# 3. COST ANALYSIS

## 3-1. Accounting Method

Cost analysis, or cost accounting is a system of accounting in which records of all cash and non-cash costs as well as returns. They are kept for the purpose of preparing an account to show costs of production, returns, and net profit or loss on the enterprise. Examples are labor, power, machinery use, building use, fuel, and interest charges.
When we will examine economical evaluation of farm mechanization, we should evaluate the profit of the farm management system. Generally, the profit is the difference between the income and expenditure. Machinery cost is the major expenditure of farm management system; therefore we will examine it in this chapter. [PR=PS-TC]
Accounting methods of machinery cost are two different ways, which are (1) Cost accounting method and (2) Expenses accounting method.

### 3-1-1. Cost accounting method (ideal or theoretical)

Cost accounting method is to express capital, material and labor for production, e.g. rice production, in terms of money irrespective of whether or not actual payment is made in cash.
For instance:

a) The same machine purchased on subsidy aid or at a reduced price is calculated at the same price.

b) When a son operates a tractor, the wages are calculated as an employed operator.

This method is used for accurate comparison on unified assessment. This is adopted for;

(i) comparison with others for improvement and analysis of management
(ii) to study adaptable newly introduced machinery, and
(iii) development and establishment of new mechanization in the research work for the comparison of economy with that of a conventional method.

### 3-1-2. Expenses accounting method (management expenses)

In spite of purposes, all actual payment and expenditure will be counted in Expenses accounting method, which is called management expenses, too. In this way, when a subsidy is received, it is calculated cheaper accordingly. This method of accounting will reflect the actual condition of incoming and outgoing in the use of machinery, and therefore, has a merit of making many obvious for the management. On the other hand, it is unfit for comparison with machinery service in

other management and consideration for a long-term improvement of management.

Exercise 3-1.

**Table 3-1-1 Contents of Expenses**

| Contents of expense to be involved in | | |
|---|---|---|
| Expense accounting | Expense & cost accounting | Cost accounting |
| Included in expense accounting but not in cost accounting, e.g. neutral expense | Purchase expense or fundamental expense | Expenditure included in cost accounting but not in expense accounting: additional cost |
| Example | | |
| 1. Expenses unrelated to production directly, like as machine depreciation not in present use<br>2. Special depreciation of machinery damage by natural disaster, like floods, fires and earth-quake<br>3. Besides, cash outcomings and outgoings not directly related production | 1. Depreciation<br>2. Repair cost<br>3. Fuel cost<br>4. Lubricant cost<br>5. Wages<br>6. Besides purchase expenses for production | 1. Estimated wages for family labor<br>2. Estimated interest on self-capital<br>3. Machine obtained free of charge because of a sample or for an experiment<br>4.Subsidy to machinery and installation purchased subsidized by the National Treasury<br>5. Beside, estimated price of self-supplies used for production, e.g. home-gathering compost<br>6. Landowner cost |

## 3-2. Fixed Cost

Total cost for the accumulated use of a machine divided by the number of accumulated time units. Usually the time units are years or hours. Total cost is the sum of fixed (ownership) and variable (operating) costs. One of the most important costs influencing profit in farming operations is the cost of owning and operating machinery. There are two main types of machinery costs, as follows;

1. Fixed (Ownership) Costs

Fixed (Ownership) Cost is the cost, which is depend more on how long a machine is owned rather than how much it is used. Ownership costs is defined in ASAE like as; the costs which do not depend on the amount of machine use. Examples are depreciation, interest on investment, taxes, insurance, and storage.

(Refer to ASAE-P496: ASAE-SD.htm : asp496-4)

2. Variable (Operating) Costs.

Variable (Operating) Cost is called operating costs, which is the cost varying in proportion to the amount of machine use. Operating costs are defined in ASAE like as; the costs which depend directly on the amount of machine use. Examples are labor, fuel, lubrication, and repair and maintenance costs.

(Refer to ASAE-P496: ASAE-SD.htm : asp496-4)

Fixed cost is needed whether machinery is used or not, as follows:

1) Depreciation, 2) Taxes, 3) Garage, 4) Insurance, and 5) Interest and 6) Repairing cost sometimes.

The distinction between fixed costs and operating costs is clear for all items listed except depreciation and repairs. While depreciation is more a fixed cost than an operating cost, it is somewhat affected by the amount a machine is used, particularly if the annual use is unusually high or low.

On the other hand, repairs usually vary according to amount of use, but the need for some repairs seems to result from deterioration due to the age of a machine as well as how much it is used.

### 3-2-1. Depreciation

The service life of a machine is needed to estimate depreciation. Service life in turn depends on the feasibility of repairing or replacing worn parts.

The economic life of a machine is a more pertinent measure of the period of time for which depreciation should be estimated. Economic life is defined as the length of time from purchase of a machine to that point where it is more economic to replace with a second machine than to continue with the first.

As a cost, depreciation means a loss in the value of a machine due to time and use. Often, it is the largest of all costs. Machines depreciate, or have a loss of value, for several reasons, including

1. Life, 2 Wear, 3. Obsolescence. Refer to reference 3)

Economic Life of machine is defined in ASAE like as; The useful service life of a machine before it becomes unprofitable for its original purpose due to obsolescence or wear. (Refer to ASAE S495 )

Table 3-2-1. shows the economic life of machine in Japan.

**Table 3-2-1 Economic life (Years of Durability) of Farm Machinery**

| Machinery | Name of machine | Economic life (Years of Durability) |
|---|---|---|
| Prime mover | Motor | 10 |
| | Gasoline engine, Diesel engine | 8 |
| Riding type tractor | | 8 |
| Plow & leveling equipment | Plow, Rotary, Harrow, Puddling machine, | 5 |
| Seeder, Cultivator | Manure spreader, Fertilizer & seeder, Rice transplanter, Power sprayer | 5 |
| Irrigation & Drainage equipment | | 8 |
| Harvesting machine | Combine, Thresher | 8 |
| Post-harvesting machine | Milling machine, Flour machine | 10 |
| | Box for crop after harvesting | 3 |
| Processing Machine | Rush grass harvester, Straw rope machine | 5 |
| Equipment of animal husbandry | Forage harvester, Hay mower, Hay baler, Milker | 5 |
| | Self-propelled forage harvester etc. | 8 |
| Transporting Machine | Trailer, Wagon | 4 |
| | Vehicle (less than 2000 cc) | 3 |
| | Vehicle (more than 2000 cc) | 5 |
| Other farm equipment | Snow remover | 4 |
| | Machinery mainly made by steel | 10 |
| | Others | 5 |

References: Ministry of Agriculture, Forestry & Fishery in Japan

(Refer to Table A-426. in appendix)

There are two different ways mainly to calculate depreciation, as follows:

1. Straight-line depreciation (Constant amount each year)
2. Declining-balance depreciation (Constant rate each year)

a) Straight-line depreciation (Constant amount each year)

With the straight-line depreciation method, an equal reduction of value is used for each year over the economic life of a machine. This method can always be used to estimate costs over a specific period of time, provided the proper salvage value is used for the life of the machine.

