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ESTABLISHING DESIGN CRITERIA FOR IMPROVED RICE MILLING TECHNOLOGIES

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16. Abstracts

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The first section contains description of existing milling technologies now used in the Philippines. The second section examines some important structural charateristics of the rice processing industry in the Philippines while the third is devoted to an economic evaluation of alternative milling systems. The last section is an attempt to synthesize the results into a series of recommendations relating to research on the design, development, and/or modification of milling equipment.

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ESTABLISHING DESIGN CRITERIA FOR IMPROVED RICE MILLING TECHNOLOGIES

by

Bart Duff and Ida Estioko[1/]

Introduction

It is an irony that use of the new rice technology, while expanding total output significantly, may inadvertently lead to concomittant increases in the level of grain losses. Continued reliance on production, processing, and marketing systems employing traditional techniques may maintain the share of losses as a percentage of output but at higher quantitative levels. Emerging problems of this type which involves processing and marketing systems are often labeled second generation problems because their emergence stems directly from the first round output impact of the improved varieties (Falcon, 1970).[2/]

This paper addresses itself specifically to the problems of modernizing and upgrading the rice milling industry. More precisely, it is an attempt to critically assess the efficiency and economics of existing rice milling technologies. The objectives are to determine the potential for technical improvements in existing systems and, where feasible, the efficacy of initiating activities to design and develop new technologies which will increase efficiency and reduce losses. The analysis is confined principally to milling equipment and does not include an evaluation of issues relating to storage or drying.

The first section contains a description of existing milling technologies now used in the Philippines. The second section examines some important structural characteristics of the rice processing industry in the Philippines while the third is devoted to an economic evaluation of alternative milling systems. The last section is an attempt to synthesize the results into a series of recommendations relating to research on the design, development, and/or modification of milling equipment.

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[2/]Names in brackets refer to appended list of references.

Rice Milling Technologies

Milling methods in the Philippines can be classified loosely under four broad headings. These are: hand hulling, Engleberg mills, como mills, and "modern" or rubber roller mills. The first category, because of its declining use in the Philippines, is not considered in this analysis. It should be recognized, however, that this technique is still widely used in other countries, the most notable being Indonesia (Timmer, 1972). For the remaining three categories, there exists a wide range of variation within mill types both in milling capacity and in the composition and configuration of individual milling systems.[3/] Figure 1 illustrates some possible combinations.

Engleberg Huller (Kiskisan)

The Engleberg huller removes husk and bran in a single operation. Paddy is fed into one end of a hollow cylinder containing a rapidly rotating fluted roller (fig. 2). Axial movement of materials is accomplished by the action of an integral, truncated screw conveyor located at the point where paddy enters the mill. The lower half of the hollow cylinder is composed of slotted sheet metal. Husking is the result of the shearing action produced on the grain by the movement of the roller flutes past a stationary blade. The combination of rapid rotation, high pressure and inter-grain contact results in removal of both hulls and bran as the material moves axially through the machine. Hull, bran and broken rice pass through the perforated screen in the lower half of the cylinder while milled grain is discharged at the terminal end of the mill. Some control over the degree of milling may be achieved by adjustment of the distance between the static blade and the rotating fluted roller. A variety of accessories may be added to the Engleberg mill. Two common attachments are a polisher composed of a rotating cylinder with leather strips attached to the periphery which rotates in a perforated housing, and a single husk aspirator.

If the area to be serviced is small and localized, if transportation facilities are poor and costly, and if quality standards are not critical, use of the Engleberg huller may represent a viable economic alternative. Use of this mill results in notoriously low recovery rates, a high percentage of broken grains, mixing of bran and hulls, and a relatively high power requirement per unit of milling capacity. Total rice recovery from this method is generally less than 60 percent by weight, with head rice composing less than 50 percent of total milled rice. The Kiskisan does offer the advantages of simplicity in design, ease of maintenance, and is manufactured in the Philippines.

[3/] In analyzing processing technologies, the elements which make up a milling system should be decomposed and evaluated independently to allow precise determination of areas where improvements will result in maximum benefits.

Cono

A second alternative, which processes the greatest share of rice entering the commercial market, is the cono system. It usually consists of one or more under-run disc sheller units operated in conjunction with a number of vertical cone polishers. The hulling section of the cono mill (fig. 3) consists of two cast iron discs which are coated with an abrasive composition material, usually emery stone. The upper disc remains stationary during operation while the lower rotates. Materials are fed into a central opening and centrifugal action causes radial movement of the paddy into the space between the discs. Contact of the grain with the two stones removes the husk from the grain. The machine has provisions for adjustment of the vertical clearance between the two discs, allowing a good level of precision in husk removal. Non-uniformity in grain size will result in some rough rice emerging from the machine. Unhulled paddy must be separated from brown rice and recycled through the huller. Bran is removed in a separate process in the cono system. The most common machine used is the vertical cone pearler as shown in fig. 4. Consisting of an inverted cone coated with composition emery stone which rotates in an enclosed perforated screen housing, the machine removes bran by a carefully controlled abrasive action on the brown rice which occurs between the composition stone and perforated screen while milled rice passes out the bottom.

Produced in the Philippines, the cono installation produces an appreciably higher recovery rate (up to 68% by weight) than the Engleberg huller. In addition, head rice recovery is also higher, bran and hulls are separated, and the degree of milling can be more closely controlled. The capacity of these installations ranges from less than 100 to over 1000 cavans of paddy per 12-hour-day. Unlike the kiskisan, mills in this category are more fully attuned to commercial markets. A greater percentage of the business of these mills is derived from buying, processing, and selling milled rice than is the case for the kiskisan, which is largely a custom milling operation.

Modern Systems

The third general category of milling equipment is the modern rubber roller technology developed in Japan. Figure 5 illustrates the elements of this particular machine. The most distinguishing element in this system is the sheller which consists of two closely spaced rubber rollers rotating in opposite directions and at different speeds. A shearing action is created on rough rice by contact with the rubber rollers operating with a differential displacement action which removes the husk from the grain. As in the case of cono installations, variability in grain size will cause some unhusked paddy to pass through the machine. Operated in conjunction with an aspirator and paddy separator, it is possible to recycle unhulled paddy through the machine to achieve complete hulling.

When correctly adjusted for optimal operation, this method produces the highest total recovery and best head grain yields. Installations employing this technology are available in many sizes, ranging from below 100 to over 5000 cavans per 12 hours of operation. However, in spite of its high technical efficiency, high initial investment costs, combined with a lack of demand for high-quality rice, has retarded diffusion of this technology in the Philippines.

Milling Efficiency

Figure 6 is an attempt to generalize the pattern of milling efficiency for the three milling systems described above. The numbers employed in this illustration should not be accepted uncritically as there exists considerable variability both among milling technologies and between mills of the same type, in rates of milled rice recovery and head rice yields. It is generally recognized, however, that the rubber roller sheller produces the highest recovery rates and the greatest proportion of head rice followed by the under-run disc sheller (cono), with the Engleberg huller giving the poorest results. Note also that the level of efficiency may also be affected by the moisture content and variety of the grain, method and speed of drying, the precision with which adjustments are carried out on elements in the milling system, and the extent to which the practice of parboiling is utilized.

Equipment Investment Costs

Table 1 presents some typical machinery acquisition prices for a range of Engleberg huller and cono installations. These values do not include the cost of land, buildings, transportation equipment, and miscellaneous items which make up a complete processing system. Lack of widespread use of the rubber roller technology precludes its inclusion in the local cost data contained in table 1.

The Engleberg huller ranks lowest in terms of total investment requirements and investment cost per unit of rated capacity. There is also a discernible downward trend in the cost per unit of capacity for both the cono and Engleberg machines as capacity increases. The same is also true to a lesser degree for power requirement per cavan of capacity as size increases in both categories.

Structure of the Philippine Rice Processing Industry

Figure 7 depicts the distribution of milling capacity and mill numbers between the Engleberg and cono systems. While the data supporting the absolute precision of the numbers shown is subject to question, the magnitude and pattern of the distributions between alternative milling types seem consistent with other independent estimates (Mears, 1972). The kiskisan represents 80 percent of the number of mills and 53 percent of industry rated capacity. The larger average size of the cono installations accounts for this seeming disparity

From table 2, it is possible to draw some conclusions regarding the concentration of milling capacity and mill numbers. Examination of the data for the cono installations indicates that both numbers and capacity are heavily concentrated in the Central Luzon and Southern Tagalog regions. This is in contrast to the kiskisan installations which are more evenly distributed throughout the country. As mentioned previously, the cono tends to be oriented towards milling activities involving the purchase of paddy and sale of milled rice to commercial centers while the kiskisan relies heavily upon small-lot household milling for the bulk of its income. Consequently, when transportation facilities are lacking and markets are small and/or isolated, the kiskisan finds wide application. The growth of cono capacity and concentration seem to have exceeded paddy supplies in some areas. Barker's study on cono installations in Laguna Province indicates that the concentration of mills has resulted in the emergence of excess capacity in the province (Barker and Dozina, 1970).

Rice Quality

In the Philippines, the two principal factors influencing consumer preferences for rice are variety and the visual appearance of the rice grain (IRRI, 1970). The Philippines in 1968 introduced a complete rice quality classification system which was largely patterned upon FAO standards. Quality determination of milled rice includes analysis of the following:

a) the variety
b) the standard through classification
c) the moisture content

The general criteria for grade classification (b, above) includes the following:

1) Intrinsic character[b/]

a) classed by named varieties
b) classed by external characteristics such as size, shape, and appearance of whole grain

Type I - Long grain - (special, ordinary, inferior)
Type II - Medium grain - (fancy, special, ordinary, inferior)
Type III - Short grain

2) Degree of milling[b/]

a) 1st class - fully milled
b) 2nd class - medium milled
c) 3rd class - undermilled

[b/] See appended glossary for exact definition of terms.

3) Philippine Standard grades range from Grade 1 (the best grade) to Grade 5. The grades indicate in percent the head rice recovery, percent brokens, a description of the kernels, and the presence of foreign matter.

