Calculating Costs of Using Farm Machinery: A Standardized Procedure for Hawaii

Wen-yuan Huang, Herbert K. Marutani, Gary R. Vieth,
and Joseph T. Keeler

DEPARTMENTAL PAPER 55

Hawaii Agricultural Experiment Station · College of Tropical Agriculture and Human Resources · University of Hawaii

CONTENTS

Figures

Tables

ACKNOWLEDGMENTS

The authors wish to thank the farm machinery dealers and farmers who contributed information that made this study possible. Special thanks also go to Frederick W. Fujimoto, Chairman of the Oahu County Cooperative Extension Service of Hawaii, for his valuable suggestions.

THE AUTHORS

Wen-yuan Huang is a former Assistant Agricultural Economist and Assistant Professor of Agricultural Economics, College of Tropical Agriculture and Human Resources, University of Hawaii.

Herbert K. Marutani is an Associate Specialist in Farm Management, Department of Agricultural and Resource Economics, College of Tropical Agriculture and Human Resources, University of Hawaii.

Gary R. Veith is an Assistant Agricultural Economist and Assistant Professor of Agricultural Economics, College of Tropical Agriculture and Human Resources, University of Hawaii.

Joseph T. Keeler (deceased) was an Associate Agricultural Economist and Associate Professor of Agricultural Economics, College of Tropical Agriculture and Human Resources, University of Hawaii.

CALCULATING COSTS OF USING FARM MACHINERY: A STANDARDIZED PROCEDURE FOR HAWAII

Wen-yuan Huang, Herbert K. Marutani, Gary R. Vieth, and Joseph T. Keeler

INTRODUCTION

The cost of owning and operating farm machinery is often an important component of the total expenses incurred in crop production. An accurate calculation of production expenses requires a precise estimation of the cost of using machinery.

Previously, authors of cost-of-production studies for various crops in Hawaii used different methods for estimating the expense of using machinery. Consequently, the cost figures derived in the different studies are not comparable. To remedy this, a standardized procedure for estimating the costs of using the machinery is needed.

The American Society of Agricultural Engineering (ASAE) recommends a procedure for computing the costs of using machinery. This procedure, which has been adopted by some researchers in other states (*2, 5*), however, is not directly applicable to all situations in Hawaii. Some modification for cases here may be necessary. For example, the annual utilization rate—and as a result the years of life—of a tractor may vary greatly from farm to farm. This is particularly true in diversified agriculture. It is not surprising that some tractors used on vegetable farms last only a few years, while others may last over 20. This is due not only to variations in farm size but also to great differences in field operations.

The ASAE and many researchers recommend the adoption of a constant machine life, expressed in terms of years, for computing the depreciation costs of the machine. This approach, however, is unrealistic if applied to diversified agriculture in Hawaii because of the considerable variability in the years of machine life. Expressing machine life in terms of hours of machine use rather than years will more accurately reflect conditions in Hawaii.

The objective of this paper is to develop a standardized procedure, applicable to Hawaii, for computing the costs of using machinery in Hawaii. An example is included to illustrate the computation procedure, and a case study is presented to show the costs of using machinery for a typical farmer in Kahuku, on the Island of Oahu. Finally, the question of high costs because of a low annual utilization rate is examined.

Because of considerable variation in machine use among farm operators, it was impossible to determine specific cost figures that could be used by all farmers. However, a framework for computation of the costs of using machinery is presented. A farmer can insert figures to represent his particular situation and thus calculate his appropriate cost figures.

COMPUTATION PROCEDURES

Procedures for computing costs are derived from information in the 1976 Yearbook of the American Society of Agricultural Engineering (*1*). Costs include ownership as well as operating costs, and items under each are summarized below.

Ownership costs (expenses incurred by possessing the machine):

- Depreciation
- Interest on investment
- Sales and property taxes
- Housing
- Insurance

Operating costs (direct expenses from use):

- Repairs and maintenance
- Fuel
- Lubricant cost
- Operator's labor

Ownership Costs

Depreciation

Depreciation is the cost that reflects the reduction in the value of machinery with use and time. The reduction in the machine value results from wear and tear and/or obsolescence. Although the actual depreciation is never known until the equipment has been sold by the farmer, depreciation can be estimated using remaining-value techniques or knowledge of used-equipment values. Some of the techniques for computing remaining values include straight-line depreciation, declining-balance depreciation, and sum-of-the-year digit depreciation, discussions of which can be found in any accounting textbook, such as Vance and Taussig (*4*). Using one of these techniques, the beginning- and end-of-year values for the machine can be calculated. The depreciation cost for the year is the difference between these values.