Straight-line depreciation can be computed by the following formula:

$$D = (P - S) / L \qquad \text{Eq. 3-2-1}$$

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| D | Annual depreciation | $/year | 90 |
| P | Purchase price | $ | 1,000 |
| S | Salvage value | $ | Purchase Price * 0.1 = $100 |
| L | Economic life | year | 10 |

Refer to Table A-427, and fm-421b.xls

This method is the simplest as it charges an easily calculated, constant amount each year.

Durability hours (Total service hour) will show more actual value shown in Table A-426 in appendix.

Exercise 3-2.

b) Declining-balance depreciation (Constant rate each year)

A uniform rate is applied each year to the remaining value of the machine at the beginning of the year. The depreciation amount is different for each year of the machine's life.
Following equations express the relationships by formulas.

$$R_{i+1} = Ri * (1 - r) \qquad \text{Eq. 3-2-2}$$

$$S = P * (1 - r) **L \qquad \text{Eq. 3-2-3}$$

$$S / P = (1 - r) **L \qquad \text{Eq. 3-2-3a}$$

Or,

$$P - S = P * r + P *(1-r)* r + P *(1-r)**2 * r + \quad + P *(1-r)**(L-1)* r \qquad \text{Eq. 3-2-3b}$$

Where,

| symbol | term | unit |
|---|---|---|
| Ri | Remained value of i year | $ |
| P | Purchase price | $ |
| S | Salvage value, normally P * 0.1 | $ |
| L | Economic life | year |
| r | Constant depreciation rate | in decimal |

Actually constant depreciation rate r will be obtained by solving 0.1*P = P * (1 - r) **L
from Eq. 3-2-3. r = 1 - (S/P)**(1/L) and r = 1- 0.1**(1/L).

Refer to fm-421b.xls : get-r

Annual depreciation charge for i year will be as followings;

$$Di = [P * (1 - r) ** (i - 1)] * r \qquad \text{Eq. 3-2-4}$$

or,

$$Di = R_{i-1} * r \qquad \text{Eq. 3-2-5}$$

| symbol | term | unit |
|---|---|---|
| Di | Depreciation charge for i year | $ |

**Table 3-2-2 Remaining Values of Machines Expressed as Percentages of Purchase Price for Each Year of Life**

| | Year | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Straight-line | 100 | 91 | 82 | 73 | 64 | 55 | 46 | 37 | 28 | 19 | 10 |
| Declining-balance | 100 | 80 | 63 | 50 | 40 | 32 | 25 | 20 | 16 | 13 | 10 |

where r = 0.2057,10 year life and 10% salvage value assumed

Refer to fm-421b.xls , reference 3) and reference 13

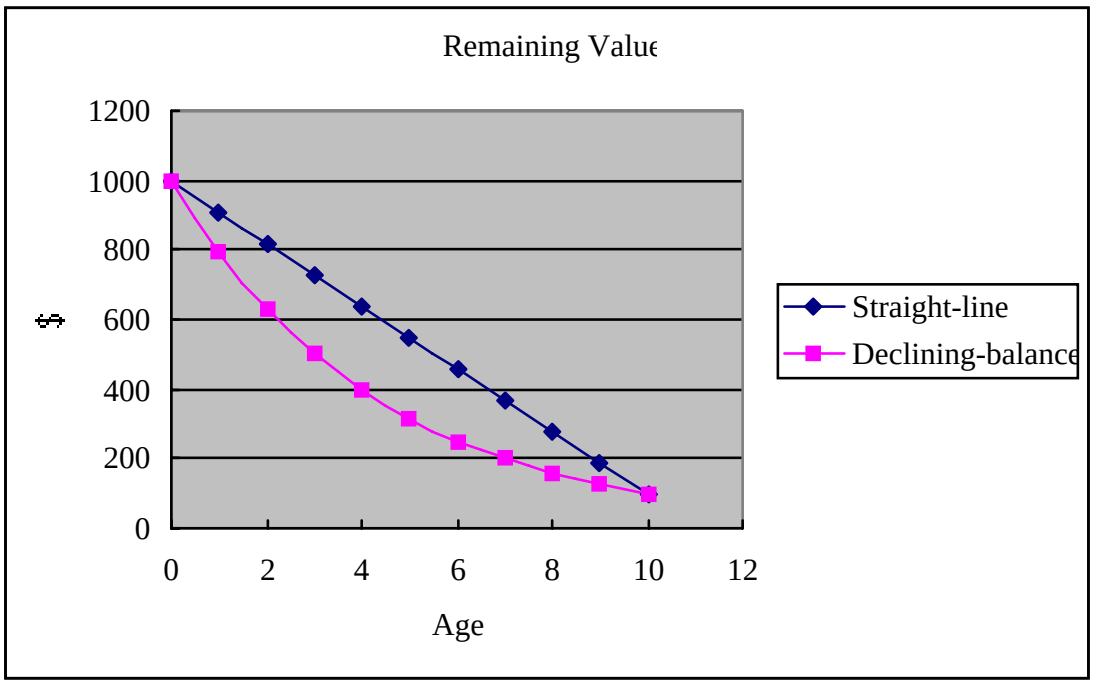


**Fig. 3-2-1 Remaining Value**

Exercise 3-3. , 3-4.

c) Obtain annual depreciation

In this textbook, next formula is used.

**AD = P * RD** **Eq. 3-2-6**

RD = (1 / L) * 100 Eq. 3-2-6a

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| AD | Annual depreciation | $/year | 125 |
| P | Purchase price | $ | 1,000 |
| RD | Annual depreciation rate | % | 12.5 |
| L | Economic life | year | 8 |

### 3-2-2. Taxes

Taxation caused by the purchase and use of machines is limited to the municipal property tax, the light car tax, the local farm machinery tax as special automobiles.

There are the registration fee, inspection fee, and the number plate fee of the tractor, but not uniform by local. The foundation for integration, strictly speaking, is considerably complicated, so it is expressed in terms or rate to initial cost. In cost calculation, approximately 0.5 % is taken into account.

Generally yearly taxation and its sum are calculated as follows.

**AT = P * rtax** **Eq. 3-2-7**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| AT | Annual taxes | $ | 5 |
| P | Initial price | $ | 1,000 |
| rtax | Tax rate | in decimal | 0.005 |
| RT | Tax rate | % | 0.5 |

Exercise 3-5.

### 3-2-3. Garage(Housing or Shelter)

Housing expense will be obtained from the following equation.