Philippine Grade No. 1 milled rice is comparable to Thailand's rice grade of white-rice 5% (fifth from the top grade) and the United States Grade No. 2 (second from the best grade). The maximum broken grain tolerance for Philippine Grade No. 1 is 10%, for Thailand Grade No. 5, 5-7%, and the U.S. Grade No. 2, 7%. The percentage of broken grains is an important factor affecting quality by international standards. Variety and grain appearance seem to be the most important quality factors by domestic standard (Barker, 1970).

Figure 8 illustrates that part of the Philippine quality classification system for grading rice based on percent broken grains. This graph should be read in conjunction with tables 3 and 4 in order to develop a full appreciation of the impact of local milling technologies on rice quality. The output of kiskisan mills rarely contains less than 50 percent broken grains with many mills producing less than 40 percent head rice. Como mills, when properly adjusted and maintained, produce samples containing up to 90 percent head rice. The rubber roller technology has the potential of supplying output containing in excess of 90 percent head rice.

Consumer demand obviously perpetuates the present system of archaic, inefficient mills producing a low-quality rice. An increase in quality consciousness would go far toward upgrading the quality of rice sold in the Philippines. It would also have the concomittant effect of increasing total rice recovery rates because of the more efficient technology necessary to produce a quality rice.

Economics of Milling

One of the most important decisions confronting a rice processor is the selection of a milling system which conforms with the technical, economic and physical conditions of his market. Because of the magnitude of the financial and human resources which are dependent on this decision, care should be exercised to ensure that the final choice of plant and equipment is optimal. In the preplanning stage, the investor should take cognizance of the following points:

1. The volume of demand for milled rice.
2. The product characteristics which the market requires, i.e. quality, form, variety, location and timing of product delivery.
3. The volume of paddy and site of the area from which supplies will be procured; the probability of an assured supply.
4. The transportation costs for shipping paddy and milled rice.
5. The range of processing technologies available and their cost and performance characteristics.

Capacity

A major determinant of the economic viability for any rice mill is the degree of capacity utilization. When large-capacity mills are operated at output levels significantly below rated capacities, average total cost per unit of output is high. Similarly, when operations are maintained at levels in excess of design capacity, repair, maintenance and administrative costs will increase resulting in a decrease in plant efficiency and a rise in costs.

To illustrate the importance of size in the selection of processing installations, a series of budgets were prepared depicting a wide range of capacities within each equipment category (table 5). The results of this exercise are shown graphically in figs. 9 to 13. Figure 9 illustrates the total costs of kiskisan installations over an annual output range of 0 to 12,000 cavans. Within this range, three discrete mill sizes were chosen for detailed analysis. The medium-sized mill, rated at 30 cavans per day, requires 7400 cavans per year and the largest, rated at 50 cavans per day, must process 7700 cavans to cover all costs. Note that the milling fee charged (in the case shown, ₱1 per cavan of paddy milled) has an appreciable effect on the level at which these mills can be profitably operated. An increase in the milling fee, which reflects the average of income derived from both custom milling and sales of rice and binlids, has the effect of lowering the required level for profitable operation. Changes in any of the components which make up the total cost curve, such as the price of machinery, fuel, wages and interest rates, will change the level and/or slope of the curves resulting in shifts in the breakeven point.

Figure 10 illustrates a series of total cost and revenue curves for the cono type installation. In this case, the breakeven levels for each mill size are considerably higher than for the kiskisan units. This is to be expected, given the higher fixed cost component for each of these installations. A similar trend is evident in fig. 11 depicting the modern milling system.

Figures 12 and 13 are average total cost curves for operation of mills within the kiskisan and cono categories respectively. Comparing these figures demonstrates that there rare economies to be derived both from operating mills at or near rated capacity and from moving from mills with lower to those with higher annual capacity. There is also an indication that as one moves from the kiskisan to the cono technology, some economies of size are possible, particularly in the larger cono mill sizes. Note again that underutilization increases costs because the fixed cost (investment) component of average total costs remains high. It is only when installations approach design capacity that the operator is able to minimize this element of total cost. When cost minimization is the primary determinant of plant size, it may be more economic to invest in a smaller unit which will be operated at or near rated capacity than to install a unit which will be operated with excess reserve capacity.

The Composition of Costs and Flexibility in Plant Utilization

Figure 14 is an attempt to depict graphically the nature of the average total cost curves for different-sized milling units within two distinct milling technologies. Because the modern milling technology is relatively more capital-intensive, its fixed cost component is higher than for traditional technologies of comparable size. This causes a more rapid decline in the individual average cost curves for the new technology. For similar reasons and because there is relatively less flexibility to adjust variable costs in the new as contrasted to the old milling methods, a relatively steeper rise in the cost curve is observed when rated capacity is exceeded. The result is a narrowly defined range of output over which minimal costs may be achieved. The relatively gradual slope of the curves depicting the traditional technologies makes their average total costs less variable over a wider range of output conditions.[5]

Increasing Milled Rice Recovery

From the previous discussions related to levels of milling efficiency and relative rates of recovery, there appears to be considerable scope for increasing the output of milled rice by improving the recovery efficiency of traditional milling technologies. As an example of the potential for increasing recovery, consider the case of a kiskisan with a capacity of 12,000 cavans per year as compared to a cono mill with an annual capacity of 20,000 cavans. Suppose the kiskisan and conos had initial total milled rice recovery rates of 60 and 65 percent by weight, respectively. Further suppose that it were possible to increase recovery rates for both mills to 70 percent. Comparing the results in fig. 15, we find that the total increase in recovery is 1200 cavans for the kiskisan as compared to 1000 cavans for the cono. The explanation for the higher increase achieved by the kiskisan lies in the greater range for increased recovery embodied in the kiskisan technology. Figure 16 shows the increased income derivable from increases in milling recovery for the two mills.[6]

Net income increases from ₱29,200 to ₱116,200 for the cono, and from ₱21,360 to ₱74,160 for the kiskisan as recovery rates rise from 50 to 70 percent. This represents an increase in net income of 247 percent for the cono and 298 percent for the kiskisan. To take a less extreme example, consider the effect

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[5] It is apparent that a more complete conceptual framework needs to be developed to make comparative analysis between traditional and "modern systems" possible and eventually operational. Uma Lele's work on rice milling in India is an example (Lele, 1970).

[6] We have assumed the following prices and costs for these calculations: Paddy - ₱35/cav; bran - ₱0.35/kg; binlids - ₱0.60/kg; milled rice - ₱1.30/kg; milling cost for kiskisan - ₱0.79/cav; for cono - ₱1.11/cav.

on income of increasing milling recovery from 65 to 68 percent. In this case, net income increases from ₱95,200 and ₱60,920 to ₱108,400 and ₱68,880 for the cono and kiskisan, respectively. These are increases of 13.9 and 13.1 percent. Even small changes in recovery efficiency will have large effects on both output and income.

Design Parameters

Based on the evidence presented in the preceding sections, it is evident that there exists considerable scope for improving the performance of the rice processing industry in the Philippines. It is the purpose of this final section to synthesize some conclusions regarding the nature of innovations or improvements which might be made and the means to implement these changes.

As they now exist, traditional milling technologies embody some potential for improvements without major investments in new capital equipment. Van Ruiten has demonstrated that improved maintenance and use of quality materials in the manufacture of milling equipment can have an appreciable effect on performance (Van Ruiten, 1971). In particular, utilization of improved composition stones, precleaning equipment, multipass whitening, and finer adjustments on the cono mill can result in increases in total rice recovery. Arboleda and de Padua have demonstrated that adjustments on the Engleberg huller also make possible increased recovery rates and higher head yields (Arboleda and de Padua, 1965).

Regardless of the source of improved milling technology, whether from upgrading existing techniques through refinement and modification or the introduction of new designs, there must be a concomittant effort to upgrade the incentives for employing innovations which result in higher recovery and better quality rice. The common practice in the Philippines of using volumetric measures in merchandising milled rice tends to perpetuate a milling system which produces large percentages of broken grains. Because of the differences in the density of broken versus whole or head rice the total weight of one ganta of brokens will be greater than a comparable ganta of head rice. Many consumers state a preference for broken rice for this reason. Another area requiring attention is the practice of paying for the milling services by payment using the bran, binlids and hulls. When the miller receives payment in bran and binlids, he has no incentive to decrease the number of broken grains which result in a higher quality bran and more binlids from the milling process.

The present price of animal feed has risen to a point where most millers are receiving cash instead of bran and binlids in payment for milling services. The mixture of bran, binlids and masticated rice hulls which emanate from the Engleberg huller are used as animal feed for both hogs and chicken. In the absence of an assured supply of cheap feed grains, the present practice of utilizing the high quality by-product mix from Engleberg mills will persist. These

are policy-related questions which deserve the attention of the industry and government.

In order to establish criteria for the design and development of new rice milling equipment, it is necessary to examine the concentration and distribution of rice milling capacity by mill size. Figure 17 contains cumulative frequency distributions showing total industry rated capacity and total industry utilized capacity. Superimposed on this chart are the ranges over which the kiskisan and cono type installations operate. Note that approximately 70 percent of the rated capacity falls within the size range of kiskisan installations, while the cono installations cover approximately 50 percent of the range. The increasing segment of the frequency function from a size of 40 cavans up to 110 cavans per day contains approximately 50 percent of the industry rated capacity. It is this range which appears to offer the greatest potential for design and development of new milling technologies.

Note also that there appears to exist about 25 percent excess capacity in the milling industry, although it seems to be about evenly distributed over the entire range of mill size.

With increased commercialization, it would appear appropriate to move towards the upper end of the range selected for improved equipment and concentrate development efforts there. This allows realization of some economies of size in milling operation which are not now available to small mills, while at the same time keeping initial investment requirements at a level comparable with existing milling technologies. Employing the information contained in tables 1 and in conjunction with the above data, the general design parameters are specified as follows:

Capacity - 80-110 cavans/day
Power required - 0.8 - 0.9 hp/cavan of capacity
Total power - 8-10 hp
Investment cost - ₱60-₱80/cavan of capacity (including engine)
Total investment - ₱4800-₱8800
Variable costs - ₱0.35-₱0.40/cavan of output

Utilizing these general and very rough estimates, it remains an engineering problem to determine the feasibility of a design.

