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SECTION III - ECONOMIC ANALYSIS FOR EVALUATING GRAIN DRYING AND MILLING TECHNOLOGY: SOME SUGGESTED TECHNIQUES

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INTRODUCTION

The examples provided in this paper are hypothetical, and not based on past or present research in Thailand. Costs and benefits are stated in Thai Baht (THB) but do not necessarily reflect actual 1985 prices in Thailand for the items concerned. It is suggested that readers focus on the concepts and techniques presented rather than specific values.

I. ECONOMICS OF GRAIN DRYING*

OBTAINING ECONOMIC DATA

Grain drying, either by traditional sun-drying or using artificial drying methods, have associated costs and benefits.

Costs of drying can be:

- constructing and/or renting floor space
- labour
- fuel as a heat source
- fuel to generate and maintain mass transfer of heated air
- cost of drying equipment or material and labour costs to construct a dryer
- repairs and maintenance of a dryer
- interest on capital investment

Benefits from drying can be:

- reduced quantitative losses from spoilage
- reduced qualitative losses from spoilage

* Drying here refers to small capacity dryers usually found in rural farmer associations and small private mills.

- reduced costs for later storage
- reduced loss of seed viability
- improved head rice recovery in milling

Even during the initial dryer design and construction phase of a research project, it is important to have information on benefits and costs. During a period of performance evaluation tests of one or more types of drying technologies, accurate data on all of those costs and benefits listed above, needs to be recorded. Researchers are encouraged to be sure that they know where to get this information and that it can be obtained. For example, information on drying benefits is often more difficult to obtain or estimate, than on drying costs. Table 1 lists the type of drying Cost and Benefit and possible source of this data.

TABLE 1

COST	SOURCE
.construction/renting drying floor place	- local builder/grain miller or wholesaler
.cost of dryers plus repair and maintenance	- equipment dealers, existing dryer users
.fuel as heat source/mass transfer	- commercial fuel dealers, dryer users, public utilities
.labour	- local unskilled, semi-skilled, skilled wage rates (best if obtained from business using post harvest equipment)
.interest	- commercial bank, government credit, private non-bank credit source
BENEFIT	**SOURCE**
.reduced quantitative and qualitative loss	- farmer, farm association, transporter, trader, private and government dealers, seed center
.reduced loss of seed viability	- farmer, farm association, seed dealer, seed center
.reduced costs for storage	- farmer, farm association, private and government grain dealers
.improved head rice in milling	- private and government millers

CALCULATING SPECIFIC TYPES OF COSTS AND BENEFITS

COST

A. Unit area floor space for sun-drying:

(i) Assume 15 weeks of drying a year, 7 days a week, 8 hours a day = 840 hours/year. Life of drying floor equals 15 years, therefore 12,600 hours. Add total material and labour costs for constructing unit area.

$$\text{Fixed Hourly Cost of Drying (unit area)} = \frac{\text{(material + labour in construction)}}{12{,}600}$$

(ii) Hourly Cost to rent existing floor space.

B. Cost of Dryers:

(i) $$\frac{\text{Actual price paid for drying equipment}}{\text{No. of years of equipment use}} = \text{Annual Depreciated Cost}$$

(ii) $$\frac{\text{Sum of quantities of materials and labour X unit prices of materials and labour to build a dryer.}}{\text{No. of years of equipmenut use}} = \text{Annual Depreciated Cost}$$

C. Fuels:

Unit price X quantities consumed.

D. Labour:

Unit price x quantities used.

E. Repairs and Maintenance:

(i) Estimate at 5% of annual (depreciated) cost of dryer.

(ii) Actual labour and equipment used.