**AG = P * rg** **Eq. 3-2-8**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| AG | Annual garage cost | $/year | 56 |
| P | Initial price | $ | 10,000 |
| rg | Garage cost rate | in decimal | 0.0056 |
| RG | Garage cost rate | % | 0.56 |

### 3-2-4. Insurance

Insurance is necessary against the risk of accident or disaster. In the calculation of insurance fee, it is expressed in the rate of insurance fee to initial price and generally 0.25- 0.5 % is estimated and is obtained from the following equation.

**AP = P * rp** **Eq. 3-2-9**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| AP | Annual insurance fee | $/year | 25 |
| P | Initial price | $ | 10,000 |
| rp | Premium rate | in decimal | 0.0025 |
| RP | Premium rate | % | 0.25 |

### 3-2-5. Interest

A large expense item for agricultural machinery is interest. It is a direct expense item on borrowed capital. Even if cash is paid for purchased machinery, money is tied up that might be available for use elsewhere in the business. Interest rates vary but usually will be in the range of 5 to 12 percent.

Capital interest decreases according as machinery gets old and assessment falls. Actually, however, it is convenient to know it as yearly mean interest like as depreciation.

**AI = [(P + R) / 2] * ri** **Eq. 3-2-10**

We use R=0 in planning of farm work in this textbook, then:

**AI = P / 2 * ri** **Eq. 3-2-10a**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| AI | Annual interest | $/year | 308 |
| P | Initial price | $ | 10,000 |
| R | Remaining value | $ | 1,000 |
| ri | Yearly interest rate | in decimal | 0.056 |

Exercise 3-6.

### 3-2-6. Repairing cost (include maintenance)

Maintenance and repair costs vary depending on (i) how to use machinery, (ii) attention an operator skill, (iii) age of the machine, (iv) service hours, and (v) service environments, naturally resulting in a difference each.

But for mechanization planning, yearly mean repair cost including economic life (years of durability) will be used. In the calculation of repair cost in mechanization plan generally overall repair cost from purchase to disuse is shown at the rate to purchase price.

A part of them is accounted as fixed cost, because maintenance is necessary seasonally. Also, it is occurred proportional to working hour, that is, a part of them is accounted as variable cost.

We introduce Ratio of fixed to total of repairing cost (rfr=0.5) for how to estimate the repair cost; an example shows a half of Total repair cost [TRC] as fixed cost, and a half of it as variable cost.

**TRC = P * er** **Eq. 3-2-11**

**TRC = TRCf + TRCv** **Eq. 3-2-12**

**TRCf = TRC * rfr = P * er * rfr** **Eq. 3-2-13**

Annual repair fixed cost [AR] will be obtained from Total repair cost as fixed cost [TRCf] dividing by Economic life [L].

**AR = TRCf / L**

**= P * RR / 100** **Eq. 3-2-14**

Where, RR = er *100 * rfr / L = ER * rfr / L

| symbol | term | unit | Example |
|---|---|---|---|
| P | Initial price | $ | 5,000 |
| er | Overall repair cost coefficient | in decimal | 0.6 |
| ER | Overall repair cost coefficient | % | 60 |
| TRC | Total repair cost | $ | 3,000 |
| rfr | Ratio of fixed to total of repairing cost | in decimal | 0.5 |
| TRCf | Total repair cost as fixed cost | $ | 1500 |
| TRCv | Total repair cost as variable cost | $ | 1500 |
| RR | Repair cost rate | % | 3.75 |
| AR | Annual repair fixed cost | $/year | 187.5 |
| L | Economic life | year | 8 |

Repair cost coefficient will show more actual value shown in Table A-426. in appendix.

Refer to fm-427Fixedcost.xls [3.Machine-FC]

## 3-2-7. Annual fixed cost (annual ownership cost)

(How to obtain and use fixed cost)

Other fixed costs: Taxes, housing, and insurance can be estimated as percentages of the purchase price. If the actual data are not known, the following percentage can be used:

-- taxes 0.5 - 1.0 %

-- housing 0.75 - 1.0 %

-- insurance 0.25-0.5 % of purchase price

Total annual fixed costs: A simple estimate of total annual fixed costs is given by multiplying the purchase price of the machine by the fixed cost percentage.

**FC = AD + AT + AG + AP + AI + AR** **Eq. 3-2-15**

**RAF = RD + RT + RG + RP + RI + RR** **Eq. 3-2-16**

**FC = P * raf** **Eq. 3-2-17**

FC = P * RAF / 100 Eq. 3-2-17a

Where,

AD = P * RD /100
AT = P * RT /100
AG = P * RG /100
AP = P * RP /100
AI = P * RI /100
AR = P * RR /100

| symbol | term | unit | Example |
|---|---|---|---|
| FC | Annual fixed costs | $/year | 3,260 |
| AD | Annual depreciation | $/year | 1,667 |
| AT | Annual taxes | $/year | 100 |
| AG | Annual garage cost | $/year | 300 |
| AP | Annual insurance fee | $/year | 50 |
| AI | Annual interest | $/year | 560 |
| AR | Annual repairing cost | $/year | 583 |
| RAF | Annual fixed cost rate | % | 16.3 |
| RD | Annual depreciation rate | % | 8.33 |
| RT | Annual taxes rate | % | 0.50 |
| RG | Annual garage cost rate | % | 1.50 |
| RP | Annual insurance rate | % | 0.25 |
| RI | Annual interest rate | % | 2.80 |
| RR | Annual repairing cost rate | % | 2.92 |
| P | Initial price | $ | 20,000 |
| raf | Annual fixed cost rate | in decimal | 0.163 |

Refer to reference-7 ASAE-P496 ( ASAE-SD.htm ), Table 3-2-3 and fm-427Fixedcost.xls [3.Machine-FC]

Exercise 3-7.