It is obvious that the above estimates are contingent upon the level of wages and prices now in effect. Changes in the economic environment or policies affecting the economic environment may change the level and/or composition of these estimates.

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Glossary

1) Hulling, husking, or shelling:- process of removing hulls from the grain.

2) Scouring, or pearling:- process of bran removal. (Locally known as polishing.)

3) Polishing:- the removal of very fine bran clinging to the milled rice and smoothing of its surface to appear glossy and clean.

4) Milling degree:- the extent or degree of removing the different bran layers which cover the rice grain as a result of polishing.

5) Milling recovery:- weight of milled or commercial rice recovered from the original rough rice or palay. Usually expressed in percent.

6) Kernel:- edible portion of palay seed.

7) Paddy or palay:- unhulled rice.

8) Milled rice:- whole or broken kernels where the hull and at least the outer bran layers and a part of the germ are removed and cannot contain more than 1% seeds or foreign matter.

9) Head or whole-grain recovery:- weight of whole grain recovered from the milled rice expressed in percent of the original rough rice (kernels not less than 3/4 of the whole grain).

10) Brokens:- milled rice with 25% or less than 3/4 to 1/2 of a whole grain.

11) Brewer or "binlids":- milled rice whose sizes range from 1/2 to 1/4 of a whole grain.

12) Chalky kernels:- milled rice containing 25% or larger white portions.

13) Flinty kernels:- kernels which are less than 2% white.

14) Foreign matter:- impurities such as weed seeds, stones, sand, dust, etc. which are foreign to milled rice.

15) Red rice:- rice with any degree of redness.

Table 1. Average investment costs for "kiskisan" and "cono" rice mills, by capacity.

Kiskisan[a/]

Capacity per 12 hours (cavans)	Engine size BHP	Average price[d/] (P)	Power HP/cavan capacity	Investment cost[c/] P/cavan capacity
30-100) with	5-12	1,789.00	.167 - .12	113.19
120-180) polisher	16-20	2,896.00	.133 - .11	72.13
30-100) without	5-12	897.50	.167 - .12	99.48
120-180) polisher	16-20	1,545.00	.133 - .13	67.63
30-100) with	5-12	1,574.00	.167 - .12	109.88
120-180) blower	16-20	2,413.00	.133 - .11	68.91
40-100) without	5-12	967.00	.125 - .12	93.36
120-180) blower	16-20	1,765.00	.133 - .11	64.59
30-100) with	5-12	2,246.00	.167 - .12	120.22
120-180) polisher,) sifter	16-20	3,417.00	.133 - .11	75.60
40-100) with	5-12	2,011.00	.125 - .12	108.28
120-180) blower,) sifter	16-20	2,971.00	.133 - .11	72.63

Cono[b/]

50-100	15-24	16,799.00	.300 - .24	376.37
150-250	25-30	36,417.00	.167 - .12	286.08
250-350	32-45	47,481.00	.128 - .13	260.65
350-450	45-55	56,936.00	.128 - .12	219.13
450-700	60-80	83,601.00	.133 - .11	193.14
700-1000	90-140	146,027.00	.129 - .14	204.10

[a/] Source: Survey of 6 major equipment suppliers by Ag. Eng. Dept., IRRI.

[b/] Source: Survey of 7 major equipment suppliers by Ag. Eng. Dept., IRRI

[c/] Taken at midpoint of capacity range. Includes cost of prime-movers.

[d/] Prime movers (diesel engine) are priced separately:

5-12 BHP	= P 5,568.50	25-30 BHP	= P20,800.00
16-20 "	= 7,923.00	32-45 "	= 30,715.00
15-24 "	= 11,429.00	50-90 "	= 27,455.00

Table 2. Rice milling capacity by mill type and region, Philippines, 1968.[1]

Region	Cono				Kiskisan				Total			
	Number	%	Capacity[2]	%	Number	%	Capacity	%	Number	%	Capacity	%
Ilocos	7	0.4	1325	0.5	1186	16.9	39377	12.3	1193	13.7	40702	6.8
Cagayan Valley	63	3.6	11685	4.2	526	7.5	25975	8.1	589	6.8	37660	6.3
Central Luzon	768	44.4	146595	52.5	960	13.7	61311	19.2	1728	19.8	207896	34.7
Southern Tagalog	291	16.8	33904	12.2	1222	17.5	55382	17.3	1513	17.4	89286	14.9
Bicol	116	6.7	17974	6.4	658	9.4	33474	10.5	774	8.9	51448	8.6
Western Visayas	114	6.6	24073	8.6	992	14.2	39639	12.4	1106	12.7	63712	10.6
Eastern Visayas	186	10.8	8917	3.2	468	6.7	20422	6.4	654	7.5	29339	4.9
Southern & Western Mindanao	97	5.6	19206	6.9	724	11.1	34359	10.7	871	9.9	53565	8.9
Northern & Eastern Mindanao	86	5.0	15269	5.5	205	2.9	10201	3.2	291	3.3	25470	4.3
Philippines	1728		278938		6991		320140		8719		599078	

[1] Source: Rice and Corn Administration, Quezon City.

[2] Capacity expressed in cavans per 12 hour operation.

Table 3. Standard grade requirements for Philippine milled rice.

Grade	Broken (Max)	Binlid	Head rice (Min)	Yellow & damaged kernels (Max)	Chalky kernels (Max)	Paddy number per 500 grams (Max)	Other varieties (Max)	Red rice (Max)	Foreign matter (Max)	Moisture content (Max)	Size of broken
	%	%	%	%	%			%	%	%	
1	10	None	90	0.25	Trace	None	2	None	None	14	Less than 3/4 of a kernel
2	20	None	80	0.5	5	1	4	Trace	0.5	14	Less than 3/4 of a kernel
3	30	0.5	70	0.75	15	2	5	0.5	0.75	14	Less than 2/3 of a kernel
4	40	1.5	60	1.0	25	2	7	1.0	1.0	14	Less than 1/2 of a kernel
5	50	3.0	50	3.0	30	4	15	5	2.0	14	Less than 1/2 of a kernel

General requirements:

1. No mixture of varieties.
2. Free from unpleasant and/or repulsive odor.
3. Free from insect infestation.
4. The unit of trading shall be in kilograms or metric tons.

Table 4. Description of classification standards used for Philippine milled rice.*

	First Class	Second Class	Third Class (Brown Rice)
Milling degree	Polished milled rice with shiny, smooth edge; no streaks or lines, foreign matter and bran from 0-0.5%.	Polished milled rice with slightly smooth edge; with 2-3 streaks with brownish color or spots and rice bran sticking to the kernels.	First stage in the milling where only the husk is removed, leaving a thin layer of the seed coat; very rough, brownish and full of lines.

	Type I	Type II	Type III
Type	Long grain. Length shall be above 5.9 mm.	Medium grain. Length ranges from 5.0 to 5.9 mm.	Short grain. Length shall be below 5.0 mm.

	Fancy	Special	Ordinary	Inferior
	The kernels have a flinty uniform appearance, glossy shiny, transluscent or creamy white.	The kernels have a desirable uniform white, creamy, white or light gray color.	The kernels exhibit a white to dull white or light gray color.	Milled rice with colored pericarps (due to handling and storage).

*Source: Zin, U Thet. "Rice Inspection and Grading Covering the Sampling, Inspection, Grading and Certification." Paper prepared for the FAO International Food Technology Training Centre, Central Food Technological Research Institute, Mysore, India, March, 1971.

Table 5. Estimated investment and operational costs for alternative rice milling technologies.

	Kiskisan			Cono			Modern		
	Small (15 cav per day)	Medium (30 cav per day)	Large (50 cav per day)	Small (86 cav per day)	Medium (160 cav per day)	Large (240 cav per day)	Small (2 TPH)	Medium (5 TPH)	Large (10 TPH)
I. Investment costs									
Bldgs. & machinery	8,516	15,677	23,818	30,494	51,104	52,320	120,800	302,000	604,000
Land	2,430	3,550	3,930	14,210	16,572	23,428	56,776	96,640	271,800
Transport equipment	570	1,140	1,900	3,500	6,550	9,800	17,640	31,752	47,628
Miscellaneous	45	90	150	300	580	880	1,760	3,344	5,016
Total investment costs	11,561	20,457	29,798	48,504	74,806	86,428	196,976	433,736	928,444
II. Operational costs									
A. Fixed costs:-									
Depreciation	711	1,135	1,667	4,574	7,666	9,040	18,120	45,300	90,600
Interest	511	941	1,429	1,830	3,066	3,139	7,248	18,120	36,240
Maintenance	360	480	600	650	1,000	1,500	1,950	4,875	9,750
Insurance	200	375	420	1,276	2,010	2,771	3,828	9,570	19,140
Taxes	163	266	304	1,331	1,746	2,358	5,056	9,952	18,392
Total fixed costs	1,945	3,197	4,420	9,661	15,488	19,616	37,002	87,817	174,122
B. Variable costs:-									
Labor	2,160	2,400	2,880	8,340	16,140	21,120	29,820	37,920	46,020
Fuel and oil	756	1,510	2,057	3,560	5,022	6,570	14,170	28,340	56,678
Electricity	72	108	144	576	720	864	2,016	2,880	4,320
Total variable costs	2,988	4,018	5,081	12,476	21,882	28,554	46,006	69,140	107,018
Variable cost/cavan	0.83	0.56	0.42	0.60	0.57	0.50	0.35	0.21	0.16
Total operational costs	4,933	7,215	9,501	22,137	37,370	48,170	83,008	156,957	218,140
III. Annual capacity (cavans) (240 days)	3,600	7,200	12,000	20,640	38,400	57,600	130,752	326,400	653,760
Unit cost at capacity	1.37	1.00	0.79	1.07	0.97	0.83	0.63	0.48	0.33

Footnotes in separate sheet.

Footnotes to Table 5

I. Investment costs:

1) Buildings & machinery - based on price lists of 7 major rice mill manufacturers and dealers surveyed by Agricultural Engineering Department, IRRI, 1972. (See Table 1.)

