Government of Papua New Guinea

Guidelines for Mechanical Rice Milling Service in Papua New Guinea

Under Department of Agriculture & Livestock (NDAL) and

Japan International Cooperation Agency (JICA)

Project on Promotion of Smallholder Rice Production [Phase 2]

February 2015

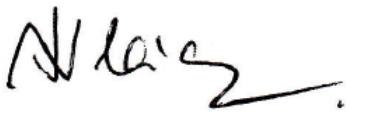
FOREWORD

The Department of Agriculture & Livestock is pleased endorse these Guidelines for Rice Mechanical Rice Milling Services in Papua New Guinea. It is timely and important that such information material on Mechanical Rice Milling Services is made available to all the stakeholders in PNG's domestic rice production and processing development programme.

Smallholder households scattered throughout rural Papua New Guinea have from one time or another cultivated rice with little success in milling their rice for home consumption. Governments through their local constituencies have had difficulties in providing mechanised rice milling services that are sustainable and providing effective services to the rice growing communities on long-term basis. Despite the increase number of rice milling machines been procured by local governments, community leaders like members of Parliament, LLG Presidents or Ward councillors, many of these investment and machineries are in dis-use and idling due to number of reasons.

It is hoped that the development and production of this document will help district planners, agriculture technical managers, district rural development officers, and rice development officers within each district, LLG, and province and all the stakeholders in the development of the smallholder rice farming system and rice milling services in establishing and operationalising rice milling services that not only will sustain the rice farming culture put in place by the Departments' technical cooperation with JICA from Year 2003 to 2015, but also will enhance the capacity of all the operators and managers of all the rice milling machinery or unit throughout Papua New Guinea.

A sustainable rice milling service will boost rice production throughout the regional Papua New Guinea where smallholder rice growers and households live. It is also a business opportunity for those who have close attachment to machine and their operation. At present, rice milling services are provided by government support and funding. In many rice growing nations, rice milling services are provided by private entrepreneurs and it is hope that these Guidelines for Mechanical Rice Milling Service can provide the basis for individual Papua New Guineans to take up rice milling services as a business opportunity under the Government's Small-and-Medium Enterprise programme.



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The development and the production of the Guidelines for Mechanical Rice Milling Services in Papua new Guinea was made in concert with the development and production of the Guidelines for Establishing Smallholder Rice Extension in Papua New Guinea and the two Handbooks that complements the Guidelines, namely, the Handbook on Rice Post-Harvest Techniques and the Handbook on Upland Rice Cultivation. These publications have been made possible by the bilateral technical cooperation between the Japan International Cooperation Agency (JICA) and the Department of Agriculture & Livestock (DAL), with its collaborating provinces of East Sepik, Madang, Milne Bay and Manus.

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Preface

This guidelines focusing on mechanical milling service which has been produced through the activity through the Project on Promotion of Smallholder Rice Production [Phase 2] under control of Department of Agriculture & Livestock (hereinafter referred to as "NDAL") and Japan International Cooperation Agency (hereinafter referred to as "JICA") with target provinces; East Sepik, Madang, Manus and Milne Bay form December 2011.

In Papua New Guinea (hereinafter referred to as "PNG"), the milling of rice is generally done as commissioned milling at publicly or privately run milling facilities each. In some regions where there is no milling facility or no access available, the Kiser or other manual milling devices are utilized. In PNG, where rice production levels are limited, commercial milling services are not very popular, and the area is home to just one large-scale milling company, engaged in husking and milling imported paddy.

In PNG, 70–80% of the population work in the agricultural sector, many of whom are either smallholders cultivating and harvesting taro, banana, and cassava, including those growing wild, for subsistence, as well as producing cocoa, copra, coffee, and coconut, or they are either wage workers working at such plantations. In these circumstances, rice is considered an important staple food items in PNG, but most of the rice supply depends on imports, resulting in high cost, influencing family finances. Increase in the demand for rice is partly attributable to a change in culinary taste—people are becoming increasingly fond of rice. Thus, from the perspective of food security in PNG in the future, it is indispensable to improve the self-sufficiency ratio of rice.

