and

Tables 9, 8, 7 also show that the annual use varies with the age of the tractor and accordingly the hourly costs change. The total cost per hour ranges from Le 20.32 for one year old tractor to Le 41.27 for an eight year old tractor in the Gezira scheme, and from Le 23.19 for a six years old tractor to Le 36.6 for a ten years old tractor in the Sakhad scheme.

The annual use and age are both important factors in determining cost per hour of tractor. This result was confirmed by Moses and Frost (1965).

Table 10 shows that the hourly average costs of operating tractors were Le 29.19 for the Gezira tractors, Le 29.9 for the Sakhad tractors and Le 26.02 for the New Halfa tractors.

The hourly average ownership cost and operating cost percentages of the average total cost per hour of the tractor were respectively, 76.1 and 63.9 for the Gezira tractor, compared with 77.1 and 59.0 for the Sakhad tractor, 46.2 and 53.8 for the New Halfa tractor. These results are supporting Fairesa et al (1971) findings in which they reported that operating costs of tractors were greater than ownership costs.

Figures 9-6-9 illustrate the percent contribution of each item of cost with respect to the total cost per hour of the machine in each scheme.
In each scheme, hourly costs of each item of equipment are calculated to determine their cost to the total cost. The importance of each item is then evaluated.
Labour cost was high in the Gesira scheme because they employ two drivers with each tractor.

Repair and maintenance cost comprised a large item of the total cost of Gesira and Rahad tractors because the group of tractors taken for this study in Gesira and Rahad included old tractors.

Table 11 shows ownership cost, operating cost and total cost for an eight years old tractor and a one year old tractor in the Gesira scheme. It can be seen that the one year old tractor has a ownership cost, operating cost and total cost of 48.85%, 49.46%, 49.24% with respect to the costs for an eight years old one, because new one had less hourly repair cost and more annual use than eight years old tractor. This result agrees with Sukhari (1988) and Bahamo et al (1979) findings.

Table 12 shows that ownership cost, operating cost and total cost of a six years old tractor in Rahad scheme were 77.42%, 99.13% and 89.16% respectively, as related to the costs of a six years old tractor in the New Halfa scheme, because working hours of the New Halfa tractor were less than that of similar age tractor in the Rahad scheme.
<table>
<thead>
<tr>
<th>Year Old</th>
<th>1 Year Old</th>
<th>2 Year Old</th>
<th>3 Year Old</th>
<th>4 Year Old</th>
<th>5 Year Old</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Comparison between one year and 5 years old tractor in the field operation.
Table 13 shows that in the Rahad scheme the ownership cost, operating cost and total cost of a six years old tractor are 66.09%, 61.65% and 65.36%, respectively, as compared with the costs of a ten years old tractor. High costs of a ten years old tractor due to the low annual use and high repair costs.

These results agree with those reported by Kadamole (1974) and Buchhari (1982).

Table 14 shows a comparison between hourly cost of an eight years old tractor in the Gezira scheme and a ten years old tractor in the Rahad scheme and both were at the end of their economic lives, the ownership cost, operating cost and total cost of an eight years old tractor in the Gezira scheme are 110%, 114% and 112.7% respectively as compared with costs for a ten years old tractor at Rahad scheme. This is explained by the fact that the annual amount of depreciation, interest and labour charges for the Gezira tractor are more than that of the Rahad tractor.

4.2.3 Cost of Using Implements

The hourly average cost of operating a disc plow, an off-set disc harrow and a ridger in the Gezira, Gezira and New Halfa schemes are summarized in Tables 15, 16, and 17.