2) Land - P10/sq.m. for "kiskisan" mills. P20/sq.m. for "como" and modern mills.

3) Transport equipment - includes costs for trucks and jeeps which may be bought brand-new or second-hand.

4) Miscellaneous - office/plant supplies and fixtures.

II. Operational costs:

A) Fixed costs:

1) Depreciation - Depreciation on buildings is calculated at 5 per cent and on machinery at 10 per cent. The life of the machine is said to be about 35 years (quoted by manufacturers).

2) Interest - 6 percent annually.

3) Taxes - includes real estate tax, BIR taxes, and license.

B) Variable costs:

1) Labor - wages paid for a mill operator and a laborer-helper at P240/mo. and P180/mo., respectively. Number of helpers varies with size of mill. (Comos and modern mills include in its staff an accountant, assistant manager, drivers, secretary, security guards.)

2) Fuel and oil - based on diesel oil consumption at specified BHP capacity. (P).29/liter.)

3) Electricity - based on daily electricity consumption to light the rice-mill area. (P0.25/kwh.)

III. Annual capacity - volume of palay milled daily for 240 days in a year.

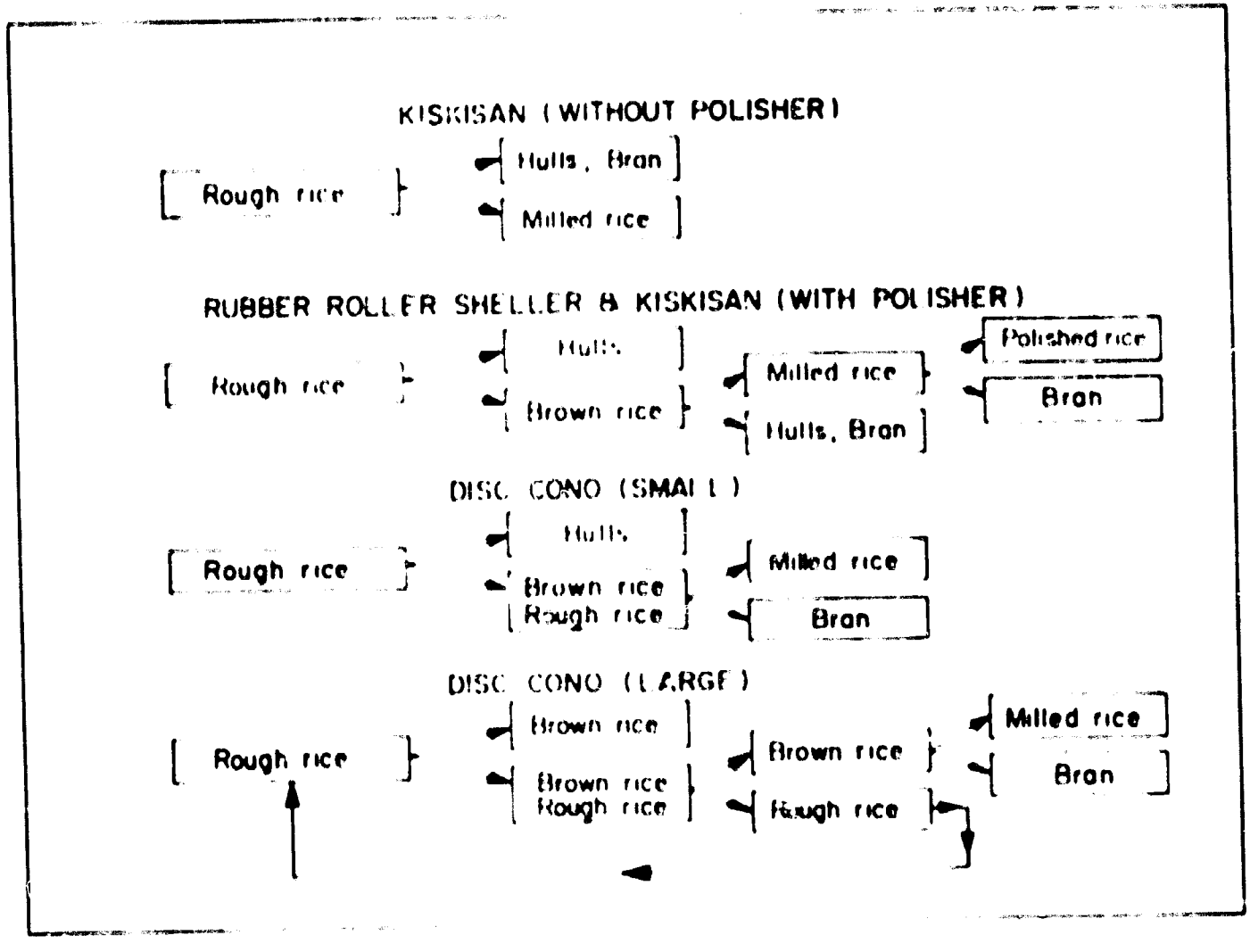

Fig 1 Some alternative rice milling systems

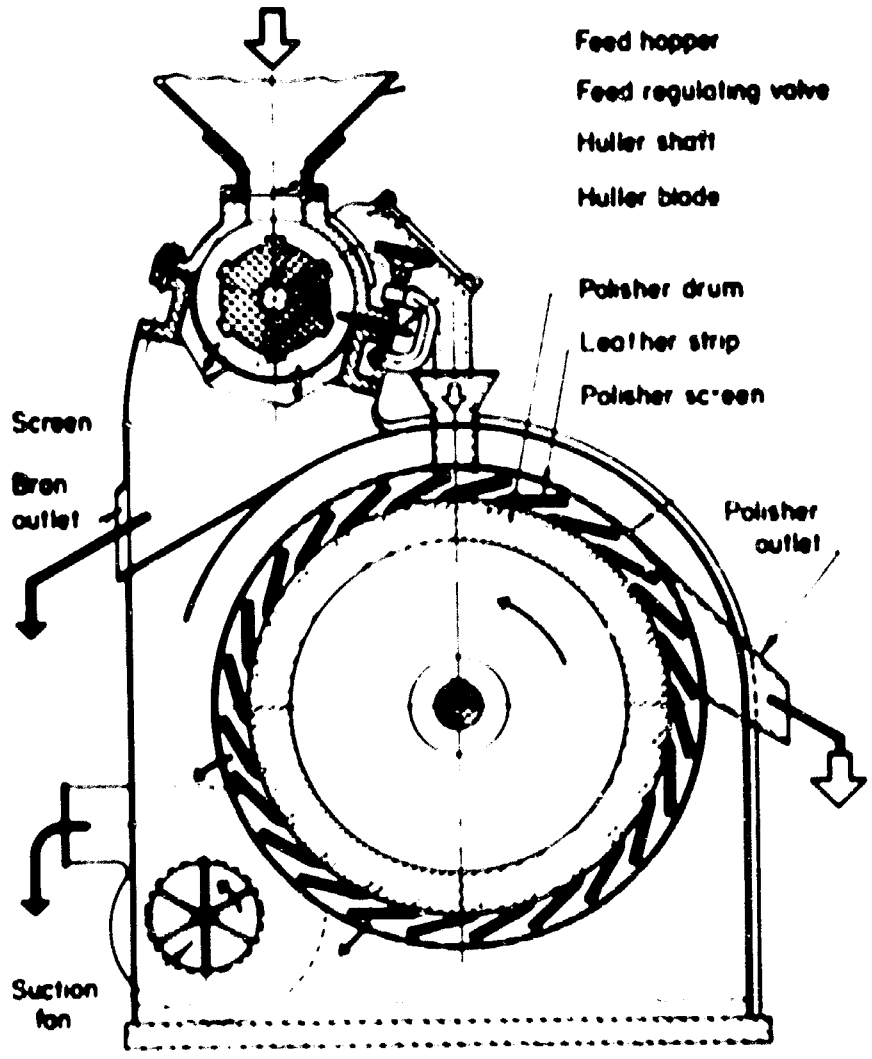

Fig 2 Schematic illustration of Engelberg huller equipped with polisher

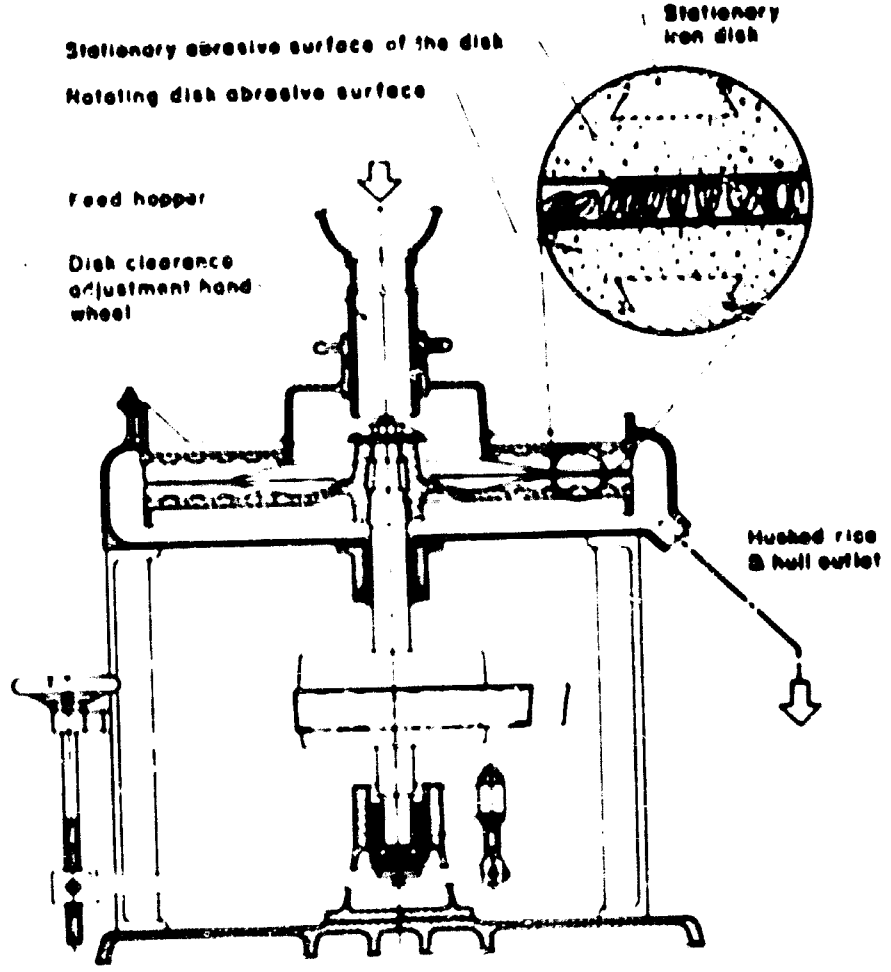

Fig 3 Schematic illustration of an under-run disk sheller

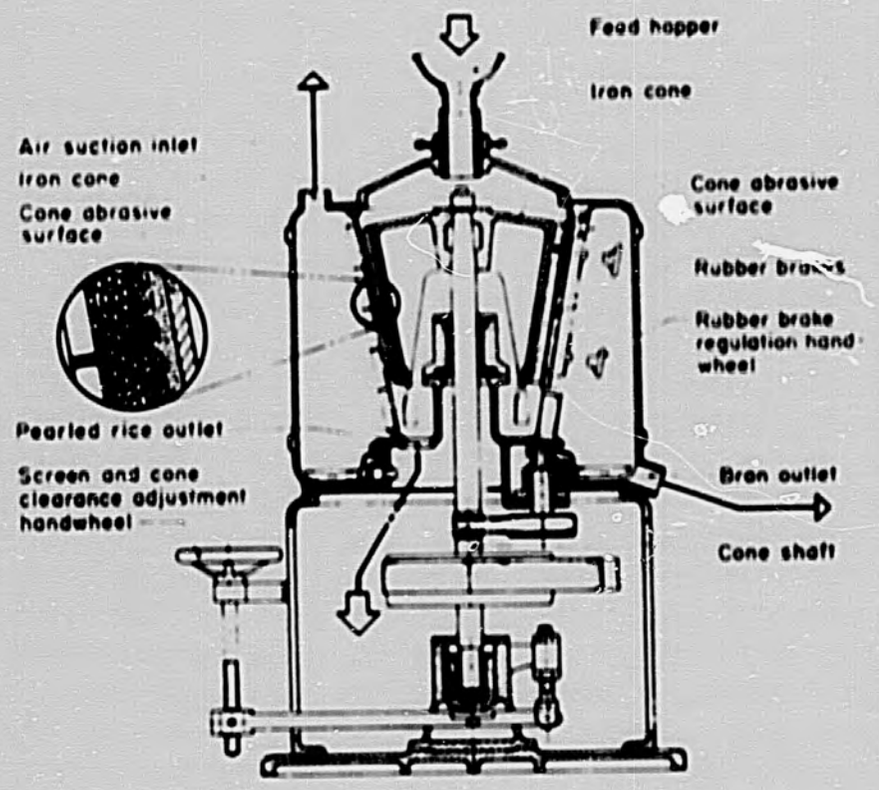

Fig. 4 Schematic illustration of a vertical cone pearling machine