In order to raise this self-sufficiency ratio, it is necessary to increase the number of rice-producing farmers, rice-planting areas, and the unit yield of rice, while the necessity of mechanical milling services, which can help alleviate farming labor, is vociferously advocated. In PNG, however, not only rice cultivation but also post-harvest techniques including the milling of rice are unfamiliar to people in general, and in such a situation, the introduction of milling services faces substantial challenges, including operational difficulties.

In these guidelines, explanation is given on such challenges to be addressed in a comprehensive and succinct manner, hopefully leading to the sustainable operation of milling facilities.

The major means of rice milling in PNG are characterized by a unique type of commissioned milling not found in other countries. From the preparation of seeds and start of rice production, to the mouths of consumers, regarding white rice, farmers and milling facilities are consistently involved in each process of post-harvest treatment. Taking into consideration this unique situation

that is different from other countries, the milling yield ratio and the sustainable methods of operating milling facilities are described in these guidelines.

If not appropriately maintained, milling machines operated at milling facilities are prone to mechanical failure or may become difficult to operate after several years of operation. In order to prevent such a situation, the effective operation of milling facilities and sustainable maintenance methods are to be explained.

Chapter 1 through Chapter 3 can be utilized by business owners and government officials who are trying to start new facilities or upgrade/expand existing facilities when they start new businesses; and Chapter 4 and thereafter are meant to be guidelines for everyone who is engaged in the operation of milling facilities. Also, it is desirable that those who have already been operating milling facilities see the contents of Chapter 1 through Chapter 3, for reference. Standard operational procedures are described, thus surely those chapters are considered to be helpful for daily operation.

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1. General information

1.1 Background

In PNG, agriculture is a major industry for supporting people's livelihood, accounting for about 27.9% of its real GDP in 2012. Around 80% of all PNG people are engaged in the agricultural sector, many of whom are smallholders cultivating subsistence crops, as well as cash crops for export, such as copra, coffee, and cocoa, etc. The country used to be self-sufficient in food; however, due to population increase, urbanization, industrial development, and changes in dietary habits, demand for food has dramatically increased. As a result, in recent years, grains, meats, and many other foods are imported. In particular, PNG people have come to prefer eating rice, causing increase in rice demand; therefore, from the viewpoint of food security, it is necessary for the country to raise the self-sufficiency ratio of rice.

Under such circumstances, the PNG government, in technical cooperation with JICA, has implemented and reinforced rice production policies in four target provinces (East Sepik, Madang, Manus, and Milne Bay provinces) through the Food Security Bureau, Department of Agriculture and Livestock (DAL), and its umbrella unit, the REU (Rice Extension Unit). By establishing a model-farmer approach and local government-led dissemination services, the PNG government has been disseminating and expanding smallholder rice production techniques, aiming at increasing rice production. Rice is an important staple for PNG, but the country depends on most of its supply through imports from abroad; as a result, rice costs are high, influencing people's livelihoods. Regarding the reason why demand for rice has increased, PNG people have come to prefer eating rice. Moreover, aside from the cultivation of rice, the PNG-side has requested that, in order to raise the self-sufficiency ratio, the provision of mechanical milling services is indispensable for alleviating the labor force on the part of rice-producing farmers. However, although some equipment has already been provided, sustainable operation is lacking (including the appropriate maintenance of facilities), with no advances in the sustainable management of the facilities, which has been influencing the number of rice-producing farmers. It has thus become necessary to prepare guidelines for improving mechanical milling services at publicly/privately run milling facilities, for introducing milling machines appropriate for the abilities on the PNG-side and for improving milling services, as well as for providing technical guidance on the repair/maintenance of machinery.