F. Interest (Annual):

$$\frac{(\text{Cost of Dryer X Amortization Factor})^{*}\ (n) - \text{Cost of Dryer}}{n}$$

*for n and interest rate - see Grant E.L. & W. Grant Ireson (1970) Principles of Engineering Economy

BENEFIT

A. Reduced Quantitative Loss:

(Unit price of grain) X (Difference in quantity available for sale when grain dried compared to not drying or alternative drying method)

$$(P_y) \quad X \quad (Q_d - Q_{nd})$$

B. Reduced Qualitative Loss:

(Difference in unit price of grain) X (Total quantity of grain dried and sold)

$$(P_d - P_{nd}) \quad X \quad (Q_d)$$

C. Reduced Loss of Seed Viability:

(i) Quantity of grain dried for seed X Difference in unit price of seed

$$(Q_{sd}) \quad X \quad (P_{sd} - P_{snd})$$

(ii) Cost of seed/ha/yield estimate/unit time = $[P_{(c)} \times Q_{(s)}] + [S \times Q_{(s)}]$

where $P_{(c)}$ = unit price of seed if sold as part of the crop

Q_s = quantity of seed sown/ha/yield estimate/unit time

S = unit cost of on-farm seed handling and storage

and,

$Q_{(s)} = a - V$

where a = farmers' perceived minimum seed requirement

V = seed viability

Improved post-harvest drying technology for seed can benefit the farmer by reducing the loss of seed viability from handling and during storage. The savings can be estimated by putting in a new value for $Q_{(s)}$, as a result of a change in V.

D. Reduced Costs for Storage:

(i) Increased returns per quantity stored per unit time, because of reduced quantitative and qualitative loss (as discussed above).

(ii) Reduced costs for - pest control, modified and/or controlled atmosphere storage methods (per quantity stored per unit time).

E. Increased Head Rice Yield:

(Difference in quantity of head rice from milling a unit of dried and non-dried grain) X (Price of head rice - Price of broken rice)

$(Q_{hd} - Q_{hnd}) \quad X \quad (P_h - P_b)$

ECONOMIC OPTIMUM LEVEL OF DRYING

For any given capacity of dryer; there is a technical relationship between air temperature/relative humidity/rate of mass transfer and the reduction in grain moisture content (MC) per unit time. Technically, optimum MC's are usually 13-14% for maximum head rice, 14% for medium term (i.e. less than 6 months) storage and 12-13% for long term (i.e. more than 6 months) storage. If, based on known volumes of grain to be dried per season, scientists have constructed a dryer of minimum required capacity; the relevant economic question is - what is the relationship between the costs of drying down to the technically preferred MC and the benefits from drying down to that MC? Table 2 (Example 1) provides an illustration of this.

TABLE 2 (Example 1): Relationship between Costs and Benefits of Drying over a range of Moisture Contents (1000 kg of 26% MC grain)

Fuel (1)	MC	Price of Fuel (THB)	Price (kg) of Grain (THB)	Marginal Cost of MC (THB)	Marginal Value of Grain (THB)	Total Revenue (TR)*	Total Cost (TC)	Profit (TR-Tc)
0	26	10	5			5,000	0	5,000
				150	1,000			
15	24	10	6			5,840	150	5,690
				130	1,000			
28	22	10	7			6,640	280	6,360
				110	1,000			
39	20	10	8			7,400	390	7,010
				80	2,000			
47	18	10	10			9,020	470	8,550
				60	3,000			
53	16	10	13			11,450	530	10,920
				60	**4,000**			
59	14	10	17			14,620	590	**14,030**
				160	0			
75	12	10	17			14,280	750	13,530
				200	- 2,000			
95	10	10	15			12,330	950	11,380

The example in Table 2 shows that for a dryer of 1,000 kg capacity (26% MC) and a given technical performance, the most economic MC to dry grain is 14% where profit is maximized. In this case, drying from 14 - 12% MC requires an additional 160 THB in fuel but gives no additional returns in the value of the grain dried.