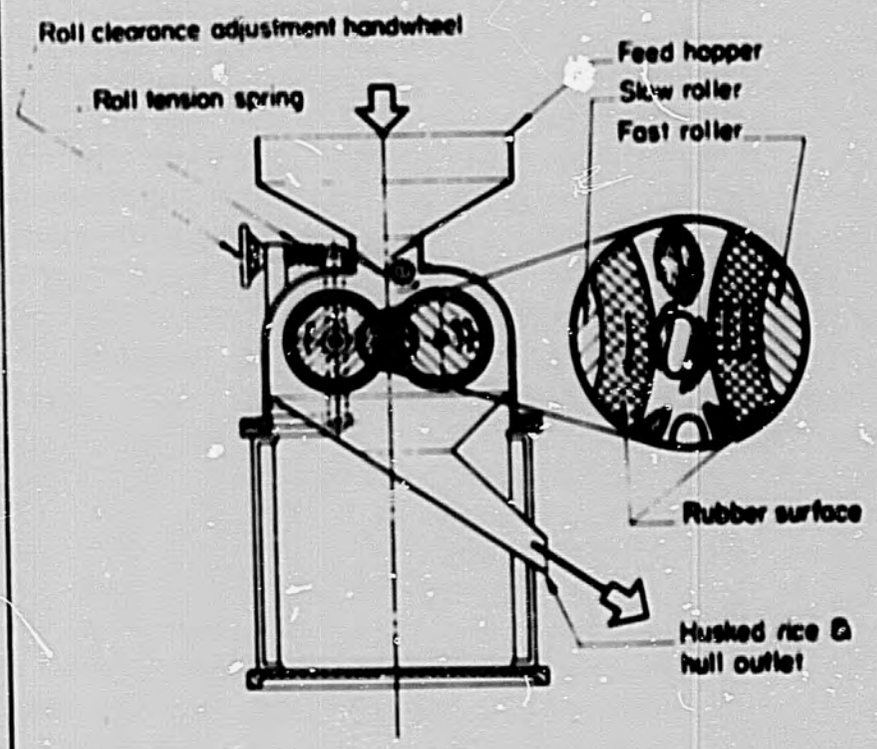

Fig. 5 Schematic illustration of a rubber roller sheller

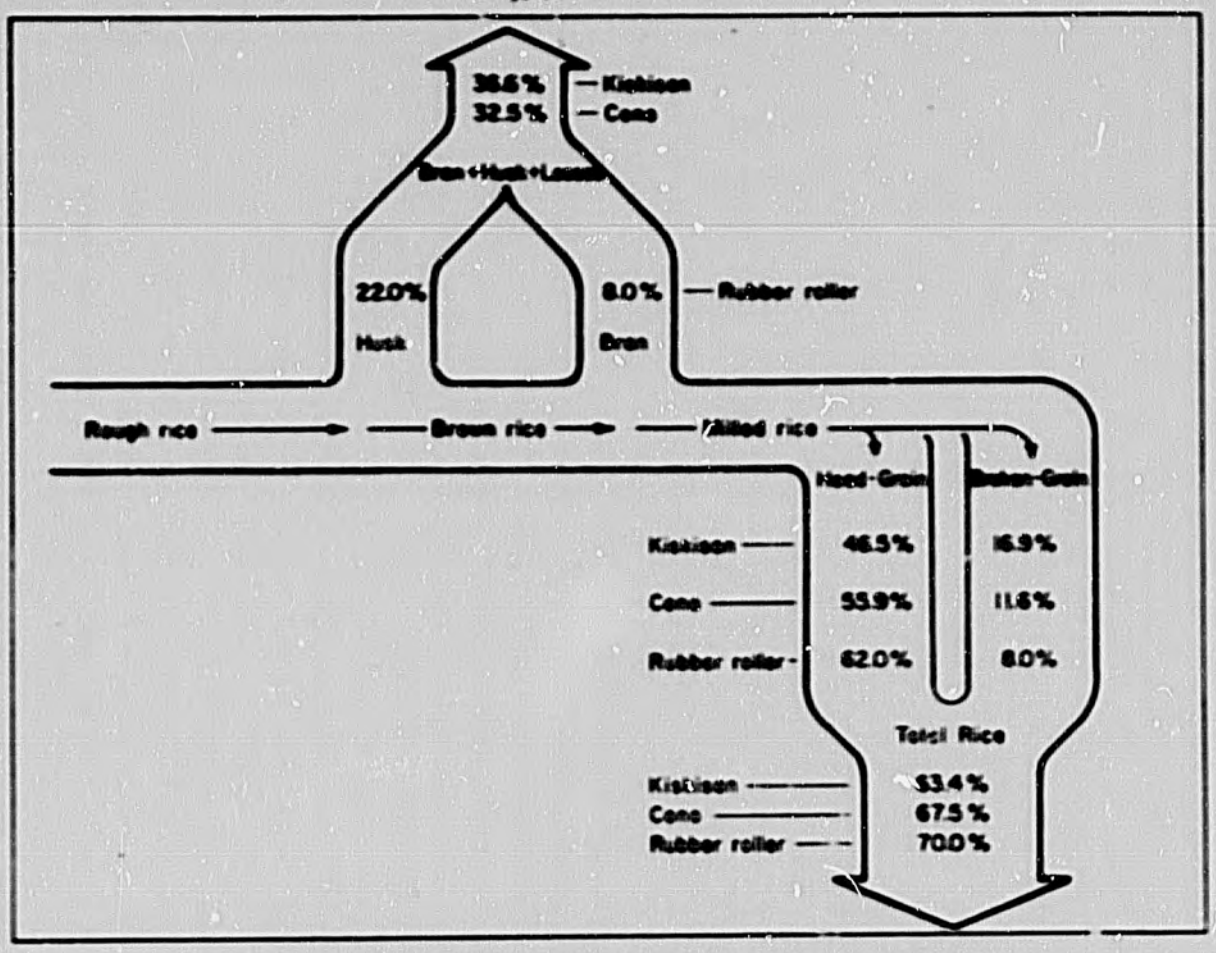

Fig. 6 Recovery efficiency for three rice milling systems

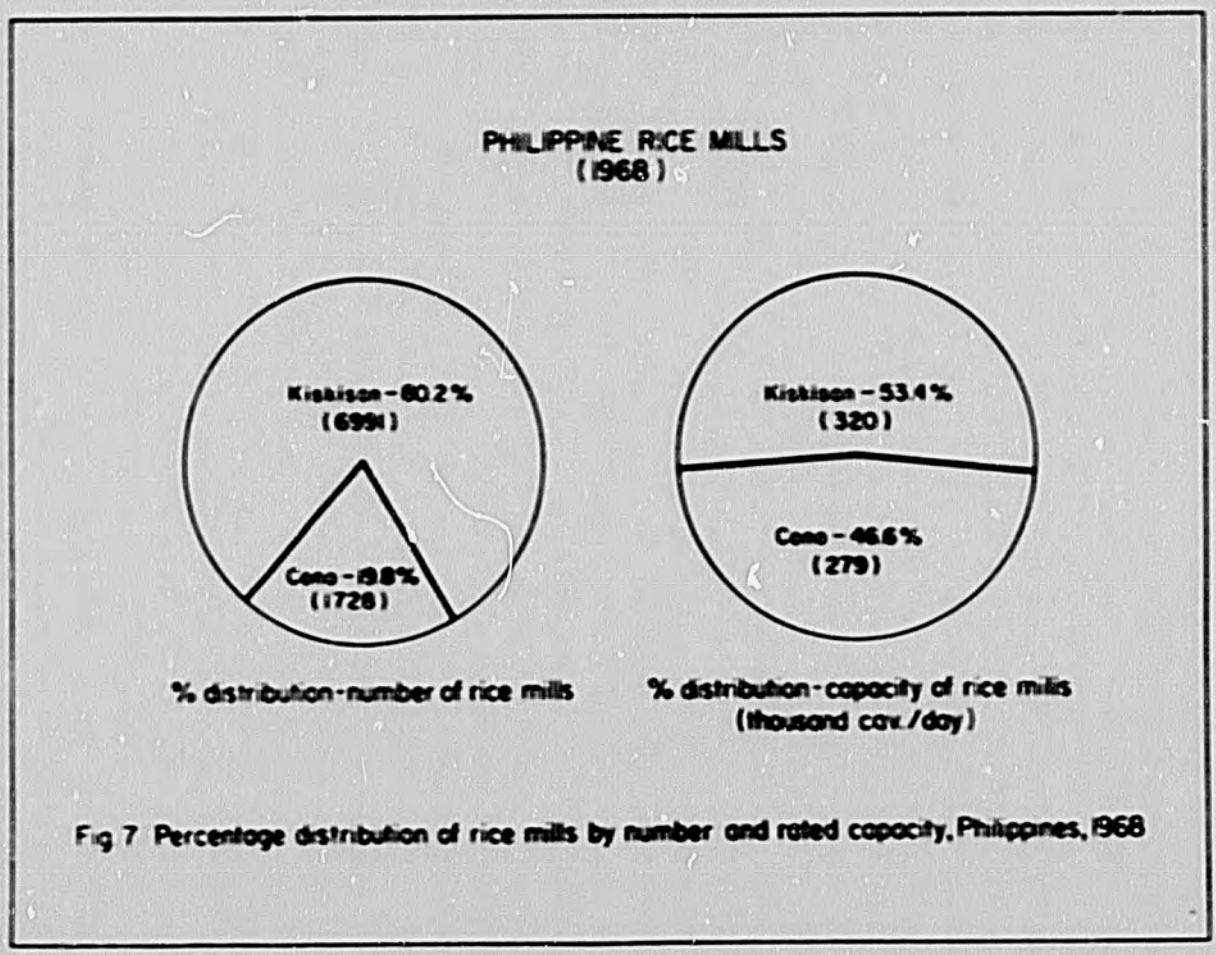

Fig. 7 Percentage distribution of rice mills by number and rated capacity, Philippines, 1968

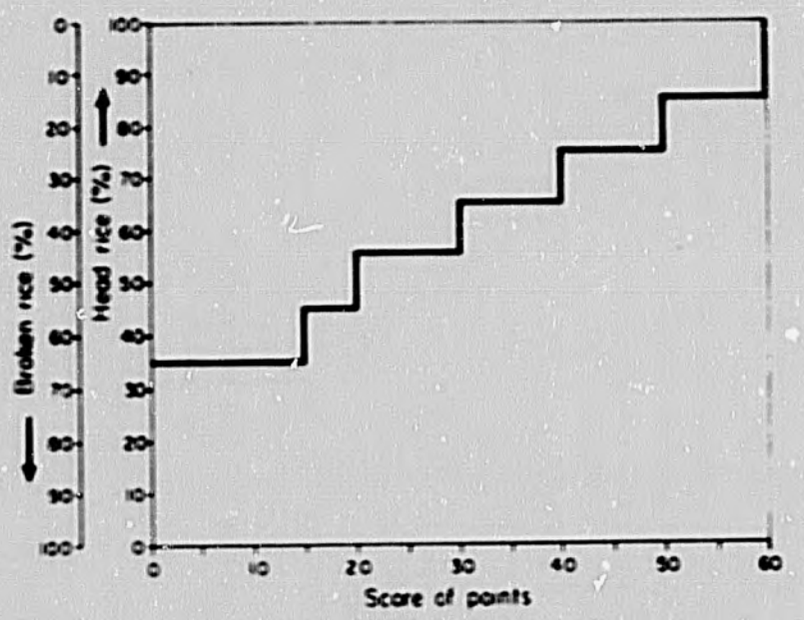

Fig. 8 Point allocation method for broken rice under Philippine rice quality classification system.

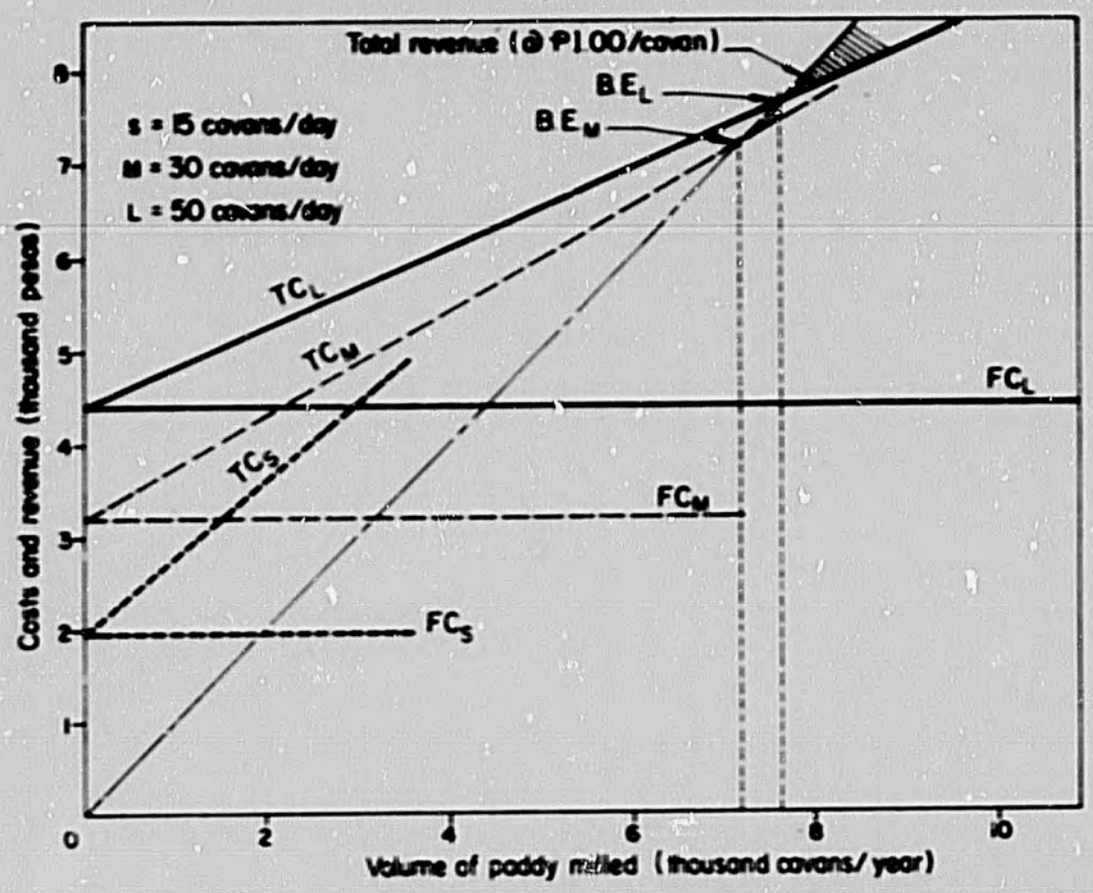

Fig 9 Estimated total cost and revenue curves for three alternative sized kiskisan rice mills, Philippines, 1972

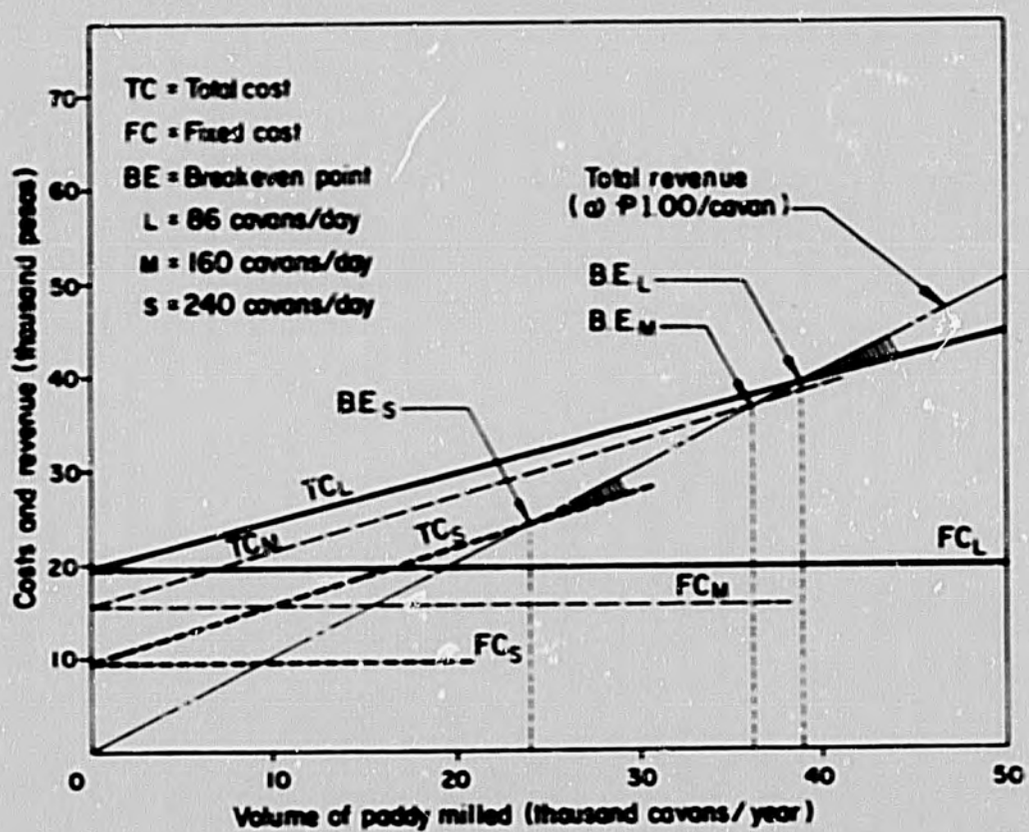

Fig 10 Estimated total cost and revenue curves for three alternative sized cono mills, Philippines, 1972