Every year, the National Farm Power Equipment Dealer's Association estimates the remaining values of machinery from survey data. However, it is doubtful that these estimates can be applied as well to Hawaii as to the United States Mainland, because of the great variability in machine utilization rates in diversified agriculture.

The straight-line method of computing depreciation costs is simple and is used by most farmers in their computation of income tax deductions.[1] The annual depreciation cost (D) is computed by using the formula:

$$D = \frac{P - S}{M} \qquad \ldots (1)$$

where P is the list price of the machine (or equipment)

S is the salvage value

M is the estimated life of the machine (or equipment) in years.

$$M = \frac{\text{Wear-out life, in hours}}{\text{Number of use hours in one year}}$$

[1] To obtain a better estimate for the depreciation cost of equipment in Hawaii, perhaps a survey method should be conducted every year in Hawaii. However it is very doubtful that enough samples for making a reasonable estimation can be obtained.

Interest, Taxes, Housing, and Insurance

Interest, the cost of having money tied up in machinery, can be either a direct out-of-pocket cost or an opportunity cost, depending on whether the money is borrowed or owned. If the money is borrowed, the cost is the interest charge that must be paid. If the money is from savings or earnings, the appropriate charge is an opportunity cost—i.e., what the money could have earned in its best alternative use. The current interest rate for borrowing money is generally used as an estimate of the opportunity cost.

Personal property taxes must be paid on machinery owned (although in Hawaii there are no property taxes for owned machinery), and sales taxes have to be paid for customer service. The housing cost is the expenditure for building and maintaining shelter for the machinery. Insurance is the cost for protection against machinery losses from fire, theft, vandalism, and others; this cost is represented by insurance premiums paid.

The cost of interest is computed from the remaining value of the machinery when a straight-line method is used to calculate the amount of annual depreciation, D. The remaining value of a piece of machinery after K years of use is given as $RV = P - (K \times D)$.

The formula for computing the yearly cost of interest, taxes, housing, and insurance for a piece of equipment in $K + 1$ years of use is:

$$IT = (P - K \times D) \times R + T + H + I \qquad \ldots (2)$$

where IT is the yearly cost
- R is the interest rate
- T is the annual payment for taxes
- H is the annual payment for housing, and
- I is the annual payment for insurance.

If the average annual costs (AC) for these items over the total life of the machine are needed, the costs can be computed by using the following equation:[2]

$$AC = \frac{P(1 + R)^M - S}{[(1 + R)^M - 1]/R} - D + T + H + I \qquad \ldots (3)$$

---

[2]Traditionally, the annual interest charge has been calculated by

$$\frac{P + S}{2} \times R \qquad (A)$$

Kay (*3*) (1973) illustrated that use of the straight-line depreciation method and equation (*A*) for computing average depreciation and interest costs consistently underestimate the "true" costs. He proposed the following formula:

$$\text{Annual depreciation and interest costs} = \frac{P(1 + R)^M - S}{[(1 + R)^M - 1]/R} \qquad (B)$$

This formula is based on the concept that the annual charge for depreciation and interest must be an amount that, when invested at the opportunity rate of return (R) for the remaining life, equals the amount that could have been obtained from the alternative investment.

Equation (*B*) can be used to compute the average annual depreciation and interest costs directly if there is no need to calculate them individually.

When separation of depreciation and interest costs is desired, the average annual interest cost can be computed by using the formula

$$AC = \frac{P(1 + R)^M - S}{[(1 + R)^M - 1]/R} - D \qquad (C)$$

where D is the annual depreciation cost.

To use the above formula to calculate the depreciation, values for the estimated life (M) and salvage value (S) are needed. Under normal use conditions, the life of a machine is determined by dividing the estimated wear-out life in hours (see Table 1 of Appendix) by the hours used annually. This estimate should be considered the upper bound of the machine life. The figures for machines in Hawaii will be lower because climatic factors cause machines to deteriorate faster. Based upon interviews of several farm equipment dealers in Hawaii, 60 to 80 percent of each figure will reasonably reflect local conditions.