From Tables 15, 16, and 17 it is clear that for the three implements mentioned above the hourly cost of operation shows the highest values at New Halfa and the lowest values at Gezira. This is due to the fact
<table>
<thead>
<tr>
<th>Year</th>
<th>Cost/Year</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>$37,875</td>
<td>$189,375</td>
</tr>
<tr>
<td>6</td>
<td>$33,428</td>
<td>$200,568</td>
</tr>
<tr>
<td>7</td>
<td>$29,185</td>
<td>$210,120</td>
</tr>
<tr>
<td>8</td>
<td>$25,098</td>
<td>$220,128</td>
</tr>
<tr>
<td>9</td>
<td>$21,105</td>
<td>$230,233</td>
</tr>
<tr>
<td>10</td>
<td>$17,205</td>
<td>$240,538</td>
</tr>
</tbody>
</table>

Table 2: Comparison between 5 and 6-year old tractors and ten-year old tractor.
that the annual use of the disc plow, off-set disc harrow and the ridger in the Gezira scheme are the highest and in the New Halfa are the lowest.

4.2.3 Tractor and Implement Cost

Tables 12, 16, 17 also show that the total hourly costs of using a tractor with an implement in the Rahad scheme are marginally higher than in Gezira and New Halfa schemes. Comparing the total hourly costs of using tractor and implement for New Halfa and Rahad the difference can be explained by the fact that tractors used in Rahad were noticeably old in ages (6-10 years) as compared with those used in New Halfa (6 years old).

On the other hand the discrepancy in the total costs between Rahad and Gezira are attributed to the high amount of annual use in Gezira (1000-1500 hrs) as compared to Rahad (500-1250 hrs).

4.2.4 Cost of Tillage Operations per Feddan

After a comprehensive survey on different agricultural governmental and private schemes. It was found that the average capacity of plowing using a standard disc plow is 1 feddan per hour and for harrowing and dry ridging is 7-8 feddans per hour.

Tables 15, 16, 17 show that for the operations under consideration disc plowing was the highest operation in cost and the dry ridging was the lowest operation in cost. The high cost of disc plowing is due to the
<table>
<thead>
<tr>
<th>Year</th>
<th>Budget (dry)</th>
<th>Item 1</th>
<th>Item 2</th>
<th>Item 3</th>
<th>Item 4</th>
<th>Item 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>1234.5</td>
<td>6.7</td>
<td>8.9</td>
<td>10.1</td>
<td>12.3</td>
<td>14.5</td>
</tr>
</tbody>
</table>

Place Show

Note: Use Irrelevant operation cost in the column above.
In the Gezira scheme the charges for disc plowing and harrowing were higher than calculated costs, this may be attributed to the high over head costs usually added to the costs of some operations. Moreover the great variation between the private machine owners' charges (Le 100) and the Gezira disc-plowing cost (Le 70) created a great demand on the Gezira plows by the private farm-owners. To gain a profit and to restrict the growing demand on disc plowing, the Gezira Board increased charges for plowing to narrow the range between their costs and the private sector charges.

4.3 Combine Harvester Operations Costs

4.3.1 Direct Combining of Wheat

Table 19 shows the hourly average total costs of using combine harvesters with aged ranging between one to eight years old for direct combining of wheat in season 1983/84.

The hourly ownership cost and operating cost of combine harvester in direct harvesting of wheat comprised 65.1 percent and 34.9 percent of the total cost per hour respectively. This result verifies the previous findings of Fetherbeak of U2 (1971) who reported that ownership cost of combine harvester was greater than operating cost.

Figure 8 shows the relative importance of all items of cost to the total costs of a combine harvester in direct combining of wheat.
Fig (b)  

Cost components of various items of cost:

- Owner's costs: 31.9% 
- Tax & marine: 3.3% 
- DM: 4.3% 
- Lab: 5.5% 
- Fuel: 4.57% 
- O&M: 0.8%
Costs of depreciation, interest, repair and maintenance were the highest items of cost due to the high purchase price of the combine harvester. Oil and lubricant, taxes and insurance contributed very little to the total costs.

Table 20 shows that the ownership costs per hour of 3-4, 5-6 and 7-8 years old combines compared with a 1-2 years old combine are greater by 10.37 percent, 19.9 percent and 44 percent respectively, because the annual use of combine decreases when it becomes old.