* calculated as follows: $[\text{Price of Grain}] \times \left[\frac{(1 - .26) \times 1000}{1 - \%\ MC}\right]$

BREAKEVEN LEVEL OF OUTPUT AND AVERAGE RATE OF RETURN ON OPERATING COST FOR A GRAIN DRYER

Table 2 (Example 1) focussed only on a comparison of the additional costs of fuel for drying grain to lower MC's compared to the additional returns. The objective of that exercise was to determine the most profitable MC to dry grain to regardless of how much grain was dried. That is necessary, but not the only economic decision that must be made in order to evaluate the overall economic performance of a dryer. It is also useful to know; how much grain must be dried in order to recover both fixed[1] and variable[2] drying costs, i.e. is the dryer profitable to cover all investments?

Example 2:

Assume a 1,000 kg capacity (at 26% initial MC) dryer which operates for 500 hours a year drying grain from 26% MC to 14% MC in 10 hours. Assume price of grain at 26% MC is THB 2,500/tonne and at 14% MC is THB 5,000/tonne. Variable drying costs for fuel and labour are THB 500/tonne and a fixed (annually depreciated) dryer cost of THB 25,000. Therefore:

Annual Sales of 14% MC grain	=	THB 215,000=[5,000 X (50 X .86)]
Variable costs	=	150,000=[(50 X 500) + (50 X 2,500)]
Fixed Costs	=	25,000

[1] Fixed costs are costs that do not change as output changes.
[2] Variable costs are costs that vary with the level of output.

Difference between Sales and Variable Costs = THB 65,000. It is this difference that is used to recover fixed costs. The calculation to determine the breakeven capacity of the dryer to cover fixed costs is as follows:

$$\text{Breakeven Capacity} = \frac{\dfrac{\text{Fixed Cost}}{\text{Sales - Variable Cost}}}{\text{Units of Capacity}}$$

$$\text{In this example} = \frac{\dfrac{25{,}000}{215{,}000 - 150{,}000}}{100\%} = 25{,}000 \times \frac{100\%}{65{,}000} = 38\%$$

This means that if the dryer operates at more than 38% of annual capacity, profits will be made (for the conditions specified). It shows that at 38% capacity, equal to drying 19.2 tonnes of 26% MC grain, there is no profit; at 100% capacity, there is a THB 65,000 profit. This profit provides an <u>average rate of return on operating cost</u> (profit divided by total operating cost) of 37%.

$$\left(\frac{\text{Profit}}{\text{Annual Fixed + Variable Costs}} \times 100\%\right) = \left(\frac{\text{THB } 65{,}000}{175{,}000}\right) \times 100$$

This is a useful measure (modified) for those dryer operators who perform service drying and need to ensure an adequate fee is charged per quantity of 26% MC grain dried. For example, if a dryer owner had customers for drying and he wanted to maintain a 37% average rate of return on operating cost, then the drying fee per tonne he should charge is:

$$\frac{\text{(1 + Av. Rate of Return on Operating Cost) X (Fixed + Variable Costs)}}{\text{Quantity of Grain Dried to 14\% MC}}$$

$$= \frac{(1.37)\ (25{,}000 + 25{,}000^{*})}{50}$$

$$= \frac{\text{THB } 68{,}500}{50}$$

= THB 1,370/tonne

* Subtracting out cost of 26% MC grain as this is not a cost in service drying.

DRYING COST

This is calculated on the initial 26% MC grain and does not include the cost of the grain.

$$\text{Drying Cost} = \frac{\text{Fixed Cost + Variable Costs for fuel and labour}}{\text{Quantity of 26\% MC grain dried}}$$

$$= \frac{\text{THB } 50{,}000}{\text{50 tonnes}} = \text{THB } 1{,}000\text{/tonne}$$

SENSITIVITY ANALYSIS (PARAMETRIC BUDGETS)

The above example would indicate potentially a very profitable dryer for the conditions stated. However, actual and estimated values for both technical input/output relationships and prices of inputs and outputs are subject to change. Based on previous research experience and known local market conditions, scientists should attach certain probabilities to how and by how much technical relationships and economic values are likely to change and then calculate the impact on returns and the breakeven capacity.