The salvage value of a machine will be negligible if the machine has been used to the limit of its life. Five percent of the original machine list price is a reasonable salvage value.

The annual average ownership costs (AOC) are the sum of the depreciation (D) and the charge for interest, housing, taxes, and insurance (AC). That is:

$$AOC = D + AC \qquad \ldots (4)$$

The average ownership costs per hour of use ($AOCH$) are computed by dividing the annual ownership costs (AOC) by the yearly total hours of use (N). That is:

$$AOCH = \frac{AOC}{N} \qquad \ldots (5)$$

Operating Costs

Annual operating expenditures include yearly costs for repairs and maintenance, fuel, lubricant, and operator's labor. These costs vary directly with the hours of use of the machine. Hourly operating costs, however, are considered constant.

*Repairs and Maintenance (*RM*)*

Repairs (R) are those costs related to restoring a machine that has deteriorated through normal wear; these costs are directly related to use. Maintenance costs (M) incurred in preventing excessive deterioration are also directly related to use.

One way of estimating annual RM costs is to divide the expected total RM cost in wear-out life (M) of the machine (derived from Table A-1 of the Appendix and the list price) by the number of years of life. This can be represented as follows:

$$RM = P \times TR/(M \times 100) \qquad \ldots (6)$$

where TR is total repairs in wear-out life, expressed as a percentage of the list price (given in Table A-1 of the Appendix).

For example, the average annual RM costs (RM) for a 2-wheel-drive tractor can be estimated by equation 6: If the list price is \$9000 and the machine life is 25 years, the annual RM cost is ($9000 \times 120/[25 \times 100]$), or \$432.

The hourly RM cost (HRM) is computed by dividing the annual RM cost by the number of hours (N) that the machine is used yearly. That is:

$$HRM = \frac{RM}{N}$$

$$= \frac{P \times TR}{L \times 100} \qquad \ldots (7)$$

where L is wear-out life in hours.

Fuel and Lubricant

Average gasoline consumption in gallons per hour (*GPH*) can be estimated by the formula:

$$GPH = 0.06 \times PTO \text{ hp, max}^{3} \qquad \ldots (8)$$

A diesel tractor will use approximately 73 percent as much fuel, in gallons, as a gasoline tractor. Average diesel consumption in gallons per hour (*DPH*) is:

$$DPH = 0.73 \times GPH^{4} \qquad \ldots (9)$$

The average cost for fuel per hour (*ACF*) is:

$$ACF = P_f \times GPH$$

or

$$P_f \times DPH \qquad \ldots (10)$$

where P_f is price of fuel.

Lubricant cost is the expense for engine oil and filter changes. Based on 100-hour oil change intervals, the consumption of lubricants ranges from 0.01 to 0.025 gallon per hour, depending upon the volume of the engine's crankcase. If oil filters are changed with every second oil change, hourly engine lubricant costs (*LC*) are approximately 15 percent of the hourly fuel cost.[4] That is:

$$LC = 0.15 \times ACF \qquad \ldots (11)$$

Labor

The cost of labor, or the wage rate (*W*), varies. For hired operators, a constant hourly rate is appropriate; for owner-operators, the labor charge should be the opportunity cost. In no instance should the charge be less than the typical community labor rate.

Total Operating Cost

The total operating cost per hour (*TOCH*) is:

$$TOCH = HRM + ACF + LC + W \qquad \ldots (12)$$

Total Cost

The total hourly cost (*THC*) for using the machine is the sum of the average ownership cost per hour and the total operating cost per hour:

$$THC = AOCH + TOCH \qquad \ldots (13)$$

The cost per acre (*CA*) for using the machine is:

$$CA = THC \times \frac{825}{MPH \times W \times E} \qquad \ldots (14)$$

where *MPH* is the traveling speed of the machine in miles per hour

W is the working width of the farm equipment in feet, and

E is the field efficiency of the machine operation. The efficiency is given in Table A-2 of the Appendix.

[3]*PTO* hp, max refers to maximum horsepower of the tractor being considered in the calculations. The consumption formula is given by American Society of Agricultural Engineers *(1)*.

[4]These formulas are recommended by the American Society of Agricultural Engineers *(1)*.

Discussion

These procedures are also applicable to used farm machinery. In such cases the price in the computation is the actual purchase price of the used machinery. The remaining life of the machinery is estimated by subtracting the number of hours that the machinery has been used from the number of hours of normal wear-out life.