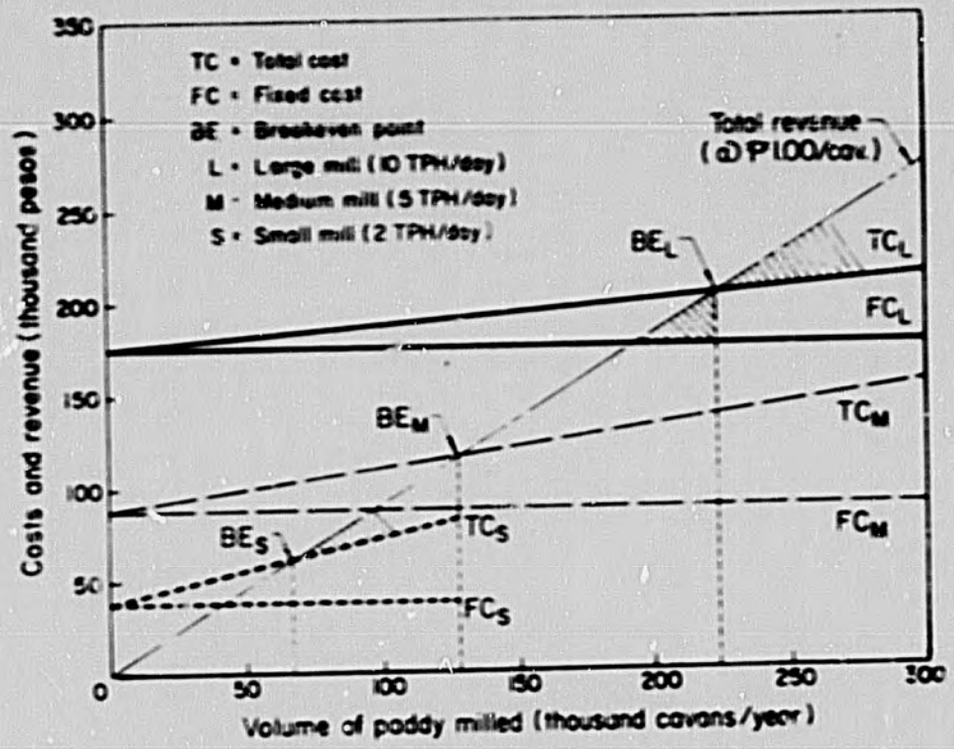

Fig. 11 Estimated total cost and revenue curves for three alternative sized modern rice mills, Philippines, 1972.

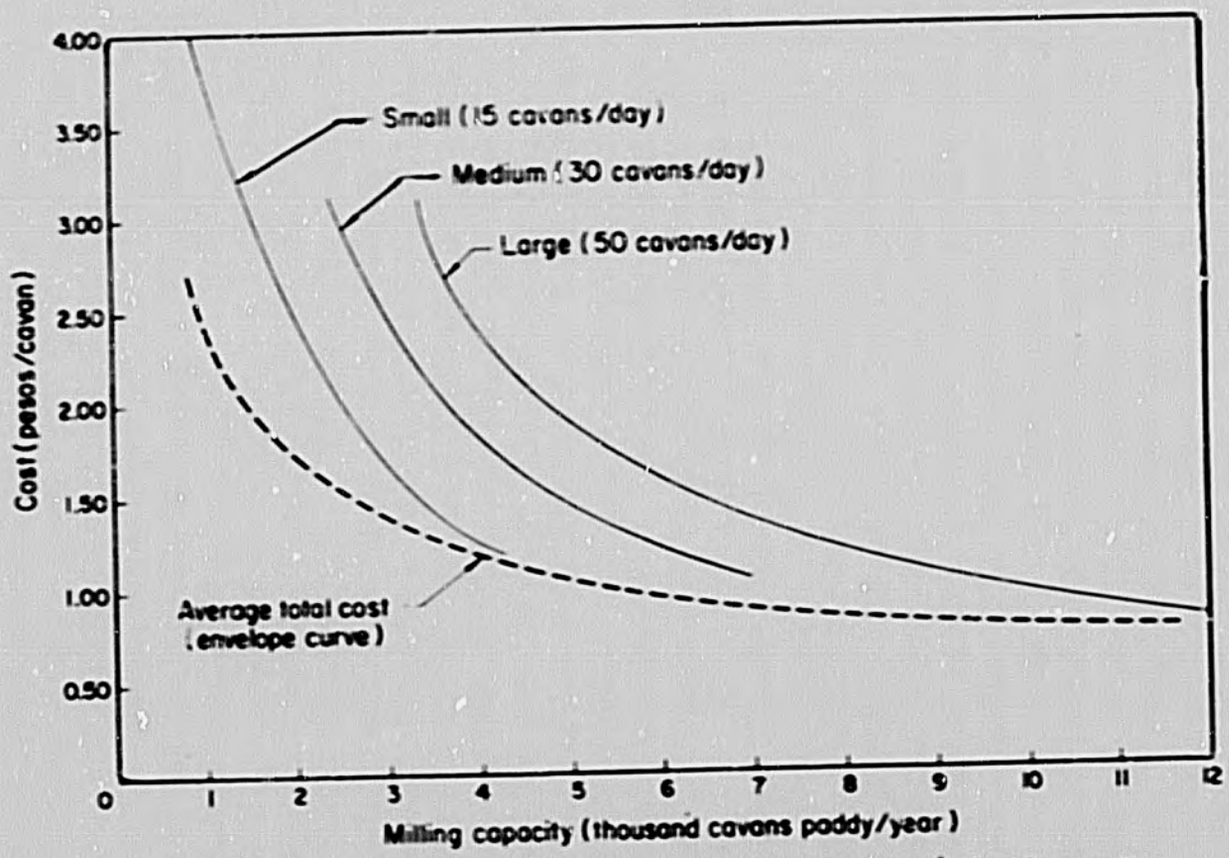

Fig. 12 Estimated total average cost curves for three alternative sized kaskasan rice mills, Philippines, 1972

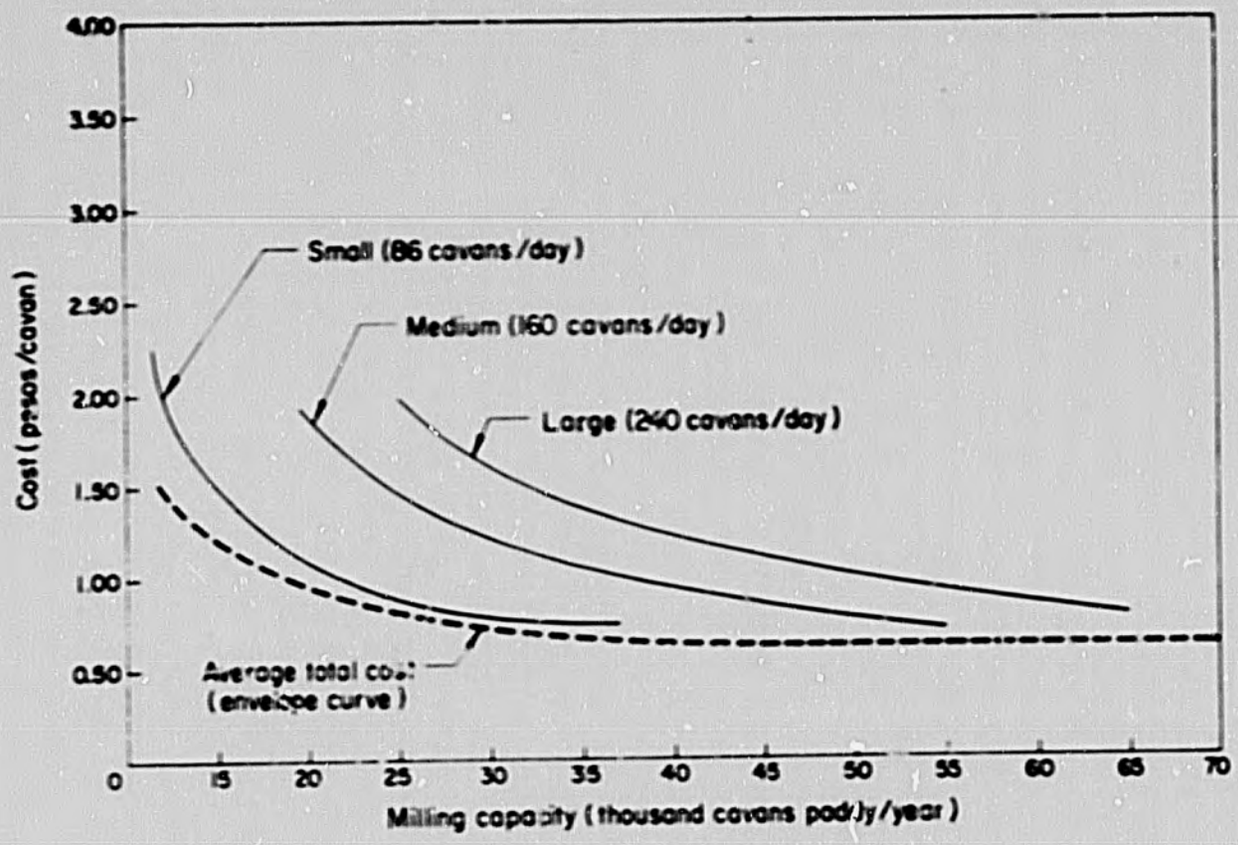

Fig.13 Estimated total average cost curves for three alternative sized 'cono' rice mills, Philippines, 1972