## Table 3-2-3 Annual fixed cost rate

| | | Annual fixed cost rate (%) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Name of machine | Economic life | Annual fixed cost rate | Depreciation | Repair cost | Garage cost | Capital interest | Tax fee | Insurance fee |
| Symbol | L | RAF | RD | RR | RG | RI | RT | RP |
| Unit | year | % | % | % | % | % | % | % |
| Walking type tractor | 10 | 19.6 | 10.00 | 2.50 | 3.5 | 2.80 | 0.50 | 0.25 |
| Riding type tractor | 12 | 16.3 | 8.33 | 2.92 | 1.5 | 2.80 | 0.50 | 0.25 |
| Plow for tiller | 8 | 21.6 | 12.50 | 2.50 | 3.0 | 2.80 | 0.50 | 0.25 |
| Japanese plow for tractor | 10 | 18.6 | 10.00 | 2.00 | 3.0 | 2.80 | 0.50 | 0.25 |
| Bottom plow | 10 | 21.1 | 10.00 | 2.00 | 5.5 | 2.80 | 0.50 | 0.25 |
| Rotary | 8 | 23.2 | 12.50 | 3.13 | 4.0 | 2.80 | 0.50 | 0.25 |
| Disk harrow | 10 | 20.6 | 10.00 | 2.00 | 5.0 | 2.80 | 0.50 | 0.25 |
| Teeth harrow | 15 | 16.7 | 6.67 | 1.00 | 5.5 | 2.80 | 0.50 | 0.25 |
| Sub-soiler | 10 | 17.6 | 10.00 | 1.00 | 3.0 | 2.80 | 0.50 | 0.25 |
| Trencher | 8 | 21.2 | 12.50 | 3.13 | 2.0 | 2.80 | 0.50 | 0.25 |
| Roller | 15 | 17.9 | 6.67 | 1.67 | 6.0 | 2.80 | 0.50 | 0.25 |
| Culti-packer | 15 | 17.9 | 6.67 | 1.67 | 6.0 | 2.80 | 0.50 | 0.25 |
| Puddling machine | 6 | 26.1 | 16.67 | 0.83 | 5.0 | 2.80 | 0.50 | 0.25 |
| Puddling harrow | 8 | 23.6 | 12.50 | 2.50 | 5.0 | 2.80 | 0.50 | 0.25 |
| Manure-spreader | 10 | 17.1 | 10.00 | 1.50 | 2.0 | 2.80 | 0.50 | 0.25 |
| Lime-sower | 10 | 20.1 | 10.00 | 1.00 | 5.5 | 2.80 | 0.50 | 0.25 |
| Broad-caster | 10 | 18.1 | 10.00 | 1.00 | 3.5 | 2.80 | 0.50 | 0.25 |
| Drill-seeder | 10 | 17.6 | 10.00 | 2.00 | 2.0 | 2.80 | 0.50 | 0.25 |
| Rice Transplanter | 7 | 24.9 | 14.29 | 3.57 | 3.5 | 2.80 | 0.50 | 0.25 |
| Power sprayer | 8 | 20.1 | 12.50 | 2.00 | 2.0 | 2.80 | 0.50 | 0.25 |
| Power duster | 8 | 20.1 | 12.50 | 2.00 | 2.0 | 2.80 | 0.50 | 0.25 |
| Speed sprayer | 8 | 20.1 | 12.50 | 2.00 | 2.0 | 2.80 | 0.50 | 0.25 |
| Reaper | 8 | 20.6 | 12.50 | 2.50 | 2.0 | 2.80 | 0.50 | 0.25 |
| Head-feeding type Combine | 7 | 22.9 | 14.29 | 3.57 | 1.5 | 2.80 | 0.50 | 0.25 |
| Standard-type Combine | 10 | 17.6 | 10.00 | 2.50 | 1.5 | 2.80 | 0.50 | 0.25 |
| Power thresher | 8 | 19.9 | 12.50 | 1.88 | 2.0 | 2.80 | 0.50 | 0.25 |
| Power husker | 10 | 17.1 | 10.00 | 1.50 | 2.0 | 2.80 | 0.50 | 0.25 |
| Grain dryer | 9 | 19.3 | 11.11 | 1.67 | 3.0 | 2.80 | 0.50 | 0.25 |
| Forage-harvester | 10 | 19.6 | 10.00 | 2.50 | 3.5 | 2.80 | 0.50 | 0.25 |
| Self-propelled type forage harvester | 10 | 18.1 | 10.00 | 2.50 | 2.0 | 2.80 | 0.50 | 0.25 |
| Potato harvester | 10 | 19.6 | 10.00 | 2.50 | 3.5 | 2.80 | 0.50 | 0.25 |
| Self-propelled type potato harvester | 10 | 18.1 | 10.00 | 2.50 | 2.0 | 2.80 | 0.50 | 0.25 |
| Beat harvester | 10 | 19.6 | 10.00 | 2.50 | 3.5 | 2.80 | 0.50 | 0.25 |
| Self-propelled type beat harvester | 10 | 18.1 | 10.00 | 2.50 | 2.0 | 2.80 | 0.50 | 0.25 |
| Trailer | 12 | 15.7 | 8.33 | 0.83 | 3.0 | 2.80 | 0.50 | 0.25 |
| Trailer for tiller | 8 | 20.3 | 12.50 | 1.25 | 3.0 | 2.80 | 0.50 | 0.25 |
| Truck | 8 | 19.1 | 12.50 | 1.56 | 1.5 | 2.80 | 0.50 | 0.25 |
| Rice nursery plant | 8 | 18.3 | 12.50 | 1.25 | 1.0 | 2.80 | 0.50 | 0.25 |

from: Zennoh, H2, 1990 etc. See appendix/fm-427FixedCost.xls

**Example**: Calculation of Annual fixed cost

Calculation of Annual fixed cost of a work will be varied by share of each machine, and it is shown by following equation.

a) Share % of this machine operating time at a work: Sp

[Sp] will be obtained from [operating time at a work] divided by [total operating time per year of this machine].

**FC_W = FC * sp** **Eq. 3-2-18**

where,

| symbol | term | unit | Example |
|---|---|---|---|
| FC_W | Fixed cost of a work | $ | 300 |
| FC | Fixed cost | $ | 1,000 |
| sp | Share of machine at a work | in decimal | 0.30 |
| Sp | Share of machine at a work | % | 30 |

Exercise 3-8.

## 3-3. Variable Cost

Variable cost is needed in actual operation, as follows:
1) Fuel, 2) Lubrication, 3) Maintenance and Repairs, and 4) Labor cost.

### 3-3-1. Fuel

Fuel cost is the cost of average fuel consumption for tractors or machinery. Annual average fuel requirements for tractors or machinery may be used in calculating overall machinery costs for a particular enterprise. However, in determining the cost for a particular operation such as plowing, the fuel requirement should be based on the actual power required.

Estimate fuel consumption rate per hour (FRh) or per hectare (FRa) is shown in Table A-211 and A-431 in appendix.

Average annual fuel consumption for a specific make and model tractor can be approximated from the Nebraska Tractor Test Data.

Refer to reference-7 ASAE-P496 ( ASAE-SD.htm )

Exercise 3-9.

### 3-3-2. Lubrication

There are two ways to consider regarding lubricant cost.

(1) One is to measure actual engine oil, and grease to be fed when at work, and calculate of lubricant cost actually.

(2) The other is to calculate fuel costs including lubricant, engine oil, and grease collectively multiplying given rate. Cost calculation method can be use 30 % of fuel cost.