As for the current situation of milling services in PNG, there is just one large-scale private milling company, which undertakes commercial milling to produce white rice for the domestic market, utilizing modern milling equipment. Aside from this company, milling services are mostly performed at publicly/privately run milling facilities, to which farmers bring their paddy; where commissioned milling is done utilizing diesel engine-driven small-size milling machines. However, there are many facilities where machines are left idle for many years, as workers do not know how to use them. Or, even if they can operate the machines, there are few capable op-

erators able to repair machines in case of trouble; and adding to such a situation, it is often difficult to procure parts and components for repair. In the worst case, there are many facilities that have lost the opportunity to operate machines due to a lack of paddy to mill, leading to an "open but inactive" situation.

In short, both the production of rice and machine milling services are critical, and guidelines on "mechanical milling services" are indispensable for helping continue rice production.

1.2 Purpose

The purpose of these guidelines is to provide national and local government staff in charge of publicly/privately run milling facilities as well as milling facility managers in PNG with guidelines to aid them in sorting out basic concepts and agenda necessary for starting the operation of milling facilities, so that milling facilities can be operated in a sustainable manner.

In addition to targeting persons who are starting the operation of new milling facilities, these guidelines include all the points necessary to be referred to for those in the milling business, along with managers of governmental milling facilities, when those who are already operating milling facilities want to renew their machinery or expand operation. Important points are summarized.

Therefore, these guidelines describe not only milling service-related general points and the basic points necessary for producing quality white rice but also indispensable points necessary for realizing the sustainable operation of milling facilities.

1.3 Definition of terminology

1.3.1 Milling

"Milling" is defined as a process of firstly removing the hull from a paddy (hulling) and secondly removing bran (Pericarp, testa and part of aleurone) and embryo (germ) from brown rice (hulled rice), in order to obtain, the perfect-grain condition of rice (milled rice), most of which are not broken, endosperm-style rice with a desirable surface.

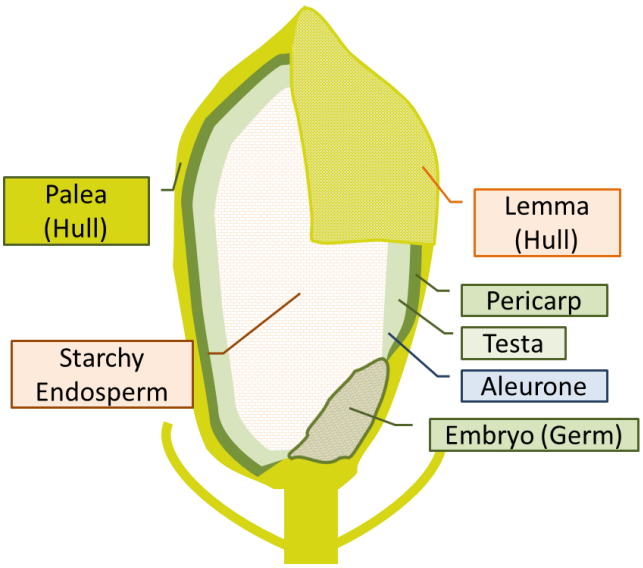

Figure 1: Figure of Paddy

1.3.2 Milling services

"Mechanical Milling service" refers to paid services for hulling paddy and polishing brown rice to obtain white rice (milled rice) at publicly or privately run milling facilities. This refers to all aspects of post-harvest techniques utilizing operation, including the management of milling facilities, operation, maintenance, the repair of milling machines, and the marketing and handling of white rice and by-products (such as broken rice, bran, and hull). It also includes accounting management such as the collection of commissioned milling fees as well as the purchase and sales of paddy for commercial milling.

1.3.3 Milling recovery

"Milling recovery (%)" refers to the percentage of weight of white rice (including broken rice) divided by the weight of the paddy (without foreign matter and immature grain).

Example: (Weight of white rice/weight of paddy) x 100 = Milling recovery (%)
Calculation is done in units of 100 g.

The milling recovery serves as an index indispensable for both the technical and managerial aspects of milling facility operation. For instance, see below:

(1) Operational status of machinery: A "barometer" for replacing damaged parts or worn-out components.

(2) Quality of paddy material: Showing which points to improve on regarding cultivation and post-harvest techniques, such as the foreign matter ratio and cracked rice ratio.