4.5.1.1 Combine Field Capacity and Cost per Feddan

In direct combining of wheat the average area covered per hour by different age combines investigated here was four feddans (Table 21). This result agrees with Giza Board (1987) estimation.

The average operating cost calculated in this study is Le 49.37 per feddan for direct combining of wheat, and the custom charges per feddan estimated by the Giza Board scheme is Le 95.

The annual use that justifies the ownership of a combine harvester using the standard method is 733 feddans per year or 183 working hours per year in direct combining of wheat.

4.5.2 Partial Combining of Grain

Table 22 shows the hourly average ownership, operating and total costs of operating combines from one to eight years old in stationary threshing of grain under irrigation conditions.
Table 20: A comparison between ownership costs for a 1-2 year old combine and 3-4, 5-6, 7-8 years old combines.

<table>
<thead>
<tr>
<th>Combine Age Group</th>
<th>1-2 year old combine</th>
<th>3-4 year old combine</th>
<th>5-6 year old combine</th>
<th>7-8 yrs old combine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Hours</td>
<td>3220</td>
<td>1020</td>
<td>860</td>
<td>650</td>
</tr>
<tr>
<td>Ownership cost (La/Ar)</td>
<td>114.73</td>
<td>126.63</td>
<td>137.5</td>
<td>155.58</td>
</tr>
<tr>
<td>% own. cost increase with respect to 1-2 years old combine</td>
<td>10.37%</td>
<td>13.94%</td>
<td>44%</td>
<td></td>
</tr>
</tbody>
</table>
Table 21: Field capacity of different age combines in each operation.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Field capacity in wheat harvesting (bu/hr)</th>
<th>Field capacity in grain harvesting (bu/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 years old</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>combine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-4 years old</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>combine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-6 years old</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>combine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7-9 years old</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>combine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Over all average</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>capacity</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The hourly ownership cost and operating cost percent of the total cost per hour were 73.8 and 26.2 respectively. These results agree with Fairbanks et al. (1971) findings.

Figure 9 shows the contribution of different items of cost to the total cost per hour of the combine harvester in the stationary threshing of grain.

Percentages of costs due to depreciation and interest were the highest items of cost. Labour wages in stationary threshing represent 10.4 percent of the total cost because more labours were required for feeding grain heads into the combine harvester. Fuel consumption, oil and lubricant, taxes and insurance represent small items of cost.

4.3.2.1 Combine Capacity and Cost per Ton

The average capacity of different aged combines when operating in stationary threshing of grain was 6 tonnes per hour under Oshira scheme conditions. (Table 21)

The average cost found in this study is Ls 30.7/ton. The custom charges for the ton was 39.7 percent higher than calculated cost. This is attributed to the unreliable method used in determining costs of grain threshing.

The annual capacity that justifies the ownership of a combine in stationary threshing according to the existing custom charges is 1169 tonnes under irrigated conditions.
The following could be concluded from the study:

1. **Operating costs of tractors were greater than ownership costs.**

2. **Age and annual use were both important factors in determining the hourly costs of tractors.**

3. **Old tractors had less annual use and higher hourly costs as compared with new ones.**

4. **Increase of annual use of both tractors and implements resulted in lower operational costs.**

5. **In each scheme, disc plowing had the highest operation cost followed by disc harrowing and dry ridging respectively.**

6. **There were variations between costs of disc plowing, harrowing, and dry ridging calculated in this study and costs estimated for these operations in the schemes and what had been reported in the literature. The pattern of variations is not systematic.**

7. **The ownership costs of combine harvesters were greater than operating costs in both direct combining of wheat and stationary threshing of dura.**

8. **The hourly costs of combine harvesters in the two operations were related to combine age, and old combines had higher costs than new ones.**

9. **Costs of direct combining of wheat and stationary threshing of dura calculated in this study were both lower than actual charges estimated for these operations in the schemes.**

10. **The annual use that justifies the ownership of a combine harvester is 733 feddans in direct combining of wheat and 1,169 tonnes in stationary threshing of dura according to the existing charges for these operations.**
REFERENCES


Chapter 2, 17.


