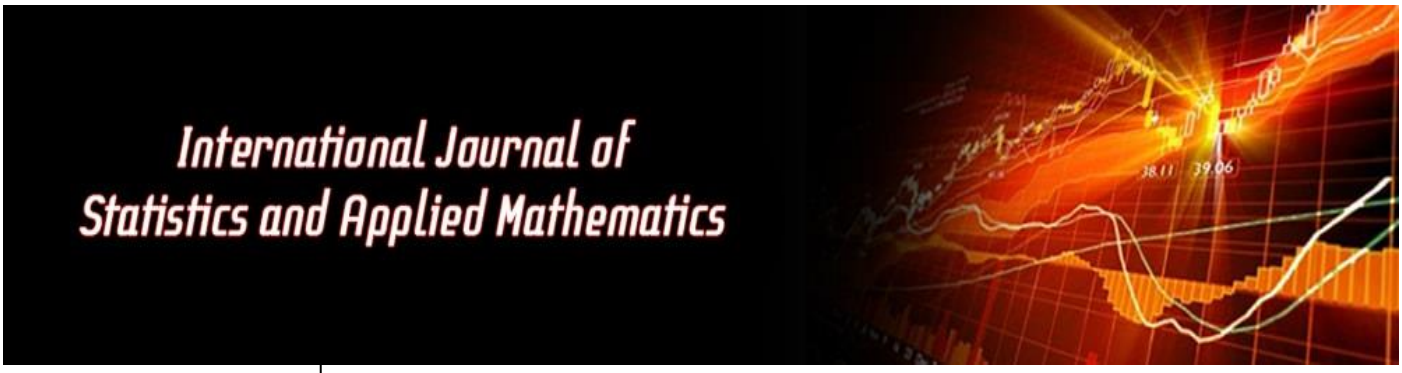

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Review on cost estimation of farm power and machinery

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Abstract
The study aims to assess the various factors influencing the overall cost of owning and operating farm tractors, contributing valuable insights to farmers, manufacturers, and policymakers in the agricultural sector. The research methodology employed a multifaceted approach, combining field surveys, interviews with industry experts, and data collection from diverse sources to ensure a holistic understanding of the cost dynamics involved. The study encompasses both initial acquisition costs and ongoing operational expenses, including fuel consumption, maintenance, and depreciation. Key findings reveal a nuanced interplay of factors affecting tractor costs, such as engine power, brand reputation, and technological features. The analysis delves into the impact of scale, exploring how the size and type of farming operations influence the cost-effectiveness of different tractor models. Moreover, the study evaluates the role of technological advancements, investigating how precision farming technologies and automation contribute to efficiency gains and operational cost reduction. These insights are crucial for farmers seeking to optimize their investments and for manufacturers striving to align product offerings with the evolving needs of the agricultural industry.

Keywords: Encompasses, consumption, maintenance, depreciation

Introduction
In agricultural companies' tractors and other machinery and equipment represent significant expenses (Calcante *et al*., 2013) [1]. The cost of machinery and power has increased recently due to a number of factors, including larger machines, new technology, greater pricing for parts and new machinery, and rising energy prices. One of the most important power sources in agriculture today is the tractor (Singh *et al*., 2014) [7]. Tractor power has a significant impact on agriculture. In recent decades, the employment of modern technology has led to a remarkable increase in agricultural productivity (Rasmussen and W. D. 1982) [2]. Farm equipment and tractors are significant examples of this contemporary technology. There may be significant differences in the quality of the labour and land production in both scenarios as a result of the mechanization inputs (Verma and S. R. 2006) [3]. When land is excluded, the expenses of owning and running farm equipment range from 35 to 50 percent of the total costs of agricultural production (Hunt, 2008) [4]. Under the costs that are associated with running and owning a business is the cost of repair and maintenance, or R and M. Other than repair and maintenance expenses, expenditures typically go down as consumption goes up, but the opposite is true for those expenses. In the beginning, repair and maintenance costs account for 10% of the overall cost; as agricultural machinery age, these costs rise until they represent the greatest portion of the total cost of ownership and operation. Several investigations on the maintenance and repair of farm tractors have been conducted by agricultural technicians (Smith and H. P. 2020) [5]. Numerous research projects were undertaken in developed as well as developing countries, with the aim of creating models to estimate costs over a given time frame or obtaining precise figures to depict the cost of owning and operating specific tractors. When making decisions on machinery management, such as when to trade, what size to buy, how much to buy, etc., accurate cost estimates are crucial.

Specifics of the several tractor cost analysis techniques

Farm machinery expenses fall into two categories: fixed costs, which are incurred regardless of how often the machinery is used, and operating costs, which are directly correlated with machine usage (www. ccs.com).

Fixed costs

These costs depend on how long a machine is owned rather than how much it is used. Fixed cost includes depreciation, interest, taxes, shelter and insurance (Kastens and T. L. 1997) [8].