Example 3:

In Example above, it was assumed that the normal operating capacity of the dryer was 100% for all 500 hours of operation. If we change this assumption so that normal operating capacity is 60%, what are the new values for breakeven capacity, average rate of return on operating cost, the drying fee required to maintain a 37% average rate of return and the drying cost/tonne?

(i) Breakeven Capacity $= \dfrac{25{,}000}{\dfrac{129{,}000 - 90{,}000}{100\%}}$

$$= 25{,}000 \text{ X } \frac{100\%}{39{,}000}$$

$$= 64\%$$

The values that changed in the equation are for Sales and Variable cost. Fixed cost did not change because it is 'fixed', regardless of quantity dried. 100% is used because units of capacity are measured in terms of % of normal capacity. However, the breakeven quantity of 26% MC grain that must be dried remains unchanged at 19.2 tonnes [(50)(.60)(.64)].

(ii) Av. Rate of Return on Operating Cost $= \dfrac{\text{THB } 39{,}000}{115{,}000} \times 100$

$= 34\%$

The rate of return has decreased by 8.1% $\left(\dfrac{3}{37} \times 100\right)$

(iii) Drying Fee (for 37% rate of return) $= \dfrac{(1.37)(40{,}000)}{30}$

$= \text{THB } 1{,}827$

The drying fee would have to increase by 33% $\left(\dfrac{1827-1370}{1370} \times 100\right)$

(iv) Drying Cost/tonne $\dfrac{\text{THB } 40{,}000}{30 \text{ t}} = \text{THB } 1{,}333/\text{tonne}$

Example 4:

Let us change the assumption on the price of 14% MC from THB 5,000/tonne to THB 4,500/tonne and calculate the changes in breakeven capacity (at normal capacity of 100%), rate of return on operating cost, the required drying fee and drying cost/tonne.

(i) Breakeven Capacity $= \dfrac{25{,}000}{\dfrac{193{,}500 - 150{,}000}{100\%}} = 25{,}000 \times \dfrac{100\%}{43{,}500}$

$= 57.5\%$

This is equivalent to 28.5 tonnes of 26% MC, an increase of 9.3 tonnes (or 48% more than when the price of 14% MC is THB 5,000/tonne).

(ii) Av. Rate of Return on Operating Cost $= \dfrac{\text{THB } 43{,}500}{25{,}000 + 150{,}000} \times 100$

$= 25\%$

This is a decrease of 12 percentage points or a decrease in the rate of return of 32% [(12 ÷ 37) X 100].

iii) Drying Fee (for a 37 Rate of Return) $= \dfrac{(1.37)(25{,}000 + 25{,}000)}{50}$

$=$ THB 1,370

This does not change because the dryer operator does not buy or sale given and his fixed and variable costs have not changed.

(iv) Drying Cost/tonne $\dfrac{\text{THB } 50{,}000}{50 \text{ t}} =$ THB 1,000/tonne

This is not different than the original value because fixed and variable costs did not changed and the same quantity of 26% MC grain was dried.

Example 5:

Assume the price of 26% MC grain increases to THB 2,700/tonne, the price of 14% MC grain is THB 4,700/tonne, variable costs increase to THB 550 per tonne of 26% MC dried, and normal capacity is 70%.

(i) Breakeven Capacity $= \dfrac{25{,}000}{\dfrac{141{,}470 - 113{,}750}{100\%}} = 25{,}000 \text{ X } \dfrac{100\%}{27{,}720}$

$= 90.2\%$

This is equivalent to 31.5 tonnes of 26% MC grain.