(a) **Tractor**

- **Machine make and model**: 
- **Age**: 
- **Initial price**: 
- **Interest rate**: 
- **Tax**: 
- **Insurance**: 
- **Shelter**: 
- **Annual use hours**: 
- **Expected life years**: 
- **Annual repair and maintenance costs**: 
- **Labour costs monthly**: 
- **Oil and lubricant consumption per hour**: 
  - **Engine oil**: 
  - **Transmission oil**: 
  - **Hydraulic oil**: 
  - **Grease**: 
  - **Fuel consumption gal/hr**: 

(b) **Equipment**

- **Type of equipment**: 
- **Make**: 
- **Model**: 
- **Age**: 
- **Initial cost**: 
- **Expected life years**: 
- **Annual use in fields**: 
- **Area covered per hour**: 
- **Repair and Maintenance costs**: 

---
COMBINE HARVESTER

Project: Crop: 

Costings:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine make</td>
<td></td>
</tr>
<tr>
<td>Horse</td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td></td>
</tr>
<tr>
<td>Initial price</td>
<td></td>
</tr>
<tr>
<td>Interest rate</td>
<td></td>
</tr>
<tr>
<td>Taxes</td>
<td></td>
</tr>
<tr>
<td>Insurance</td>
<td></td>
</tr>
<tr>
<td>Shelter</td>
<td></td>
</tr>
<tr>
<td>Expected life</td>
<td></td>
</tr>
<tr>
<td>Annual hours of use</td>
<td></td>
</tr>
<tr>
<td>Area covered per hour</td>
<td></td>
</tr>
<tr>
<td>Annual spare parts cost</td>
<td></td>
</tr>
<tr>
<td>Fuel consumption per hour</td>
<td></td>
</tr>
<tr>
<td>Oil and lubricant consumption per hour</td>
<td></td>
</tr>
<tr>
<td>Engine oil</td>
<td></td>
</tr>
<tr>
<td>Transmission oil</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>Grease</td>
<td></td>
</tr>
<tr>
<td>Operators wages</td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>Custom rate</td>
<td></td>
</tr>
</tbody>
</table>

Note: State whether machine used as stationary thresher: If yes:

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual hours of use</td>
<td></td>
</tr>
<tr>
<td>Tons in per hour</td>
<td></td>
</tr>
<tr>
<td>Annual spare parts cost</td>
<td></td>
</tr>
<tr>
<td>Fuel consumption per hour</td>
<td></td>
</tr>
<tr>
<td>Oil and Lubricant consumption per hour</td>
<td></td>
</tr>
<tr>
<td>Engine oil</td>
<td></td>
</tr>
<tr>
<td>Transmission oil</td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>Grease</td>
<td></td>
</tr>
<tr>
<td>Labours wages</td>
<td></td>
</tr>
<tr>
<td>Monthly</td>
<td></td>
</tr>
<tr>
<td>Charge per week</td>
<td></td>
</tr>
</tbody>
</table>
Fuel and lubricants prices in season 1986/87.

<table>
<thead>
<tr>
<th>Item</th>
<th>Price (Ls)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel price</td>
<td>3.55</td>
</tr>
<tr>
<td>Antos oil price</td>
<td>1.7</td>
</tr>
<tr>
<td>Transmission oil price</td>
<td>1.4</td>
</tr>
<tr>
<td>Hydraulic oil price</td>
<td>0.4</td>
</tr>
<tr>
<td>Grease</td>
<td>3.5</td>
</tr>
</tbody>
</table>
Sample of cost analysis procedure for one group of wheel
tractor in the Gesira scheme.