The cost per acre or per hour derived from the above procedure is an average one. The procedure does not consider variations in fuel and lubricant for different field operations, field conditions, or ages of the machines. Therefore, these computed costs are not adequate for determining the costs of a farm machine doing a specific field operation. If this information is desired, the previous formula for computing the fuel consumption, equation 8, should be replaced by the following formula:

gal/hr = (equivalent, *PTO* hp required)/(hp-hr per gal at equivalent hp output)

In this formula, the equivalent *PTO* hp required has to be estimated for the specific field operation. The estimation method can be found in the ASAE Yearbook (*1*). The hp-hr per gallon for a specific make and model of tractor can be obtained from the *Nebraska Tractor Test Data,* available from the Department of Agricultural Engineering, University of Nebraska, Lincoln, Nebraska.

An Example of the Computation

A farmer plans to use a 40-hp diesel tractor and a 14-inch plow on his own farm and wants to estimate the costs of using them. He could use the following procedure for computing costs.

Available Information

1. Original price
   Plow: \$400
   Tractor: \$9000
2. Average annual use
   Plow: 120 hr/yr
   Tractor: 300 hr/yr
3. Wage rate
   Tractor operator: \$5.00/hr
4. Fuel cost
   Diesel: \$0.50/gal
5. Plowing speed of tractor
   3 miles/hr
6. Interest rate
   9 percent

Computation of Costs

1. Depreciation

$$\text{Plow: } \frac{(\overset{\text{list price}}{400} - \overbrace{0.05 \times 400}^{\text{salvage value}})}{\underbrace{0.8 \times 2500}_{\text{expected life in hours}}/\underset{\text{annual use, hr/yr}}{120}} = \$22.8/\text{yr}$$

$$\text{Tractor: } \frac{(9000 - 0.05 \times 9000)}{0.8 \times 12000/300} = \$267.19/\text{yr}$$

2. Interest (assuming no taxes, housing, and insurance costs)

$$\text{Plow: } \frac{\overset{\text{list price}}{400}\,(1 + \overset{\text{interest rate}}{0.09})^{\overbrace{\left(\frac{2500}{120} \times 0.8\right)}^{\text{expected life in years}}} - \overbrace{0.05 \times 400}^{\text{salvage value}}}{\left[(1 + 0.09)^{\left(\frac{2500 \times 0.8}{120}\right)} - 1\right] / 0.09} - \underset{\text{annual depreciation}}{22.8} = \$23.87/\text{yr}$$

$$\text{Tractor: } \frac{9000\,(1 + 0.09)^{\left(\frac{12000}{300} \times 0.8\right)} - 0.05 \times 9000}{\left[(1 + 0.09)^{\left(\frac{12000}{300} \times 0.8\right)} - 1\right] / 0.09} - 267.19 = \$594.93/\text{yr}$$

3. Annual ownership costs
Plow: 22.8 + 23.87 = \$46.67/yr
Tractor: 267.19 + 594.93 = \$862.12/yr

4. Ownership cost per hour

$$\text{Plow: } \frac{22.8 + 23.87}{120} = \$\ 0.39/\text{hr}$$

$$\text{Tractor: } \frac{267.19 + 594.93}{300} = \$\ 2.87/\text{hr}$$

5. Repairs and maintenance

$$\text{Plow: } \frac{\overset{\text{list price}}{400} \times \overset{\text{percentage of list price}}{120}}{\underbrace{(2500 \times 0.8)}_{\text{expected life}} \times 100} = \$\ 0.24/\text{hr}$$

$$\text{Tractor: } \frac{9000 \times 120}{(12000 \times 0.8) \times 100} = \$\ 1.13/\text{hr}$$

6. Fuel

$$\text{Tractor: } 0.06 \times \overset{\text{tractor, max hp}}{40} \times \underset{\text{convert from gasoline to diesel}}{0.73} \times \underset{\text{diesel fuel price, \$/gal}}{0.5} = \$\ 0.88/\text{hr}$$

7. Lubricant

$$\text{Tractor: } 0.15 \times \overset{\text{fuel cost}}{0.88} = \$\ 0.13/\text{hr}$$