### 3-3-3. Repair cost

**TRC = P * er** **Eq. 3-3-1**

**TRCv = TRC * (1-rfr)** **Eq. 3-3-2**

**VRh = TRCv / TSh** **Eq. 3-3-3**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| P | Initial price | $ | 5,000 |
| er | Overall repair cost coefficient | in decimal | 0.4 |
| ER | Overall repair cost coefficient | % | 40 |
| TRC | Total repair cost | $ | 2,000 |
| rfr | Ratio of fixed to total of repairing cost | in decimal | 0.5 |
| TRCv | Total repair cost as variable cost | $ | 1,000 |
| TSh | Total service hour | h | 1,200 |
| VRh | Repair cost per hour | $/h | 0.83 |

Refer to 3-2-6.and .fm-4repa.xls

### 3-3-4. Labor cost

The cost of labor (wage) varies with region or location. For owner-operators, labor cost should be determined from alternative opportunities for use of time. For hired operators, a constant hourly rate is appropriate. In no instance should the charge be less than a typical, community labor rate.

**VLh1 = VWh1 * Nop** **Eq. 3-3-4**

**VLh2 = VWh2 * Naw** **Eq. 3-3-5**

**VLh = VLh1 + VLh2** **Eq. 3-3-6**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| Nop | No. of Operator | - | 1 |
| VWh1 | Wage of Operator | $/h | 13.0 |
| VLh1 | Operator cost | $/h | 13.0 |
| Naw | No. of Assistant worker | - | 2 |
| VWh2 | Wage of Assistant worker | $/h | 10.0 |
| VLh2 | Assistant worker cost | $/h | 20.0 |
| VLh | Variable cost per hour: labor | $/h | 33.0 |
| Nw | Total worker | | 3 |

### 3-3-5. Material cost

Material cost (Seed, Fertilizer, Chemicals etc.) is calculated from actual price of the material consumed in farm work.

**VMTa = MRa * Pm** **Eq. 3-3-7**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| Name | Material | | Compound fertilizer |
| MRa | Amount | kg/ha (,L/ha) | 500 |
| Pm | Price | $/kg (, $/L) | 0.77 |
| VMTa | Material cost per ha | $/ha | 385.0 |

### 3-3-6. Total variable cost

**VC = VF+ VLU + VR + VL + VMT [+ TCC]** **Eq. 3-3-8**

Where,

| symbol | term | unit |
|---|---|---|
| VC | Total variable cost of a farm work | $ |
| VF | Fuel cost of a farm work | $ |
| VLU | Lubricant cost of a farm work | $ |
| VR | Repairing cost of a farm work | $ |
| VL | Labor cost of a farm work | $ |
| VMT | Material cost of a farm work | $ |
| TCC | Total Custom (Contract) charge | $ |

### 3-3-7. Annual (total) cost per ha of a work

We will discuss the total cost of a farm work comparing with custom charge of it in this chapter. And economical evaluation of the farm work system will be done in chapter 5.

For the economic analysis of farm work, it is most important to estimate the annual cost per hectare. Annual cost per hectare of a machine or of a farm work will be obtained as follows.

**TC = FC + VC** **Eq. 3-3-9**

**TCa = FC / Aa + VCa** **Eq. 3-3-10**

Where,

| symbol | term | unit |
|---|---|---|
| TC | Annual (total) cost | $/year |
| FC | Annual (total) fixed cost | $/year |
| VC | Annual (total) variable cost | $/year |
| TCa | Annual cost per hectare | $/ha |
| Aa | Annual operation area | ha/year |
| FCa | Annual fixed cost per ha | $/ha |
| VCa | Annual variable cost per ha | $/ha |

Annual variable cost per ha (VCa) is independent from Annual operation area (Aa), therefore it is constant when Aa is changed.

Sample: 1. Land preparation: FC = 1,350 $/year, VCa = 61 $/ha, Custom charge = 300$/ha

| Annual Operation Area (ha/year) | Annual Fixed Cost ($/year) | Annual Variable Cost ($/year) | Annual Total Cost ($/year) |
|---|---|---|---|
| Aa | FC | VC | TC |
| 0.5 | 1,350 | 30 | 1,380 |
| 1 | 1,350 | 61 | 1,411 |
| 2 | 1,350 | 122 | 1,472 |
| 3 | 1,350 | 183 | 1,533 |
| 4 | 1,350 | 244 | 1,594 |
| 5 | 1,350 | 305 | 1,655 |
| 6 | 1,350 | 366 | 1,716 |
| 7 | 1,350 | 426 | 1,776 |
| 8 | 1,350 | 487 | 1,837 |
| 9 | 1,350 | 548 | 1,898 |
| 10 | 1,350 | 609 | 1,959 |

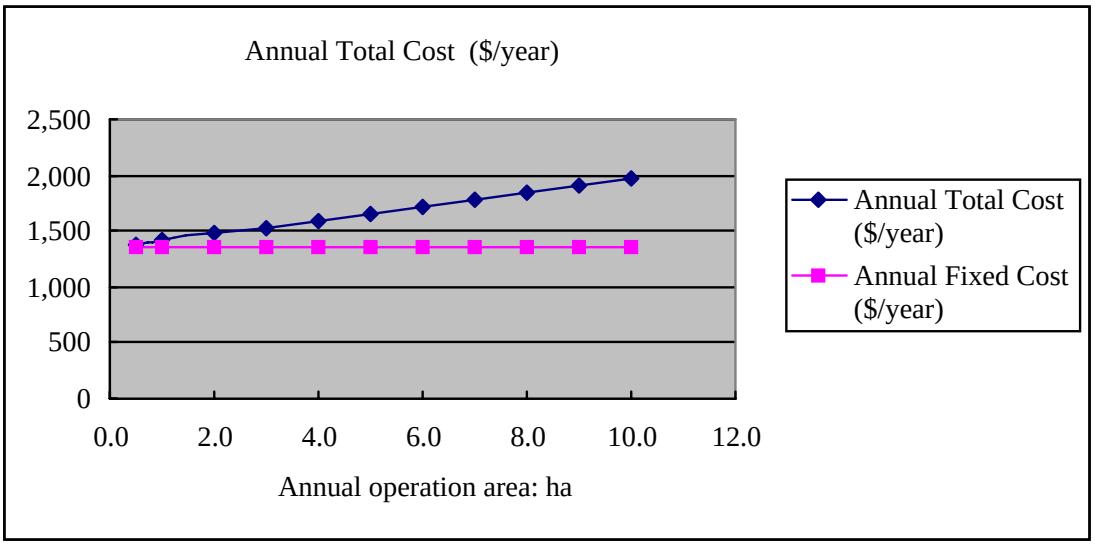


**Fig. 3-3-1 Annual Total Cost vs. Annual operation area**

Refer to fm-451p.xls : total-cost-1

Sample:2

| Annual operation area (ha) | Fixed cost per ha ($/ha) | Variable cost per ha ($/ha) | Cost per ha ($/ha) |
|---|---|---|---|
| Aa | FCa | VCa | TCa |
| 0.5 | 2,700 | 61 | 2,761 |
| 1 | 1,350 | 61 | 1,411 |
| 2 | 675 | 61 | 736 |
| 3 | 450 | 61 | 511 |
| 4 | 338 | 61 | 398 |
| 5 | 270 | 61 | 331 |
| 6 | 225 | 61 | 286 |
| 7 | 193 | 61 | 254 |
| 8 | 169 | 61 | 230 |
| 9 | 150 | 61 | 211 |
| 10 | 135 | 61 | 196 |