Tractor type: Case International

<table>
<thead>
<tr>
<th>Tractor No.</th>
<th>8754</th>
<th>8751</th>
<th>8750</th>
<th>8752</th>
<th>8760</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual use (hrs)</td>
<td>1987</td>
<td>2086</td>
<td>2257</td>
<td>2329</td>
<td>2183</td>
</tr>
<tr>
<td>Average annual use =</td>
<td>2153 hrs (8.6 = 126.2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(one year old tractor group).

Calculation

Initial cost of the tractor = Rs 88,000
Economic life = 8 years
Scrap value = Rs 16,500
Interest rate = 16%
Fuel filter = Rs 176.08
Oil filter = Rs 170.00

1. Ownership costs

(i) Annual depreciation cost = \( \frac{(P - S)}{N} \)
   
   \[ \frac{88,000 - 16,500}{8} = 8,050.5 \]

   Depreciation per hour = 8,050.5 \( \div \) 2153 = 3.71 la/hr

(ii) Interest

Annual interest = \( \frac{(P - S)}{2} \) = \( \frac{88,000 + 16,500}{2} \times 0.14 \)

   = 7,315

Interest per hour = 7,315 \( \div \) 2153 = 3.39 la/hr.
Sample of cost analysis procedure for durum and wheat combine harvesters.

**Group 1-2 years old combine**

**Durum Threshing**

<table>
<thead>
<tr>
<th>Machine No.</th>
<th>7400</th>
<th>7412</th>
<th>7421</th>
<th>7410</th>
<th>7132</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual use (hrs)</td>
<td>670</td>
<td>670</td>
<td>750</td>
<td>925</td>
<td>920</td>
</tr>
<tr>
<td>Average annual use = 780 hrs (E.D. = 101.78)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Wheat combining**

<table>
<thead>
<tr>
<th>Machine No.</th>
<th>7132</th>
<th>7320</th>
<th>7410</th>
<th>2030</th>
<th>2051</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual use (hrs)</td>
<td>503</td>
<td>526</td>
<td>680</td>
<td>502</td>
<td>200</td>
</tr>
<tr>
<td>Average annual use = 446 hrs (E.D. = 129.33)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Average use in the two operations = 1276 hrs.

**Calculation**

- Initial price of the combine = Ls 768,000
- Scrap value = Ls 150,000
- Economic life = 8 years
- Interest rate = 14%
- Insurance and taxes = Ls 1175

1. **Operating costs**

   (i) Annual depreciation = \( \frac{(768,000 - 150,000)}{8} \) = Ls 77,250

   Depreciation per hour = \( \frac{77,250}{1276} \) = 61.32 Ls/hr
(ii) Interest rate

Average value of 1987 and 1993 combined

\[ \frac{600,750 + 768,000}{2} = \text{Rs 739,375} \]

Interest rate = \[ \frac{291,375 + 291,375}{2} \times 0.14 \]

\[ = \text{Rs 61,555.25} \]

Interest rate per hour = \[ \frac{61555.25}{1250} \]

\[ = \text{Rs 49.63} \text{ Rs/hr} \]

(iii) Taxes and insurance per year

\[ = \text{Rs 1175} \]

Taxes and insurance per hour = \[ \frac{1175}{1250} \]

\[ = \text{Rs 0.963 Rs/hr} \]

The ownership costs of the group (i, ii, iii)

\[ = 63.32 + 50.45 + 0.963 \]

\[ = 114.73 \text{ Rs/hr} \]

2. Operating costs of 1-2 years old combines for
duke threshing

(i) Repair and maintenance

Average annual repair costs = \text{Rs 5960}

R & M costs per hour = \[ \frac{5960}{1250} \]

\[ = 4.76 \text{ Rs/hr} \]

(ii) Labour cost = \[ \frac{1522 + 77.25 \times 300}{300} \]

Labour cost/hr = \[ \frac{5}{15} \]

\[ = 20.0 \text{ Rs/hr} \]