Operating costs

It fluctuates according to the quantity of machinery utilized. The price of gasoline, oil or lubrication, labour, and repair and maintenance make up the operational costs (www.fao.com).

Fixed cost

1) Depreciation cost

Depreciation is a cost associated with a machine's age, wear, and obsolescence (Ross and M. H. 1960) [10]. When a machine is exchanged or sold, the degree of mechanical wear may make its worth slightly higher or lower than the average for similar equipment. An older machine's residual value may drop sharply due to rapid obsolescence caused by new technology or significant design changes. However, the most crucial elements in figuring out a machine's remaining value are typically its age and total hours of operation. The machine's economic life and its salvage value at the end of the economic life must be given before an estimate of annual depreciation can be computed (Lazarus *et al*., 2022) [11]. A machine's economic life is the number of years that expenses need to be projected. It is frequently less than the machine's service life because most farmers replace their machines before they run out of life (www.lowastateuniversity.com). Unless it is known that the machine will be exchanged sooner, it is generally advisable to adopt an economic life of 10 to 12 years for most farm machinery and 15 years for tractors.

a) Straight Line Method-

The following relationship, Alternative approach, is used to calculate the annual depreciation charge. Depreciated value following n years can be written as-

$$D = \frac{P-S}{L} \quad \text{... eq}^{n} \text{ -1}$$

Where,
P= Purchase price, Rs
S= salvage Value, Rs
L= Economic machine life, years

b) Declining-Balance Method:

It reflects the true value of a machine regardless of age as opposed to the value obtained using the sum of the digits or straight-line methods. When using the decreasing balance technique, a machine's annual percentage of depreciation remains constant, but its annual depreciation varies. The machine's residual value, which includes its salvage value, is subject to an annual uniform rate at the start of the year (Rotz, 1987) [18]. Every year that a machine is in service has a separate depreciation value. It is provided by the subsequent relationship.

$$D = V_n - V_{n-+1} \quad \text{... eqn - 2}$$

$$V_n = P(1-(X/L)^n)$$

$$V_{n+1} = P(1-(X/L)^{n+1})$$

Where,
D= the amount of depreciation charged for year (n+1)
N= the number representing the age of the machine in years at the beginning of the year in question
V= the remaining value at any time
x= the ratio of the depreciation rate used to that of the straight line methods. The value of x may be any number between 1 and 2.
P = Purchase price

2) Interest-

The interest is a sizable, costly expense for agricultural machinery after depreciation. It is a direct cost associated with borrowed money. Even if cash is used to pay for the machinery, that cash is locked up and could be used for other purposes within the company (http://ccs.meerut.ac.in). Although they vary widely, interest rates typically range from 12 to 16 percent. The following formula is used to determine annual interest on an average investment using the current interest rate:

$$I = \frac{P+S}{2} * \frac{\text{i}}{100} \quad \text{... eq}^{n} \text{ - 3}$$

Where, I = annual interest charge, Rs./year
P = purchase price, Rs.
S = salvage value, Rs.
i = interest rate, per cent

3) Taxes, insurance, and housing (TIH)

Although these three expenses are typically far less than interest and depreciation, they nevertheless must be considered. Owning farm equipment is tax-free, but as of late, tractors are subject to taxes. Farm equipment should be insured so that replacement costs can be covered in the event of an accident or fire. The remainder of the agricultural business bears the risk if insurance is not carried. The housing offered for agricultural equipment varies greatly. Ensuring that machinery has access to shelter, tools, and maintenance equipment can reduce field repairs as well as the deterioration of mechanical parts and weathering. More field reliability and a higher trade-in value should result from that. Taxes, insurance, and housing charges are anticipated to cost 3% of the purchase price per year (Makkar *et al*., 2020) [15].

1) Variable costs

a) Fuel cost

There are two methods for estimating fuel expenses. The number of fuel drums used annually is one approach. The tractor's diesel consumption per hour can be computed by dividing the total number of litres by 400 hours. Fuel consumption per hour can be precisely calculated for each operation if a fuel meter is connected to the tractor fuel line.

b) Lubrication

The amount of lubricating oil needed to keep a tractor operating properly is estimated using lubrication oil calculations. In a tractor, it makes up 30% of the total gasoline utilized.

c) Repairs and maintenance

Regular maintenance, wear and tear, and accidents all result in repair costs. Geographical differences in soil type, rocks, geography, climate, and other factors can significantly affect repair costs for a given type of machinery. Due to varying management practices and operator skill levels, repair costs

within a local area range amongst farms. The expenses associated with repair and maintenance is seen as a crucial and substantial aspect of owning machinery. A machine needs regular maintenance and occasional repairs to stay in good operating condition and guarantee a high level of dependability. The more often equipment is used, the more repairs it will require. The costs associated with labour and spare components for repairs performed in a shop or on a farm make up the repair costs (Rotz *et al*., 1991) [13]. Geographical variations in machinery utilization, labour costs, and spare part pricing all contribute to variation in repair costs. Although they tend to level out as a machine ages, repair expenses rise with machine age. The total amount spent on maintenance and repairs.

d) Labour

It is crucial to take labour expenses into account while analyzing machinery since different sized machines require varying amounts of manpower to complete operations like planting or harvesting (www.iimahmedabad.ac.in). Another crucial factor to consider when comparing ownership versus bespoke hiring is labour cost. Because of the time needed for machine maintenance and lubrication as well as travel to and from the field, actual labour hours typically exceed field machine time by 10 to 20 percent.