(3) Utilizing the information of the above (1) and (2), marketing activities can be done for users, serving as an information base.

Calculation example:

In case that 100.0kg of paddy is input afterward 60.0kg of white rice is output, the milling recovery is to be 60.0% [= 60.0kg/ 100.0kg x 100].

To be expressed in percentage for milling recovery, significant figure should be 3 digits (unit of 100g) to keep data precision (refer to "9. Weighing, Handbook for Rice Post-Harvest Techniques").

In case that 18.6kg of paddy is input afterward 11.2kg of white rice is output, the milling recovery is to be 61.2% [≒ 11.2kg/ 18.6kg x 100].

1.4 Expected outcome of utilizing these guidelines

These guidelines aims at enabling new milling facilities to be profitable through the procurement of the most appropriate size of equipment (milling machines), as well as appropriate operation. In the future, milling machines should be renewed not through the support of the government or aid organizations but with the facility's own budget set aside by means of depreciation. In addition, the durability of milling machines can be extended through appropriate maintenance by machine operators who have acquired correct operational techniques. Finally,

the improvement of post-harvest knowledge and techniques enables the reduction of post-harvest losses and the efficient production of quality polished rice. In other words, it is expected that the sustainable operation of milling facilities as well as an approach to the ideal operation of milling facilities can be realized.

2. Current situation of milling in PNG and the basic points of milling services

2.1 Current situation of milling

2.1.1 Differences between different types of milling machines: Difference between manual and mechanical milling

What should be done before discussing milling machines for milling facilities is analyzing the differences between manual milling and mechanical milling by comparison, recognizing the features and merits/ demerits of each milling method.

The major advantage of manual milling is that this method can easily be utilized by anyone and anywhere even without electricity or a power source; however, the quality of polished rice obtained through this method is not even. Manual milling devices are comparatively less expensive for farmers to buy. There are several types of such manual milling devices, including the Kiser, which was picked up in Phase 1 for which training was given regarding production method and for which dissemination was promoted, along with other types where the paddy is put into a mortar and beat with a pestle or by foot. These devices can be placed and utilized anywhere.

On the other hand, mechanical milling can produce a uniform quality in the polished rice. As an example of mechanical milling, the micro-mill (RM150) is the most popular type of milling machine in PNG, characterized as a one-pass milling machine with which hulling and milling are done with the same rotor. In particular, the Engelberg type is of an old-fashioned design utilizing a mortar mechanism. Although the milling yield of this type of machine is relatively low, this type is convenient for farmers living in mountainous areas or on islands. The micro-mill is welcomed by farmers, as it alleviates the cumbersome and hard labor of manual milling in areas where access to commissioned milling facilities is difficult and where farmers have to walk several hours to milling facilities, or in mountainous areas or on islands where only the Kiser and other manual milling devices are available.

Further, in PNG, large-scale mechanical milling facilities are monopolized by one company, as mentioned before. Polished rice thus produced is packaged in different sizes of polyethylene (PE) bags and is sold at supermarkets and retail stores throughout the country, and its quality is almost the same as imported rice though slightly less expensive. Table 1 compares manual milling and mechanical milling.

Table 1: Comparison of manual milling & mechanical milling

No	Point	Manual milling	Mechanical milling
1	Quality of milling	Uneven	Uniformed quality of polished rice produced through the adjustment (setting) of the machine
2	Uniformity of milling	Not stable, not uniform	Uniform quality of white rice can be produced anytime
3	Efficiency of milling	Not efficient, takes time to mill	Efficient; milling can be done in a short time
4	Cost of machine	Less expensive	Initial investment cost (cost of machine) high
5	Operational technique	Easy to use, anyone can operate	Technician knowledgeable in milling needed for operation and maintenance
6	Installation site	Can be installed and used anywhere	Installation site matching the needs of the machine required
7	Operation cost	Operational cost low, maintenance scarcely needed, power from manual input enough	Operation costs high, consumable part costs high
8	Workforce needed	Can be operated by one person	Often difficult to operate by just one person (though this depends on the composition of machines)