8. Labor
Opportunity cost: \$5.00

9. Operating cost per hour

Plow: 0.24	=		\$ 0.24/hr
Tractor: 1.13 + 0.88 + 0.13 + 5	=		\$ 7.12/hr

10. Total cost per hour

Plow: 0.39 + 0.24	=	\$ 0.63/hr	
Tractor: 2.87 + 7.11	=	\$ 9.99/hr	
Plow + tractor	=		\$10.62/hr

11. Cost per acre
Field capacity

$$\text{Plowing: } \frac{825}{\text{mph} \times W \times \text{field efficiency}} = \frac{825}{3 \times 1.17 \times 75} = 3.14 \text{ hr/acre}$$

The total cost per acre, therefore, is:

Plow: \$0.63/hr × 3.14 hr/acre	=	\$ 1.98/acre
Tractor: \$9.99/hr × 3.14 hr/acre	=	\$31.37/acre
Plow + tractor	=	\$33.35/acre

A CASE STUDY

A case study was conducted in 1976 to investigate the cost of using farm machinery in Hawaii. A typical watermelon farm in Kahuku, on the Island of Oahu, was selected for the study. Information obtained by interviewing the farmers is shown in Table 1.

The costs for each field operation are shown in Table 2. The hourly cost of pulverizing with the rotovator is relatively high due mainly to the low annual utilization of the rotovator. The total cost of these field operations for 1 acre of watermelon is about \$86.70 annually; costs will undoubtedly be higher if any field operation is repeated and/or if all machinery and equipment are new.

COSTS OF LOW MACHINERY UTILIZATION

By checking the hour meters of the tractors in this study, the authors observed that many farmers use their tractors for relatively few hours annually. Many of the tractors are used less than 300 hours per year. Because of this low utilization of machinery, it is important to determine whether fewer hours of annual use are associated with higher costs for using machinery. In analyzing this issue, the authors employed the computation procedure developed in this paper. As previously defined, the costs of using machinery include ownership and operating costs. By definition, the operating cost in dollars per hour for a machine is the same, regardless of the number of hours used annually. Therefore, ownership costs must be considered in an examination of the relation between annual use and cost of using machinery.

Ownership costs are divided into two parts—depreciation cost and other costs (interest, housing, taxes, and insurance). The formula for computing the depreciation cost implicitly assumes that machines will last for a given number of use hours. Therefore, the depreciation cost per hour of use will be the same, regardless of the number of hours used annually. This implies that a machine with low annual utilization will last more years than a machine with high utilization. In other words, the annual depreciation cost will be lower for the machine with lower annual usage.

The only cost items affected by a low annual use are the costs of interest, housing, taxes, and insurance. Among these, interest cost is the major item. Using the formula previously cited and the

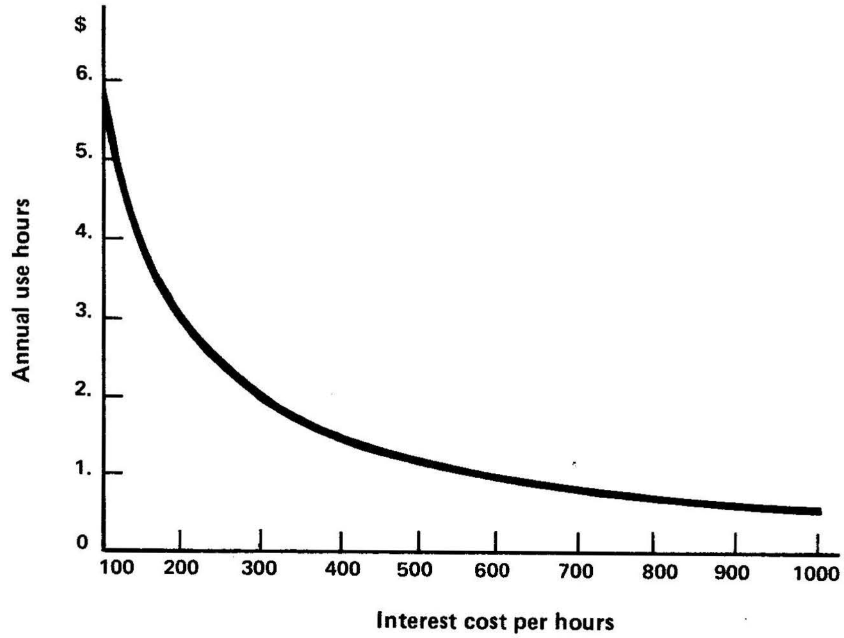

Figure 1. Annual interest cost for a 40-hp tractor with new price of $9000.