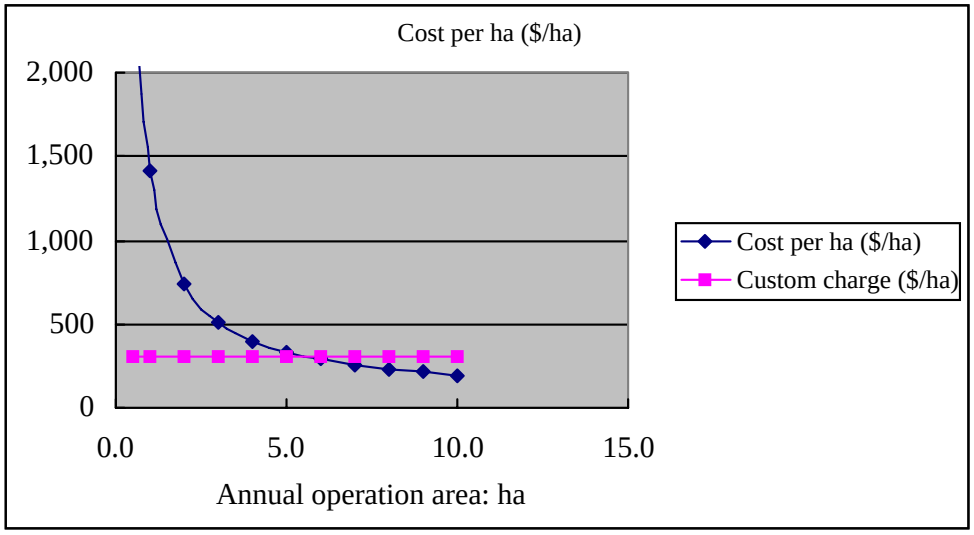


**Fig. 3-3-2 Annual cost per ha ($/ha) vs. annual operation area (ha)**

Refer to fm-451p.xls : cost-ha-1

Exercise 3-10. , 3-11.

a) Annual fixed cost per ha

**FCa = FC / Aa** **Eq. 3-3-11**

**FCa = Σ[(Pi * RAF * Sp / (Aa * 100**2))]** **Eq. 3-3-12**

where,

| symbol | term | unit |
|---|---|---|
| FCa | Annual fixed cost per ha | Yen/ha or $/ha |
| Pi | Initial price | Yen or $ |
| RAF | Annual fixed cost rate | % |
| FC | Annual (total) fixed cost | $/year |
| Aa | Annual operation area | ha |
| Sp | Share of work | % |

b) Annual variable cost per ha of a work

Annual variable cost is consist of fuel, oil, repair, labor and material cost.

$$\mathbf{VCa = VFa + VLUa + VRa + VLa + VMTa (+ CC)} \qquad \textbf{Eq. 3-3-13}$$

Variable cost per ha will be modified from variable cost per hour by using Effective Field Efficiency (EFC) as followings.

$$\mathbf{VFa = VFh / EFC}$$

Where,

| symbol | term | unit |
|---|---|---|
| VFa | Fuel cost per ha of a farm work | $/ha |
| VFh | Fuel cost per hour of a farm work | $/h |
| VLUa | Lubricant cost per ha of a farm work | $/ha |
| VLUh | Lubricant cost per hour of a farm work | $/h |
| VRa | Repairing cost per ha of a farm work | $/ha |
| VRh | Repairing cost per hour of a farm work | $/h |
| VLh | Labor cost per ha of a farm work | $/ha |
| VLh | Labor cost per hour of a farm work | $/h |
| VMTa | Material cost per ha of a farm work | $/ha |

Annual variable cost per ha (VCa_S) is summation of variable cost per ha (VCa_W) of each farm work.

c) Custom Charge

Annual variable cost per ha (VCa) will include [Custom Charge: CC] when work is done by contract operation.

Table 3-3-1 Variable Cost Sample: Puddling work

| term | symbol | unit | data |
|---|---|---|---|
| Machine-1 | | | Walking Tractor |
| Machine-2 | | | Puddling harrow |
| No. of machine set | M | | 1 |
| Type of work | **TOW** | | M |
| Machinery | | | |
| Fuel consumption | FRh | L/h | 3.00 |
| | EFC | ha/h | 0.16 |
| | FRa | L/ha | 18.8 |
| | fuel | | D |
| | Pf | $/L | 0.38 |
| | VFh | $/h | 1.15 |
| Lubricant oil | VLUh | $/h | 0.34 |
| Repair cost per hour | VRh1 | $/h | 1.13 |
| | VRh2 | $/h | 0.08 |
| Repair cost per hour | VRh | $/h | 1.20 |
| Variable cost per hour: machine | VMh | $/h | 2.69 |
| Variable cost per ha: machine | VMa | $/ha | 16.81 |
| Labor | | | |
| operator | Nop | - | 1 |
| | VLh1 | $/h | 13.6 |
| Assistant worker | Naw | - | 0 |
| | VLh2 | $/h | 0.0 |
| Total worker | Nw | | 1 |
| Variable cost per hour: labor | VLh | $/h | 13.6 |
| Variable cost per ha: labor | VLa | $/ha | 85.2 |
| Material | | | |
| Material | Name | | - |
| Amount | MRa | kg/ha,L/ha | |
| Price | Pm | $/kg, $/L | - |
| Material cost per ha | VMTa | $/ha | 0.0 |
| Material cost per hour | VMTh | $/h | 0.0 |
| Variable cost per hour: material | VMTh | $/h | 0.0 |
| Variable cost per ha: material | VMTa | $/ha | 0.0 |
| Variable cost per hour | VCh | $/h | 16.3 |
| Variable cost per ha, TOW<>C | VCa1 | $/ha | 102.0 |
| Variable cost per ha, TOW=C | VCa2 | $/ha | 0.0 |
| Variable cost per ha | VCa | $/ha | 102.0 |

Refer to FM-Plan.xls [7.Variable], fm-43Veriable.xls or Table 4-1-3.

## 3-4. Break-even Point of a work

Service charge or farm work fee by machine will be decided as not higher than custom charge by manual so that farmer (user) will get profit by hiring machine.