Regarding mechanical milling, at most milling facilities in PNG, just one milling machine of either Engelberg type or rubber roll-type for one-pass (passing just one time) milling machine is utilized; while milling machines utilized at large-scale milling factories process large amounts of paddy, and these factories are complex facilities equipped with additional machines utilized for pre-cleaning and other purposes before and after milling. At large-scale milling factories, consistent milling quality is always possible. Most of the operations involve commercial milling, thus emphasis is placed on milling recovery, and milling operation is done in a continuous manner, in order to improve efficiency.

2.1.2 Difference by milling service type

2.1.2.1 Major difference between commissioned milling and commercial milling

Milling facilities can be divided into two categories based on operational type: Commissioned milling and commercial milling.

At commissioned milling facilities, milling is done on an individual basis, where the milling amount per unit time is small. Paddy brought into a facility by a farmer is milled by lot. In most countries around the world, users pay for commission in kind or by cash for milled white rice. The amount of payment in kind differs from country to country or region to region. In many cases, the bran and hull generated in the milling process are retained by the proprietor of the milling facility.

On the other hand, commercial milling takes the strategy of placing emphasis on milling recovery. In order to improve the efficiency of machines, it is indispensable to continuously operate them. Operators are required to have technique and experience in milling machine operation. They must operate their milling machines effectively no matter the quality of the paddy. In order to realize continuous operation indispensable for commercial milling, the procurement of an adequate amount of paddy is essential.

2.1.2.2 Differences in operation between commissioned milling and commercial milling

The major differences in the two types of operation have already been explained above, and the following table shows a comparison by point. Major differences include whether emphasis is placed on milling recovery, whether milling quality is constantly even, and whether the operational method is continuous operation or intermittent operation.

Table 2: Comparison between commissioned milling and commercial milling

No	Point	Commissioned milling	Commercial milling
1	Operation efficiency	Milling amount per unit time small; operation intermittent; operation inefficient	Milling amount per unit time high; operation continuous; operation very efficient
2	Milling quality	As paddy quality varies from time to time, the quality of milled rice is not even.	Quality always even; stable quality of white rice can be produced
3	Milling yield	Milling quality not regarded important	Milling quality is regarded as important; possible to produce milled white rice meeting the market-required quality.
4	Degree of milling quality	Milling recovery not regarded important; paddy milled in line with customer's demand (or meeting machine capability)	As milling is done for profit, milling yield is regarded as important.
5	Operators' technical capabilities	As the fine-tuned adjustment of machines is not quite necessary, operators are not required to have high technical capability.	Machines require fine-tuned operational adjustment. Therefore, experienced operators are needed.
6	Initial investment	Initial investment not costly	Initial investment and running cost are likely to be expensive.
7	Composition of machines	Consisting mainly of small-scale milling machines	Consisting of more than two machines; for instance: Winnower → hulling machine → milling machine → pre-cleaning machine → gravel remover → measuring machine → packaging machine
8	Quality of paddy	Paddy brought into milling facilities differ in moisture content; some contain lots of foreign substances; the adjustment of milling is difficult.	Procurement of quality paddy material is needed. (Necessary to procure one variety of paddy; less damaged grain, less cracked rice, less foreign substances mixed in; paddy with a stable 14% of moisture)

2.1.3 Current status and challenges of milling services in PNG

Most milling facilities in PNG are run for commission, using a method of collecting all milling charges by cash. Among the commissioned milling practiced globally, this method is unique to PNG. In PNG, the unit price of milling commission is decided on the basis of unit weight. Commission is almost the same at publicly and privately run milling facilities.

The major challenges faced by milling services nationwide in PNG are as follows.