(ii) Av. Rate of Return on Operating Cost $= \dfrac{\text{THB } 27{,}720}{138{,}750} \text{ X } 100$

$= 20\%$

(iii) Drying Fee (to achieve 37% rate of return) $= \dfrac{(1.37)(44{,}250)}{35}$

$= \text{THB } 1{,}732$

(iv) Drying Cost/tonne $\dfrac{\text{THB } 44{,}250}{35} = \text{THB } 1{,}264/\text{tonne}$

ECONOMIC ANALYSIS TO COMPARE ALTERNATIVE DRYING TECHNOLOGIES

All of the above techniques have been related to the development and performance evaluation (in economic terms) for a single dryer. However, it is necessary to compare any new drying technology with the existing technology and other alternative new technologies that may be available.

The first and very important piece of information the scientist needs for a comparative analysis is: <u>what are the grain drying requirements of the intended user</u> of the technology? This information should be used in the initial design of any single type of dryer. If the intended user is an individual farmer, farmer association, private trader or government agency; each is likely to have different requirements with regards to capacity and ability to dry to a specific moisture content (within a defined critical time period). A second important and related type of data needed is: what is the maximum annual operating investment the user can put into drying?

If the intended user is a single farmer, there is no point in designing and testing a dryer whose annual drying capacity is significantly greater than farm production. If the intended user is a miller, there is no point in developing and testing a dryer whose annual capacity is less than the miller's requirements and where the investment costs in several dryers to meet capacity is greater than the miller's available capital.

The following examples will deal with the decision of which drying technology is most economic for an identified user with known drying requirements. We do not try and answer the question; "where is the most economic location of drying capacity in the post-harvest system?". (That is an important question, for example; is it more efficient for individual farmers to dry or for the farm association to dry at one central facility?).

TABLE 3: COMPARATIVE DRYING COST/TONNE FOR THREE ALTERNATIVE BATCH DRYER TECHNOLOGIES AT A PRIVATE MILL

	Item	Dryer Type A	Dryer Type B	Dryer Type C
1.	Quantity (t) of 26% MC grain required to be dried/year	70	70	70
2.	Capacity (t) [26% MC grain]	1	2	3
3.	Hours required to dry grain from 26% to 14% MC	8	12	10
4.	Hours of operation required to dry 70 tonnes of grain	560	420	233
5.	Cost (THB) of labour per hour of operation	10	15	20
6.	Cost (THB) of fuel per hour of operation	30	70	95
7.	Initial cost of dryer (THB)	13,500	21,000	30,000
8.	Life of dryer (years)	5	7	7
9.	Annual depreciated cost of dryer (THB)	2,700	3,000	4,286
10.	*Annual interest on loan for purchase of dryer	1,814	2,826	4,036
11.	Fixed costs (THB)/tonne $\frac{(9.)+(10.)}{70}$	65	83	119
12.	Variable Costs (THB)/tonne $\frac{(5.)(4.)+(6.)(4.)}{70}$	320	510	383
13.	Total drying cost (THB)/tonne (11.)+(12.)	385	593	502

* 20 percent interest amortized over life of the dryer.

The above analysis shows dryer 'A' to be the most economic. However, let us change one of the conditions. Let us now assume that the total of 70 tonnes of 26% MC grain is received uniformly over a 15-day period and must be dried within the same 15 days. Also assume that the maximum number of hours of dryer operation per day is 20. Therefore,

TABLE 4

Item	Dryer Type A	Dryer Type B	Dryer Type C
Drying requirement per day	4.7	4.7	4.7
Drying capacity (t) per dryer per day [(20÷(3.)] x (2.2)	2.5	3.3	6.0
No. of days to dry 70 t using one dryer	28	21.2	11.7
No. of dryers needed for daily drying demand	2	2	1
Annual depreciated cost of dryers	5,400	6,000	4,286
Annual interest on loan for purchase of dryers	3,628	5,652	4,036
Total drying cost/tonne	450	676	502

The results show that investing in two one-tonne capacity dryers still gives the lowest drying cost/tonne but that the potential profitability per tonne is greatly reduced because of the need to invest in a second dryer to dry all grain with 15 days.