(iii) Fuel and filter cost

Average fuel consumption = 1.8 gal/hr

Fuel cost 3.55 Rs/gal

Average fuel cost = \[ 1.8 \times 3.55 \]

\[ = 6.39 \text{ Rs/hr} \]

Filter cost = 70

Filter cost per hr = \[ \frac{70}{900} \]

\[ = 0.08 \text{ Rs/hr} \]

Fuel and filter cost per hour = \[ \frac{6.53}{900} \]

\[ = 0.073 \text{ Rs/hr} \]
(iv) Oil & Lubricant costs

- Engine oil consumption: 3 gal every 100 hrs
- Engine oil price: 12 $/gal
- Engine oil cost per hr: 0.03 x 12 = 0.36 $/hr
- Oil filter price: 118 interval every 200 hrs
- Oil filter cost per hour: 118 / 200 = 0.59 $/hr
- Transmission oil consumption: 0.003 gal/hr
- Transmission oil price: 1 $/gal
- Transmission oil cost: 0.003 x 1 = 0.003 $/hr
- Hydraulic oil consumption: 0.004 gal/hr
- Hydraulic oil price: 4 $/gal
- Hydraulic oil cost: 0.004 x 4 = 0.016 $/hr
- Average grease consumption: 0.1 kg/hr
- Grease price: 3.5 $/kg
- Average grease cost per hour: 0.1 x 3.5 = 0.35 $/hr
- Average oil and lubricant cost per hour: 0.36 + 0.59 + 0.003 + 0.016 + 0.35 = 1.298 $/hr
- Total operating costs per hour:

\[ R = K + P + L = 7.64 + 6.55 + 20 + 1.508 = 35.678 \]

Total costs = Ownership costs + Operating costs

- Ownership costs: 114.73
- Operating costs: 35.678
- Average total cost per hour of the group:

\[ 114.73 + 35.678 = 150.408 \] $/hr
3. Operating costs for direct combining of wheat, using

1-2 years old combine

(i) Average annual repair and maintenance cost = Le 6200

\[ \text{A. R & M/hr} = \frac{6200}{440} = 14.1 \text{ Le/hr} \]

(ii) Average labour cost per hour = \[ 1900 = \frac{240}{36} = 11 \text{ Le/hr} \]

(iii) Average fuel consumption

\[ \text{Fuel price} = 3.35 \text{ Le/gal, Filter price} = \text{Le 8} \]

\[ \text{Average fuel cost} = 3.35 \times 3.35 = \text{Le 11} \]

\[ \text{Filter cost} = \frac{70}{500} = \text{Le 0.14} \]

\[ \text{Average fuel and filter cost per hour} = 7.81 + 0.14 = 7.95 \text{ Le/hr} \]

(iv) Oil and lubricants

\[ \text{Engine oil consumption} = 0.05 \text{ gal/hr} \]

\[ \text{Engine oil price} = 17 \text{ Le/gal, oil filter} \]

\[ \text{Ls} 118 \text{ changed every 200 hrs} \]

\[ \text{Average engine oil cost} = 0.05 \times 17 = \text{0.85 Le/hr} \]

\[ \text{Oil filter cost} = 0.05 \times 200 = \text{0.50 Le/hr} \]

\[ \text{Transmission oil cost} = 0.03 \times 14 = \text{0.42 Le/hr} \]

\[ \text{Hydraulic oil cost} = 0.03 \times 2 = \text{0.06 Le/hr} \]

\[ \text{Grease cost} = 0.01 \times 3.9 = \text{0.039 Le/hr} \]

\[ \text{Average oil lubricant cost} = \frac{1.508}{8} = \text{0.19 Le/hr} \]

\[ \text{Average operating costs per hour} = \text{E & M + L + P + O = 14.1 + 11 + 7.95 + 0.508 = 34.558 Le/hr} \]

\[ \text{Total cost} = \text{Ownership cost + Operating cost} \]

\[ \text{Total cost per hour} = 114.73 + 34.56 = \text{149.29 Le/hr} \]