(1) There are not enough technicians capable of maintaining machines, thus many milling machines are left idle due to breakdown. (In particular regions, about one quarter or one third of all machines are out of operation continuously due to breakdown or lack of paddy material.)
(2) There is no manual or list of milling machine parts; and after-sales service by the dealer is not available.
(3) Managers and operators lack post-harvest knowledge, and they cannot provide adequate advice to users [mainly rice growers].
(4) Only a few milling facilities keep operation records.
(5) Milling machines are not maintained on a regular basis; thus, machine life is short.
(6) As a supply system for milling machine spare parts is not well developed, it takes time to obtain necessary spare parts. Further, as nameplates are not attached to machines, the model number is not known, and sometimes it is difficult to obtain necessary parts.

It is urgently needed for the country to resolve such problems as early as possible; and, for food security on the part of the PNG government, it is necessary to establish methods for the self-sufficiency of rice as well as for producing quality rice.

2.1.4 Appropriate milling services

As a basic matter for milling services, milling recovery is the most important factor for operating milling facilities; and without understanding the meaning of this, it is not too much to say that the optimal operation of milling facilities is difficult. Milling machines are used to remove surface bran from brown rice, which is obtained by removing the hull from harvested paddy, that is, paddy with optimal moisture content when milling rice, machines with smaller loss are considered to be high-yield machines. It is important for the operation of milling facilities to select high-yield machines, indicating excellent milling capability. In other words, the most important factor for milling services is to operate facilities always taking milling recovery into consideration. It is important to operate facilities while considering what is needed to improve milling recovery.

(1) Utilizing post-harvest techniques, it is necessary to plan the measures necessary to produce

quality and uniform white rice, to try to reduce operational cost and reduce the occurrence of damaged rice, and to operate milling facilities minimizing post-harvest loss.

(2) The quality of paddy material should be improved by lowering the mix rate of immature grain. This is because paddy material with less immature grain produces less damaged rice, leading to high milling recovery.

(3) As damaged rice (paddy)/ bad quality rice (paddy) [=physically ununiformed rice (paddy)] generates more damaged rice, attention should be paid on how to sun dry paddy so that paddy contain less cracked brown rice.

(4) The profitable operation of milling facilities is required. It costs managers to operate milling facilities, thus they should devise the best way for paying the cost out of their earnings from the milling facilities. Operating costs include operator wages and other fixed costs, as well as variable costs such as fuel, oil, and component costs. Managers should have at least a minimum level of knowledge regarding economics. It is also necessary for them to learn how to calculate the break-even point, which shows whether their milling facilities make profit or loss.

2.1.4.1 Key considerations for commissioned milling services

Regarding key considerations for realizing appropriate milling services at milling facilities, in the case of commissioned milling, it is necessary to pay attention to the following.

(1) Milling machines should be operated so that milling recovery improves. Unreasonable or fruitless operation should be avoided.

(2) Milling facilities should not undertake the transportation of paddy/rice; and as far as transportation systems to collect paddy are not available, users should bring paddy to the milling facilities and bring back white rice by themselves. In order to make it possible to sun dry paddy at milling facilities when excessively moist paddy are brought in, it is necessary to prepare a minimum amount of blue sheets for sun drying, along with mixing rakes and winnowing baskets for wind sifting/ winnowing, etc.

(3) Milling commission should be charged on a paddy material basis. If charged on a white rice basis, users tend to pay little attention to the quality of paddy material, leading to a low ratio of healthy grain in paddy material, as well as to extremely low machine efficiency relative to the white rice produced and to high operational cost owing to low milling yield and equipment loss. If charged on a paddy material basis, the mixing of immature paddy and foreign substances including dust is nothing but disadvantage for users, which means that this charging method helps improve the quality of paddy material with only a simple advice.

(4) Milling services should be performed in line with the capabilities and abilities of the milling machines used. In the case of large high-power milling machines, they should not be operated for small lots of 10 to 15 kg; and continuous operation when a certain amount of paddy is accumulated (twice per week, etc.) would result in operational cost reduction.

(5) In order to prevent the generation of damaged rice and to reduce worn-out components, rules should be established so that users wind sift/ winnow paddy in advance. This is expected to shorten operational hours, reduce damaged rice, and improve milling recovery rate.