II. ECONOMICS OF GRAIN MILLING*

OBTAINING ECONOMIC DATA

For any milling technology, there are costs and benefits.

Costs of milling can be:

- constructing and/or renting a place (i.e. small shed or storage facility) to put the mill
- labour
- fuel as a power source
- cost of milling equipment
- repairs and maintenance of a mill
- interest on capital investment

Benefits from existing milling and/or improved milling technology can be:

- production of a higher value food product
- production of "by-products" for sale
- improved head rice yield (less brokens) and total rice recovery
- a cleaner milled product (less foreign particles)

Even during the initial mill design and construction phase of a research project, it is important to have information on benefits and costs. During a period of performance evaluation tests of one or more types of milling technologies, accurate data on all of those costs and benefits listed above, needs to be recorded. Researchers are

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* Milling here refers to small capacity single machine mills usually doing custom milling for paddy producers.

encouraged to be sure that they know where to get this information and that it can be obtained. Table 1 lists the type of milling Cost and Benefit and possible source of this data.

TABLE 1

COST	SOURCE
. construction/renting facility to put the mill	- local builder, local millers
. cost of milling equipment plus repair and maintenance	- equipment dealers, local millers
. fuel as power source	- commercial fuel dealers, millers, public utilities
. labour	- local unskilled, semi-skilled, skilled wage rates (best if obtained from business using post harvest equipment)
. interest	- commercial bank, government credit, private non-bank credit source
BENEFIT	**SOURCE**
. production of a higher value food product	- grain trader, farm association
. production of by-products for sale	- miller, farm association, pig and poultry producer
. improved head rice yield and total rice recovery	- miller, trader, farm association
. cleaner milled product	- miller, trader, farm association

CALCULATING SPECIFIC TYPES OF COSTS AND BENEFITS

COST

A. Facility to put the mill:

(i) $$\frac{\text{Cost of labour and materials to construct small shed}}{\text{No. of years of shed use}}$$

= annual depreciated fixed cost of facility

(ii) Rent for space to put mill.

B. Cost of milling equipment:

$$\frac{\text{Actual Price of equipment}}{\text{No. of years of equipment use}} = \text{Annual Depreciated Cost}$$

C. Repairs and Maintenance:

(i) Estimate at 5% of annual depreciated cost of mill

(ii) Actual labour and equipment used

D. Fuel as power source:

Unit price X quantities consumed

E. Labour:

Unit price X quantities consumed

F. Interest (Annual):

$$\frac{(\text{Cost of Dryer X Amortization Factor})^{*}\ (n) - \text{Cost of Dryer}}{n}$$

*for n and interest rate - see Grant E.L. & W. Grant Ireson (1970) Principles of Engineering Economy

BENEFIT

A. Higher Value Food Product:

(Quantity of Milled Product X Unit Price) X (Quantity of Grain Milled X Unit Price)

$$Q_m \times P_m \quad \times \quad Q_{nm} \times P_{nm}$$

B. Production of By-Products:

(Quantity produced) X (Unit price)

$$(Q_{bp}) \times (P_{bp})$$

C. Increased Head Rice Yield:

(Increase in Quantity of Head Rice) X (Price of Head Rice - Price of Broken Rice)

$$(\Delta Q_h) \times (P_h - P_b)$$

D. Cleaner Milled Product:

(Price for Cleaned Milled Product - Price for Uncleaned Milled Product) X (Quantity Sold)

$$(P_c - P_{nc}) \times (Q)$$

E. Increased Total Rice Recovery

(Increase in Quantity of Head Rice) X (Price of Head Rice - Price of Brokens) + (Increase in Quantity of Brokens) X (Price of Brokens) - (Decrease in quantity of by-products) X (Price of by-products)

$[(\Delta QL) \times (P_h - P_b) + (\Delta Q_b) \times (P_b)] -$
$[(\Delta Q_{bp}] \times [P_{bp}])$