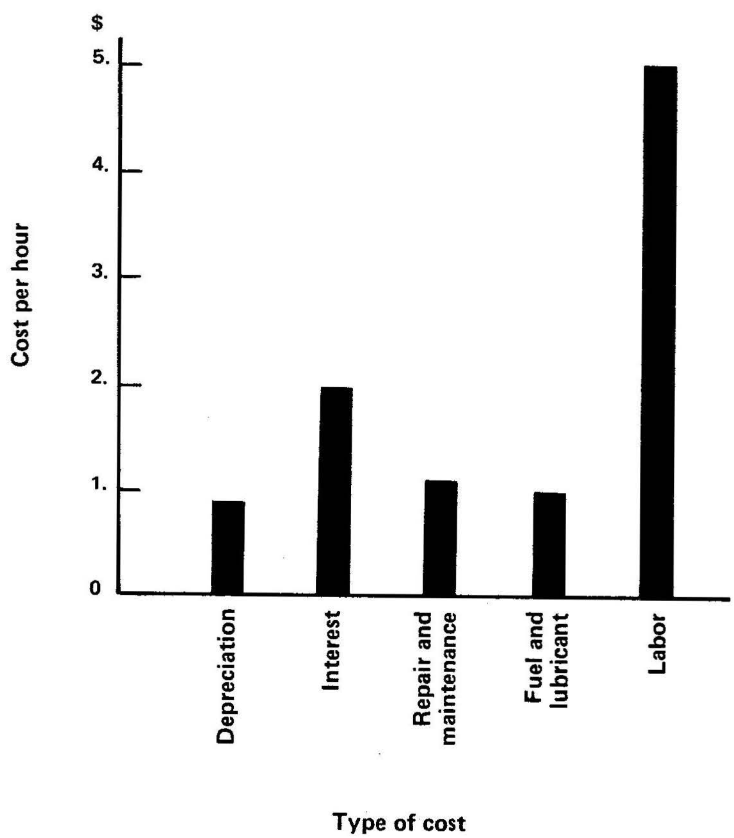

Figure 2. Itemized cost per hour of operation for a 40-hp tractor with new price of $9000 and 300 hours of annual use.

Table 1. Farm machinery on a typical watermelon farm

Machinery	Year bought	Price ($)	Annual use (hours)
Ford 3000 tractor	1969	4800	364
Bean Royal sprayer with 300-gallon tank	1972	3000	300
Ford 4000 tractor	1974	5000[a]	400
Disk harrow (5 ft)	1966	250[a]	12
Subsoiler (4.5 ft)	1966	200	7
Rotovator (5 ft)	1966	2000	6

[a]Used machinery when purchased.

Table 2. Costs of using farm machinery in Hawaii, case study

	Cost				
Operation	Tractor ($/hr)	Equipment ($/hr)	Total ($/hr)	Field capacity (hr/acre)	Cost per acre ($)
Spraying	2.67[a]	6.72	9.39	2.00	18.78
Harrowing[b]	3.97[b]	2.18	6.15	1.45	8.89
Plowing with subsoiler	3.97	2.69	6.66	1.84	12.25
Pulverizing with rotovator	3.97	31.20	35.17	1.33	46.78
Total cost					86.70

[a]Ford 3000 tractor was used.
[b]Ford 4000 tractor was used.

information on the tractor in the example, the interest cost per hour for different numbers of hours of annual use was computed. The results are shown in Figure 1. As seen, the interest cost per hour dropped from $5.72 at 100 hours of annual use to $0.62 at 1000 hours of annual use, indicating that low annual use is associated with a high interest cost for machine use. In the example, the interest cost is $595 per year ($1.98 per hour), while the depreciation cost is only $267 per year ($0.89 per hour). Also, interest is an important component of the total cost of using a machine, second only to labor (see Figure 2) for a low utilization rate. However, it should be noted that the interest cost is less important relative to the total cost of using the machine if annual hourly utilization increases.

This analysis clearly indicates that a farmer who has a low annual machine utilization rate incurs a higher cost for using the machinery. The cost will further increase if the machine does not last to its normal wear-out life (measured in use hours) due to deterioration from long years of use or obsolescence.