(6) Before the operation of machines starts, briefing meetings should be held for users, explaining rules on milling services, etc.

(7) For users, training should be repeated on paddy quality testing methods and on how to check moisture.

(8) Users should be informed of milling recovery rate by small lot.

(9) The operation, maintenance, repair, and replacement of parts, etc. should be recorded.

(10) Users should fully ensure that paddy of differing moisture or those paddy varieties of more than two are not mixed in. This is because if different paddy are mixed together, operation becomes difficult, milling takes more time, damaged rice may result, and milling yield may decrease.

(11) When measuring weight, use a platform scale as much as possible. When measuring weight, do not round up/down but measure in 100-g units. This is to avoid major errors in yield calculation.

(12) In order to avoid excess milling, leave 1–1.5 bran streaks when milling rice. (See Figure 2) This is to prevent lowering yield. [Refer to "6. Milling" of Handbook for Rice Post-Harvest Techniques]

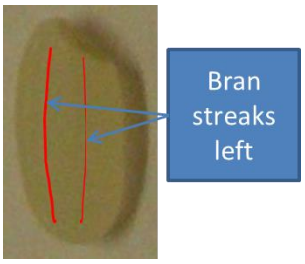

Figure 2: Bran streaks after milling

2.1.4.2 Key considerations for commercial milling services

This is mostly the same as "2.1.4.1 Key considerations for commissioned milling services," but the following two points are different.

(1) Collected paddy are pooled and stored before being milled, and treatment is necessary to make an entire paddy batch more uniform. Further, by drying and pre-cleaning paddy when necessary, they become more uniform, a single batch of paddy can be increased, and machine efficiency improves, leading to increase in the profit and healthy operation of the facilities.

(2) As for purchasing paddy, it is necessary to set up a certain quality standard and to set an appropriate price reflecting the market price.

Examples: Ratio of foreign substances/immature rice: 1% or less

Moisture: 15% or less

3. Construction plan for new milling facilities or updating/expanding facilities

3.1 Survey of the current situation of the construction site

When the construction of milling facilities is planned in response to a user request, it becomes necessary to survey the current situation of the candidate site for construction. Survey items should include: 1) the number of rice-producing farmers, 2) the rice-growing area, 3) the paddy production volumes (by variety), 4) the consumption and sales amount of white rice, and 5) the number of expected users of the milling facility. Further, in order to clarify the potential of rice production in the relevant district, the following items should be surveyed to help set up the basic policy for the construction of the milling facility.

Firstly, the number of rice-producing farmers by province/ region, rice-growing area, and paddy production volume are to be tallied by year. If possible, PDAL rice extension officers shall take initiative in calculating and tallying the rice-growing area, unit yield, number of farmers, and production size by variety. For statistical purposes, it is desirable that the same tally sheet be used all over the country.

When recording the growing area, it should be noted that most farmers do not have a distance-measuring scale and that it is difficult to obtain accurate data on the growing area. When estimating the length of a farm field, it is recommended to roughly measure the distance using one's step/stride as the unit.

As for production volume, it is necessary to confirm how the national agricultural survey implements the survey on production volume. For deciding production volume, it is quite important to correctly measure paddy weight, as well as to record it. In order to measure weight, a precise scale is needed; however, as most farmers do not have one, they have to use those owned by public or private milling facilities. These scales are of a suspended-spring type, and after long use, they are susceptible to error in measured values. Thus, for the future, precise platform scales are recommended for scales used at milling facilities in PNG. What should be noted when reading the measured values utilizing a scale is that users should read three-digit accuracy without rounding up/ down. (See "Attachment 4 Textbook on post-harvest technologies: Item 9. Weighing")

In line with the above data and requirements, it is recommended that a meeting be held before starting construction to explain the project to local people so that they can fully understand the operational style as well as the requirements, including paddy material quality.