ECONOMIC OPTIMUM MILL DESIGN AND PERFORMANCE

The general economic objective of milling is to - maximize the profit i.e. the difference between the value of head rice, broken rice, by-products and the fixed and variable costs of milling; for a given quantity of paddy per unit time. The relative quantities of head rice, broken rice and by-products are generally a function of - the quality of the paddy to be milled, blade or rubber roller clearance, and the efficiency of husk and bran separation. The first of these cannot be changed by the mill, the last two depend upon the skill of the mill operator i.e. making the correct technical adjustments. The costs of milling are generally a function of - mill capacity, durability of mill, and engine efficiency. If the miller is performing service milling, he will charge a fee equal to his actual costs plus a percentage of those costs as his return on his investment. The fee the paddy owner thinks he should pay will be determined by the 'quality' of the milled products i.e. relative quantities of head rice, brokens and by-products. The milling fee may be paid in cash or in-kind i.e. miller keeps the by-products. Therefore, for any change in the design of a specific type (i.e. steel huller or rubber roller) of mill; what are the changes in benefits i.e. total value or head rice, broken rice and by-products, and changes in costs? For example;

Example 1:

Assume an existing mill with a capacity of 150 kg/hr using a 10h.p. electric engine. Now substitute a 7h.p. diesel engine. Assume the relative quantities of head rice, brokens and by-products does not change,. Table 2 compares the hypothetical annual costs and benefits.

TABLE 2

Item	Mill Type A (10h.p. electric)	Mill Type B (7h.p. diesel)
Cost of Mill (without engine)	THB 8,000	THB 8,000
Mill Repairs and Maintenance (excluding engine)	2,000	2,000
Labour	10,000	10,000
Engine	23,000	15,000
Power	50,000	37,500
TOTAL:	THB 93,000	THB 72,500

Assuming the same quantity of paddy is milled, changing to the 7h.p. diesel engine reduces annual costs by THB 20,500.

Example 2:

Assume a change from a 125 kg/hr to a 225 kg/hr steel huller rice mill operating for 10 hours a day, 250 days a year. Table 3 shows the comparative hypothetical annual costs and benefits.

TABLE 3

Item	Mill Type A (125 kg/hr)	Mill Type B (225 kg/hr)
COSTS (THB)		
Mill and Engine	80,000	120,000
Repairs and Maintenance (mill engine)	12,000	13,000
Power	70,000	110,000
Labour	10,000	12,000
Interest	20,000	30,000
TOTAL COST:	192,000	285,000
Cost/kg of paddy:	THB 0.614	THB 0.510
BENEFITS (THB)		
By-Products (bran/husk mixture)	217,200	356,000
TOTAL PROFIT:	25,200	71,000
Profit/kg of paddy:	THB 0.086	THB 0.126

In this example, changing from a 125 kg/hr to a 225 kg/hr mill reduces annual milling cost/kg and increases profit/kg.

BREAKEVEN LEVEL OF OUTPUT FOR A MILL

Example 3:

Assume custom milling and operating at 100% capacity and annual quantity of paddy milled is 563 tonnes.

- Annual Fixed Costs for Equipment and Interest = THB 15,000
- Annual Variable Costs for power, labour, repairs and maintenance = THB 125,000
- Value (Sales) of Bran and Husk = THB 211,000

$$\text{Breakeven Capacity} = \frac{\dfrac{\text{Fixed Cost}}{\text{Sales - Variable Costs}}}{\text{Units of Capacity}} = 15000 \times \frac{100\%}{86{,}000}$$

$$= 17.4\%$$

This is equivalent to 98 tonnes of paddy (563 X 0.174).