SUMMARY AND CONCLUSION

Based on the recommended method of the American Society of Agricultural Engineering, a modified procedure for calculating the costs of using farm machinery in Hawaii was developed. This modified procedure can handle the situations of highly variable annual machine utilization rates of Hawaii's diversified agriculture. An example illustrating the computation procedure and a case study of a typical watermelon farm were presented. The procedure was also used to analyze the relation between costs and annual utilization. The analysis indicated that a farmer who has a low annual machine utilization rate incurs a high cost for using the machine, due mainly to the high interest charge.

LITERATURE CITED

1. American Society of Agricultural Engineering. 1976. Agricultural Engineers' Yearbook, 1976.
2. Economic Research Service, United States Department of Agriculture. 1976. Cost of producing selected crops in the United States, 1974. January 8, 1976. U.S. Government Printing Office, Washington, D.C.
3. Kay, Ronald D. 1973. Calculating ownership costs. Dep. Agr. and Rural Sociology, Texas Agr. Exp. Station. Information Report 73-9, September 1973.
4. Vance, Lawrence L., and Russell A. Taussig. 1972. Accounting principles and control. 3rd ed. Holt, Rinehart and Winston, Inc., New York.
5. Willet, G.S., I. O. Berge, and R. N. Weigle. 1972. Cost of farm machinery. Cooperative Extension Program, Univ. Wisconsin. August 1972.

APPENDIX

Table A-1. Wear-out life and repairs of farm machinery

Machinery	Estimated wear-out life (hours)	Total repairs in wear-out life (percentage of list price)
Stationary power unit	12,000	120
Tractor, 2-wheel drive	12,000	120
Tractor, 4-wheel drive	12,000	100
Tractor, crawler	12,000	100
Wagon and box	5,000	100
Cutter, rotary	2,000	60
Cutter, stalk	2,000	60
Fertilizer equipment, dry	1,200	120
Fertilizer equipment, liquid	1,200	120
Manure spreader	2,500	60
Rake, side delivery	2,500	100
Seeding equipment	1,200	100
Sprayers, mounted	1,200	100
Tillage (plows, planters, cultivators, harrows, etc.)	2.500	120
Truck, feed	2,500	60
Truck, farm	2,000	80
Truck, pickup	2,000	60
Wagon, feed	2,500	100
Harvester, forage, pull-type	2,000	80
Harvester, forage, self-propelled	2,000	60
Sprayer, self-propelled	2,000	80

Source: American Society of Agricultural Engineering, *Agricultural Engineers' Yearbook*, 1976, p. 329.

Table A-2. Machinery performance data

Machine	Typical range for field efficiency (percent)
Tillage	
Moldboard or disk plow	70–90
Chisel plow	70–90
Lister	70–90
One-way disk, 3- to 5-inch depth	70–90
Subsoiler	70–90
Harrow	
Single disk	70–90
Tandem disk	70–90
Offset or heavy tandem disk	70–90
Spring tooth	70–90
Spike tooth	70–90
Rod weeder	70–90
Field cultivator	70–90
Row crop cultivator	70–90
Shallow	70–90
Deep	70–90
Fertilizer and chemical application	
Fertilizer spreader, pull-type	60–75
Sprayer	50–80
Planting	
Grain drill	65–85
Harvesting	
Mower only	75–85
Mower-conditioner, cutterbar-type	60–85
Mower-conditioner, flail-type	60–85
Conditioner only	75–85
Rake	70–85
Baler	60–85
Rotary mower, horizontal blade	60–80

Source: American Society of Agricultural Engineering, *Agricultural Engineers' Yearbook*, 1976, p. 327.

DISCLAIMER

Reference to a company or product name does not imply approval or recommendation of the product by the College of Tropical Agriculture and Human Resources, University of Hawaii, or the United States Department of Agriculture to the exclusion of others that may be suitable.

Hawaii residents may order **single copies** of this publication free of charge from county offices. **Out-of-State inquiries** or **bulk orders** should be sent to the Agricultural Publications and Information Office, College of Tropical Agriculture and Human Resources, University of Hawaii, 2500 Dole Street, Krauss Hall 107, Honolulu, Hawaii 96822. Price per copy to bulk users, sixty cents plus postage.

Hawaii Agricultural Experiment Station, College of Tropical Agriculture and Human Resources, University of Hawaii
William R. Furtick, Dean of the College and Director of the Experiment Station
Noel P. Kefford, Acting Associate Director of the Experiment Station
Departmental Paper 55–December 1979 (1M)