Break-even Point: The point at which the line of cost intersects the line of earnings drawn against the quantity of production (or the quantity of sales). {JIS Z8121: Reference 17}

If the quantity of production or the quantity of sales is larger than the break-even point, the earnings are larger than the cost, and if the former is smaller, the result is reversed. In other words, this point is the turning point of loss and gain.

### 3-4-1. Break-even point or Cross point of income and expense

Break-even point or Cross point of custom charge and machinery cost is an important key-point for decision of service charge actually.

Custom charge is shown as Yen/ha ($/ha) or Yen/h ($/h). Therefore, Custom charge per hectare will be obtained by even point to machinery cost per hectare.

Machinery cost per hectare decreases when annual operation area of the machine increases normally. So, break-even point of area is calculated as follows.

$$\mathbf{FC + VCa * Abp = CC * Abp} \qquad \textbf{Eq. 3-4-1}$$

or

$$\mathbf{CC = VCa + FC / Abp} \qquad \textbf{Eq. 3-4-2}$$

$$\mathbf{Abp = FC / (CC - VCa)} \qquad \textbf{Eq. 3-4-3}$$

$$Sbp = FC * CC / (CC - VCa)$$

where,

| symbol | term | unit |
|---|---|---|
| Abp | Break-even point of area | ha/year |
| FC | Annual fixed cost | $/year |
| CC | Custom charge | $/ha |
| VCa | Variable cost per ha | $/ha |
| Sbp | Break-even point of Sales | $ |

Example: Break-even point

How many hectares, Abp (ha), do you at least need to justify ownership of a head feed combine if the custom charge (CC) is 1800 $ per ha, assuming the fixed cost (FC) is 4,500 $, the variable cost per ha (VCa) is 267 $?

Abp = 4,500 / (1,800 - 267) = 4500 / 1533 = 2.9 (ha)

a) Annual cost & custom charge vs. annual operation area

PR = TCC – TC

| Aa | TC = FC + VCa * Aa | TCC = CC * Aa |
|---|---|---|
| Annual operation area | Annual cost | Total Custom charge |
| (ha) | ($) | ($) |
| 1 | 4,767 | 1,800 |
| 2 | 5,033 | 3,600 |
| 3 | 5,300 | 5,400 |
| 4 | 5,567 | 7,200 |
| 5 | 5,833 | 9,000 |
| 10 | 7,167 | 18,000 |

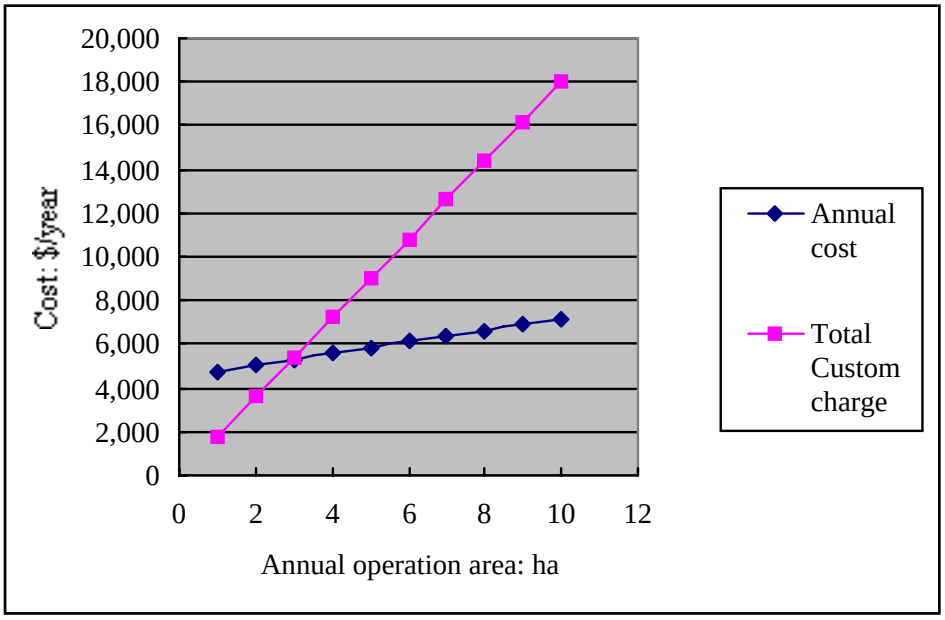


**Fig. 3-4-1 Annual cost & custom charge vs. annual operation area**

Refer to fm-461.xls

b) Annual cost & custom charge per ha vs. annual operation area

| Aa: | TCa=FC/Aa+VCa | CC |
|---|---|---|
| Annual operation area | Annual cost per ha | Custom charge |
| ha | $/ha | $/ha |
| 1 | 4,767 | 1,800 |
| 2 | 2,517 | 1,800 |
| 3 | 1,767 | 1,800 |
| 4 | 1,392 | 1,800 |
| 5 | 1,167 | 1,800 |
| 10 | 717 | 1,800 |

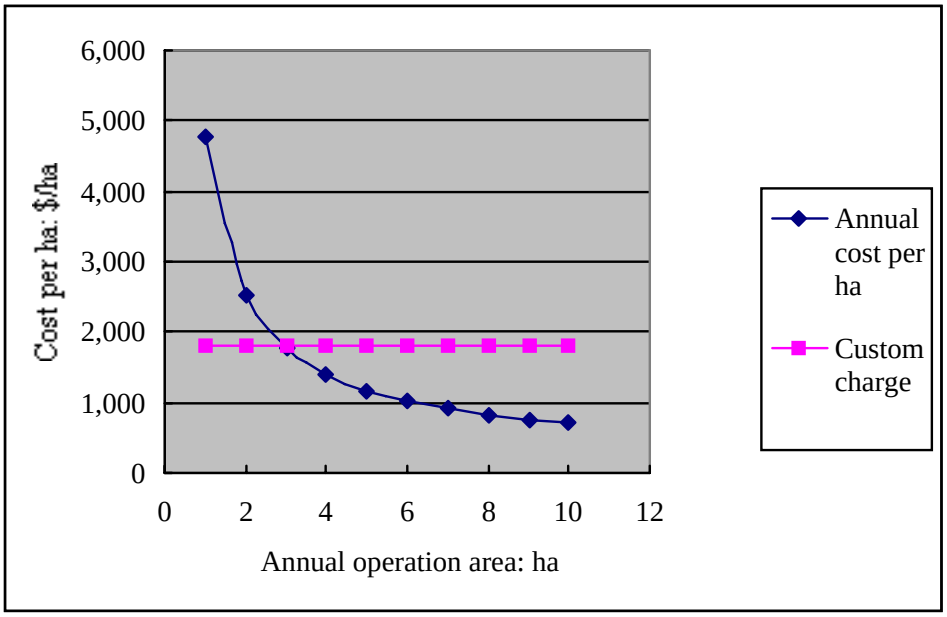


**Fig. 3-4-2 Annual cost & custom charge per ha vs. annual operation area**

Exercise 3-12. and 3-13.