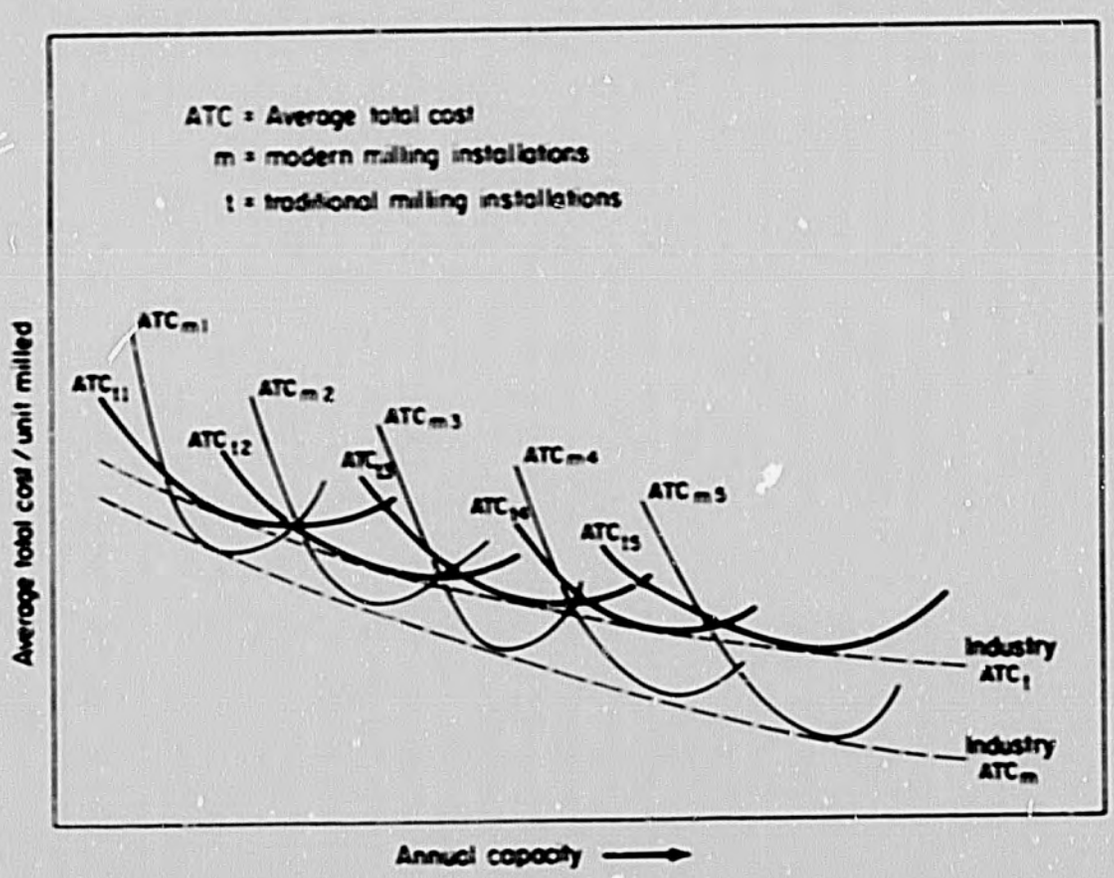

Fig.14 Hypothetical average total cost curves for two alternative rice processing systems

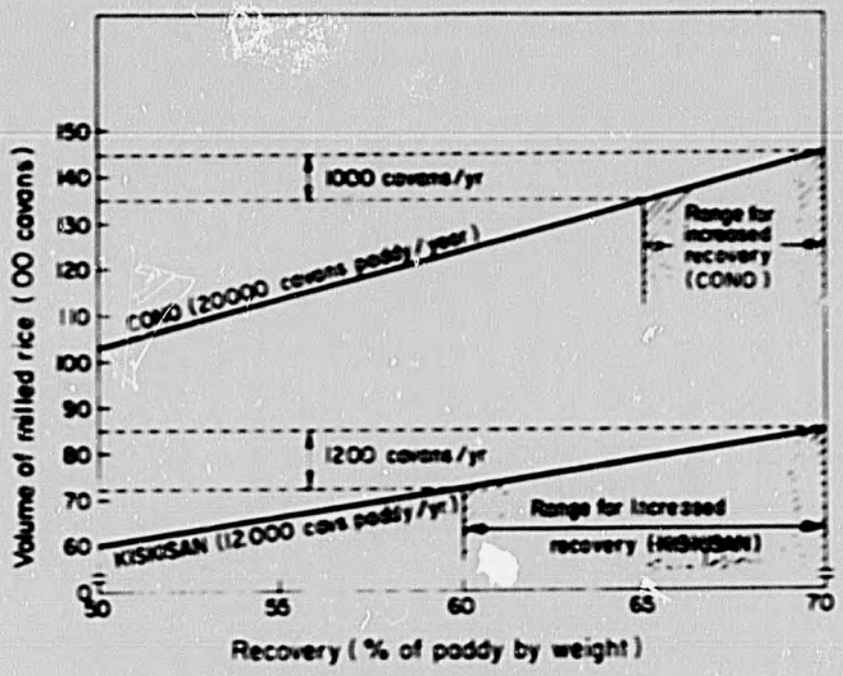

Fig. 15 Effect of increased milling efficiency on total rice recovery.

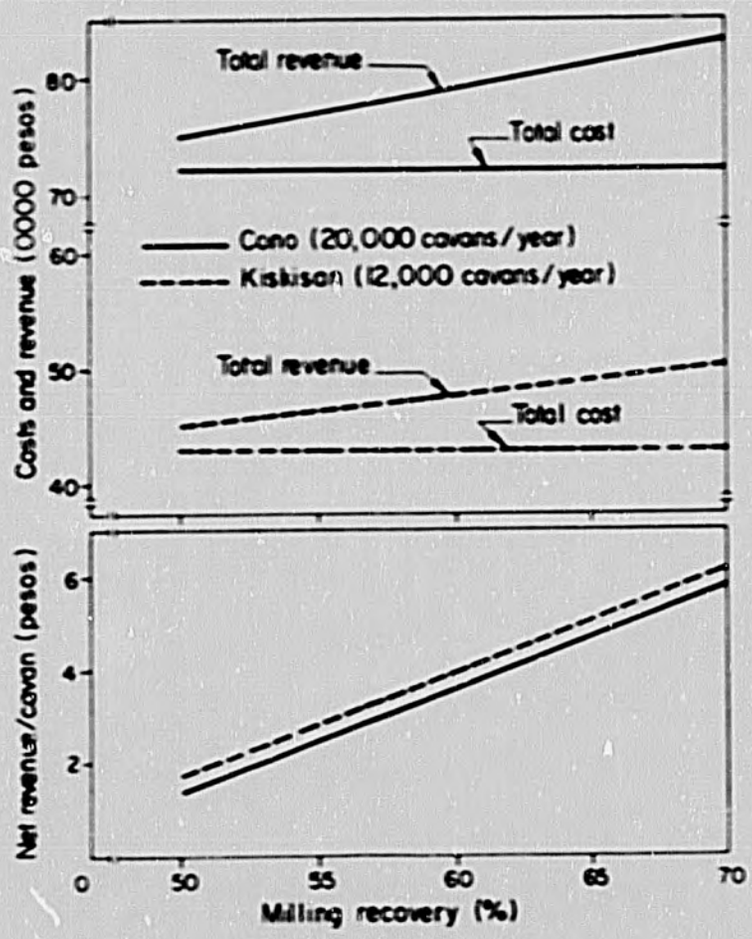

Fig. 16 Effect of increased milling recovery on total and net average revenue.

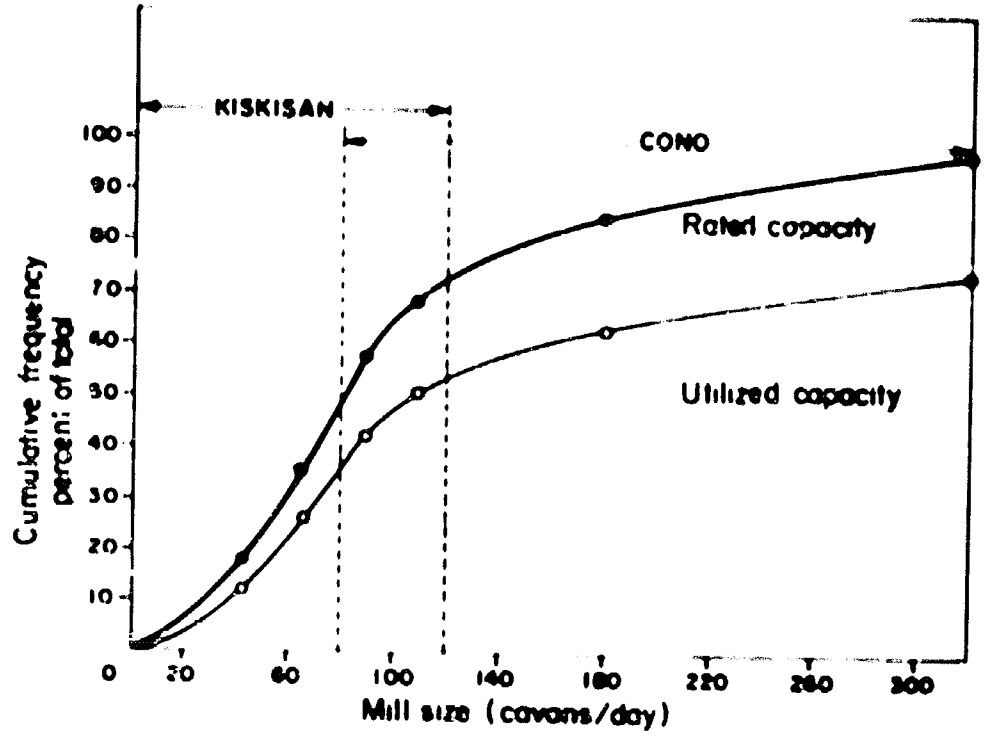

Fig 17 Distribution of milling capacity by mill size, Philippines, 1970