AVERAGE RATE OF RETURN ON OPERATING COST

Example 4:

Using the same information and data in Example 3;

$$\text{Av. Rate of Return on Operating Cost} = \frac{\text{Profit}}{\text{Fixed and Variable Costs}} \times 100$$

$$= \frac{71{,}000}{140{,}000} \times 100$$

$$= 51\%$$

MILLING COST

Example 5:

Using information and data from Example 3.

$$\text{Milling Cost/tonne} = \frac{\text{Fixed and Variable Costs}}{\text{Tonnes of paddy milled}}$$

$$= \frac{\text{THB } 140{,}000}{563 \text{ tonnes}}$$

$$= \text{THB } 248\text{/tonne}$$

SENSITIVITY ANALYSIS (PARAMETRIC BUDGETS)

As was stated in the similar section in the economic analysis of drying technology; examples 3-5 would indicate potentially a very profitable mill for the conditions stated. However, actual and estimated values for both technical input/output relationships and prices of inputs and outputs are subject to change. Based on previous research experience and known local market conditions, scientists should attach certain probabilities to how and by how much technical relationships and economic values are likely to change and then calculate the impact on returns above variable costs and the breakeven capacity.

Example 6:

Starting with information and data in Example 3, let us now assume that annual power costs are THB 125,000 and labour costs are THB 17,000. All other factors remain unchanged. Variable costs have now increased to THB 145,000 a year. Therefore;

$$\text{(i)} \quad \text{Breakeven Capacity} = \frac{\frac{15,000}{66,000}}{100\%} = 22.7\%$$

This is equivalent to 128 tonnes/yr of paddy.

$$\text{(ii)} \quad \text{Av. Rate of Return on Operating Cost} = \frac{51,000}{160,000} \times 100 = 32\%$$

$$\text{(iii)} \quad \text{Milling Cost} = \frac{160,000}{563} = \text{THB } 284/\text{tonne}$$

As shown in the previous section on drying economics, sensitivity analysis can be done for changes in the quantities and values of inputs and outputs.

ECONOMIC ANALYSIS TO COMPARE ALTERNATIVE MILLING TECHNOLOGIES

Similarly, as was stated for the drying technology, the first and very important piece of information the scientist needs for a comparative analysis is: what are the milling requirements of the intended user of the technology? This information should be used in the initial design of any single type of mill. If the intended user is a farmer association, private trader or government agency; each is likely to have different requirements with regards to demand for milling. A second important and related type of data needed is: what is the maximum annual operating investment the user can put into milling?

If the intended user is a farmer association, there is no point in designing and testing a mill whose annual drying capacity is significantly greater than total farmers' production. If the intended user is a miller, there is no point in developing and testing a mill whose annual capacity is less than the miller's requirements and where the investment costs in several mills to meet capacity is greater than the miller's available capital.

Example 7 in Table 4 shows a comparative analysis for a steel huller and rubber roller capacity mill for custom batch operation.

TABLE 4 (EXAMPLE 7): COMPARATIVE MILLING COST/TONNE FOR TWO ALTERNATIVE BATCH MILLING TECHNOLOGIES AT A PRIVATE MILL

Item	Mill Type: Steel Huller	Mill Type: Rubber Roller
1. Quantity (t) of paddy to be milled/year	500	500
2. Capacity kg/hr	200	250
3. Hours of operation required to mill 500 tonnes of paddy	2,500	2,000
4. Cost (THB) of labour per hour of operation	10	10
5. Cost (THB) of power per hour of operation	25	25
6. Initial cost of mill and engine (THB)	120,000	180,000
7. Life of mill and engine (years)	7	10
8. Annual depreciated cost of mill and engine (THB)	17,143	18,000
9. *Annual interest on loan for purchase of mill and engine	16,148	24,934
10. Fixed costs (THB)/tonne $\frac{(8) + (9)}{500}$	67	86
11. Variable costs (THB)/tonne $\frac{(4.)(3.)+(5.)(3.)}{500}$	175	140
12. Total milling cost (THB)/tonne (10.)+(11.)	242	226

* 20 percent interest amortized over life of the dryer.

In this example, the rubber roller miller is more economic by a value of THB 16/tonne or THB 8,000 for 500 tonnes.

- END -

CMC/jc

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