## 3-5. Timeliness

Timeliness is the Ability to perform an activity at such a time that crop return is optimized considering quantity and quality of product.
Timeliness coefficient is defined like as; A factor used to estimated the reduction in crop return (quantity and quality) due to lack of timeliness in performing an activity.

Refer to ASAE S495 and ASAE D497 ( ASAE-SD.htm ) and ASAD4971.xls

**TL = PS_red / PS** **Eq. 3-5-1**

Where,

| symbol | term | unit | Example |
|---|---|---|---|
| TL | Timeliness coefficient | - | 0.01 – 0.10 |
| PS_red | Reduction of drop return | $ | |
| PS | Crop return | $ | |

Delays in planting can reduce yields. Delays in harvest can reduce both quantity and quality of production. These losses are called timeliness losses.

Refer to reference 3

## 3-6. Exercise

**Exercise 3-1**.
Select following items into three group, which should be counted in 1. Expenses accounting method, or 2. Both accounting method, or 3. Cost accounting method.

| | | 1.Expense | 2.Both | 3.Cost |
|---|---|---|---|---|
| 1. | Depreciation | | | |
| 2. | Fuel cost | | | |
| 3. | Home-gathering compost | | | |
| 4. | Interest on self-capital | | | |
| 5. | Lubricant cost | | | |
| 6. | Machine depreciation not in present use | | | |
| 7. | Machine obtained free of charge because of a sample | | | |
| 8. | Purchase expense | | | |
| 9. | Repair cost | | | |
| 10. | Special depreciation of machinery damage by floods | | | |
| 11. | Subsidy to machinery purchase by government | | | |
| 12. | Wages for family labor | | | |
| 13. | Wages for hired workers | | | |

**Exercise 3-2**.
When Purchase price (P) =800$, Salvage value (S) = 80$, Economic life (L) =6 years, obtain Annual depreciation.

**Exercise 3-3**.
When Purchase price (P) =800$, Constant depreciation rate (r) = 0.25, L = 8, obtain Depreciation charge for first year, and for next year.

**Exercise 3-4**.
When Purchase price (P) =800$, Salvage value (S) = 80$, Economic life (L) =6 years, obtain Constant depreciation rate. Use S = P * (1 - r) **L

**Exercise 3-5**.
List up tax rate of your country.

**Exercise 3-6**.
When Initial price (P) =800$, Remaining value (R) = 80$, Yearly interest rate (ri) = 0.05, obtain Annual interest .
And please let me know interest rate of your country.

**Exercise 3-7**.
When Initial price (P), and Annual fixed cost rate (RAF) are shown as next table, obtain Annual fixed cost (FC) of farm work of transplanting.

**Exercise 3-8**.
When Initial price (P), Annual fixed cost rate (RAF), Share of work (Sp)=50% are shown as next table, obtain Annual fixed cost of 1: tractor and of farm work of land preparation.

| Farm Work | Machine no. | Machine name | Purchase price | Annual Fixed cost rate | Fixed cost | Share of work | Annual fixed cost |
|---|---|---|---|---|---|---|---|
| | | | P | RAF | FC | Sp | FC_W |
| | | | $ | % | $ | % | $ |
| Land preparation | 1 | Tractor | 18,000 | 16 | | 50 | |
| | 2 | Drive harrow | 3,500 | 20 | | 100 | |
| | 3 | iron cage wheel | 1,000 | 20 | | 100 | |
| Transplanting | 4 | Rice transplanter | 13,500 | 25 | | 100 | |

**Exercise 3-9**. When fuel consumption, oil, labor are shown as following table, obtain fuel cost per hour(VFh), oil cost per hour(VLUh), labor cost per hour(VLh), and variable cost per hour(VCh) and per ha.(VCa) of farm work : land preparation and transplanting.

| Work Name | fuel consumption | | | | | | Oil | operator | | Assistant worker | | labor cost per hour | variable cost per hour | variable cost per ha |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | FRh | EFC | FRa | | Pf | VFh | VLUh | Nw1 | VLh1 | Nw2 | VLh2 | VLh | VCh | VCa |
| | L/h | ha/h | L/ha | fuel | $/L | $/h | $/h | No. | $/h | No. | $/h | $/h | $/h | $/ha |
| Land preparation | 3.8 | 0.30 | 12.7 | D | 0.32 | | | 1 | 8.0 | 0 | 0.0 | | | |
| Transplanting | 1.6 | 0.21 | 7.6 | G | 0.77 | | | 1 | 8.0 | 1 | 7.0 | | | |

**Exercise 3-10**.

When FC, VCa, CC are shown as following table, obtain TC of farm work (rice transplanting) at Aa = 0.5, 1.0, 2.0, 9.0, 10.0.

And plot on graph (TC vs. Aa) and compare it with total custom charge.

| | | | |
|---|---|---|---|
| FC | Annual fixed cost | $/year | 4000 |
| VCa | Annual variable cost per ha | $/ha | 80 |
| Aa | Annual operation area | ha/year | 0.5 ---10.0 |
| CC | Custom charge | $/ha | 500 |

**Exercise 3-11**.

When FC, VCa are shown as following table, obtain TCa of farm work (rice transplanting) at Aa = 0.5, 1.0, 2.0, 9.0, 10.0. And plot on graph (TCa vs. Aa) and compare it with custom charge.

| | | | |
|---|---|---|---|
| Aa | Annual operation area | ha/year | 0.5 ---10.0 |
| TCa | Annual cost per ha | $/ha | |
| FC | Annual fixed cost | $/year | 4050 |
| VCa | Annual variable cost per ha | $/ha | 80 |
| CC | Custom charge | $/ha | 500 |

**Exercise 3-12.** .

How many hectares, Abp (ha), do you at least need to justify ownership of a rice transplanter if the custom charge (CC) is 500 $ per ha, assuming the fixed cost (FC) is 4,000 $, the variable cost is 100 $ /ha?

And calculate Annual cost (TC) and Total Custom charge (TCC) at Aa = 1, 2, 3, 10 ha.

**Exercise 3-13.** .

How many custom charge (CC) of harvesting is reasonable, if a combine price (P) is $100,000, the fixed cost rate (RAF) is 30%, annual variable cost (VCa) is 200$/ha and annual operation area (Aa) is 30ha?

**Exercise 3-14.**

Obtain Annual cost per ha of tillage (by machine) and weeding(by hand) in your country farm, after listing cost data of your conventional farm work. And compare them to their custom charge.