Table 1: Price of different Tractors

Tractor	Estimated Cost (Lakhs)
MF1035	5
HMT 6522	7.75
ARJUN NOVO 605 DI	7.45
FORD 7500	6.48
JOHN DHEERE5055 E	7.63

a) Fixed cost

It includes depreciation, interest and housing, tax and insurance.

a) Depreciation by Straight line method

The calculated data of various tractors that is estimated by the straight line method is as following.

Table 2: Depreciation cost of different Tractors

Tractor	Depreciation (Rs/hr)
MF1035	46
HMT 6522	70.2
ARJUN NOVO 605 DI	67.25
FORD 7500	58.45
JOHN DHEERE5055 E	68.34

b) Interest

The interest is a sizable, costly expense for agricultural machinery after depreciation. It is a direct cost associated with borrowed money. Interest rates can differ significantly, but typically are in the range of 10%. The calculate data for the interest is described in below table.

Table 3: Interest cost of different Tractors

Tractor	Interest (Rs/hr)
MF1035	27.45
HMT 6522	42.85
ARJUN NOVO 605 DI	41.2
FORD 7500	35.7
JOHN DHEERE5055 E	41.78

c) Insurance, housing and tax

The annual cost of shelter and insurance is equal to 3% of the purchase price. The following is the calculated figures for taxes, housing, and insurance.

Table 4: Insurance, tax and housing cost of different Tractors

Tractor	Estimated value (Rs/hr)
MF1035	14.9
HMT 6522	23.52
ARJUN NOVO 605 DI	22.45
FORD 7500	19.7
JOHN DHEERE5055 E	22.81

b) Variable costs:

It covers the price of labour, fuel, oil or lubrication, and repairs and maintenance.

a) Fuel cost

Fuel usage data is gathered from the tractor log books kept by the Central State Farm in Hisar and the Director of the Farm at CCSHAU. The fuel consumption per hour is shown below based on such data.

Table 5: Fuel cost of different Tractors

Tractor	Fuel cost (Rs/hr)
MF1035	166
HMT 6522	189
ARJUN NOVO 605 DI	180
FORD 7500	193
JOHN DHEERE5055 E	158

b) Lubrication cost

The consumption of lubrication is taken 30% of the fuel cost which is given below in table.

Table 6: Lubrication cost of different Tractors

Tractor	Lubrication cost (Rs/hr)
MF1035	49.8
HMT 6522	56.25
ARJUN NOVO 605 DI	53.9
FORD 7500	58.6
JOHN DHEERE5055 E	47.22

c) Repair and maintenance cost:

6% percent of the tractor's total cost is dedicated to maintenance and repair expenses. Here is a table that shows the estimated cost of maintenance and repairs.

Table 7: Repair and maintenance cost of different Tractors

Tractor	Repair and maintenance cost (Rs/hr)
MF1035	29.9
HMT 6522	46.74
ARJUN NOVO 605 DI	44.9
FORD 7500	39.1
JOHN DHEERE5055 E	45.62

d) Labour cost

One labourer’s cost is calculated to be Rs. 50 per hour. According to the survey, the depreciation cost at the end of the year is between Rs 60,000 and Rs 750,000, but the depreciation cost using the current methodology is different. The cost of repairs and maintenance is deducted from the tractor's overall cost at a rate of 6%; however, the survey indicates that this amount varies depending on the horsepower range of the tractor. Tractors really have a life of 12 to 15

years, not the 10 years that the current formulas assume. Although salvage value is estimated to be 10% of tractor cost in the cost analysis methodology, it is actually between 25% and 30% of tractor cost.

Conclusion

In the agriculture sector, agricultural mechanization is essential because it raises crop output by enhancing the effectiveness and efficiency of the inputs utilized in crop production. Additionally, this lessens the drudgery involved in other agriculture tasks. Ultimately, the conclusions drawn from the Cost Analysis Study of Farm Tractor contribute to a more informed and forward-thinking agricultural landscape. By promoting a balance between economic considerations, technological advancements, and environmental responsibility, this study charts a course towards a more sustainable and resilient future for the vital sector of farm tractor utilization in agriculture.

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