3.2 Examination of the candidate construction site

Regardless of whether planned milling facilities are constructed and subsidized by governments or whether already-owned funds are used, it is indispensable to check the construction site by

actually visiting it, without depending on survey by telephone or interview. It is necessary to construct a building in advance that meets the planned machinery, and it is desirable to choose the construction site that is close to the most rice fields. It is also most desirable to choose a site accessible for a majority of users and located on an arterial roadway so that cars/vans can easily access it. Further, in cases where the expansion of the facility is expected in the future, it is necessary from the beginning to choose a location where additional facilities can be built when necessary.

3.3 Relationship with local governments (provincial/district/LLG)

PNG is a country with a relatively short history of rice production, and most farmers do not know how to produce rice. However, as Japanese-style wet-field rice cultivation requires that farmers learn a broad range of production techniques, and as big budget and prolonged technical support are needed to develop farm fields and irrigation facilities, it is difficult to disseminate wet-field rice production techniques to smallholders in PNG. Therefore, when it comes to guidance on rice production for smallholders in PNG, emphasis is placed on the dissemination of dry-field rice production techniques. Guidance on the cultivation of rice targeting these farmers focuses on increase in the production volume, and little attention has been paid to guidance on post-harvest techniques, as people are unfamiliar with such an idea. It is most important for farmers in PNG to depart from the understanding that post-harvest treatment is the same as the milling of rice.

The PNG central government has been trying to promote smallholder rice production by reinforcing the management capability of the rice production promotion project, led by the Rice Extension Unit (REU), Department of Agriculture and Livestock, as well as by ensuring provincial government-specific budgets for the promotion of rice production, led by provincial governments. By building up close connections with persons in charge of rice production at provincial governments or with rice extension officers, it is expected to become easy for model farmers to learn new cultivation techniques through training and to request support from provincial governments. In the future, through technical training on post-harvest techniques, etc., led by provincial governments, including the construction of new facilities, it is expected that rice production without unreasonable/fruitless practices, the usage of appropriate post-harvest techniques, and high-quality and sustainable rice production and promotion can be ensured. Regarding the acquisition of knowledge regarding milling service-related techniques, as well as of the operational methods of milling facilities, it is required that milling businesses, including private ones, closely cooperate with local governments in gathering the necessary information and reporting on the current situation.

The requirements for each of the above “3.3 Relationship with local governments (provincial/district/LLG),” are shown below:

(1) Provision of information

(REU)/provincial/district/LLG governments ⇒ Organizations managing milling facilities

1) Training in appropriate techniques not only for milling but also for post-harvest treatment and rice cultivation

2) Maintenance method of facilities related to the sustainable operation of milling facilities

3) Accounting method indispensable for the operation of facilities

4) Necessity and method of recording daily operation

In order to know the results for establishing a governmental plan for the future based on the provision of these techniques, and to recognize the situation of milling in the area on a continuous basis, feedback will be provided by organizations managing milling facilities.

(2) Provision of information (feedback)

Organizations managing milling facilities ⇒ (REU)/provincial/district/LLG governments

1) Basic data (once every six months)

Collected paddy amount, milled white rice amount, total milling commission, number of users, relevant rice production growing area, milling machine operational hours based on milling record [refer to Attachment 3: Operation record]

2) Problems to be solved

3) Future plans of milling facilities

3.4 Schematic plans for milling equipment

3.4.1 Selection of machinery

It is necessary to select milling equipment suitable for the annual milling amount. If future increase in the milling amount is overestimated and if excessively capable milling machines are installed, even if milling yield is not so low, it might be possible that: sufficient paddy needed for the operation of the machines are not collected; the machines cannot be operated continuously; ultimately it becomes impossible to efficiently operate the machines; or the milling facility cannot make a profit, running in the red. It is very important to select an appropriate type of milling machine suitable for making a profit, taking into account the result of the survey on appropriate paddy production amount in the area where the milling facility is planned.

Based on the requirements described in 3.1–3.3 as well as on obtained data, focus will be narrowed down to several candidates taking future plans into consideration.

(1) Volumes will be set up by rough calculation referring to “4.4 Basic items on operation: Ensuring profit”.

(2) When collecting paddy, major varieties and their physical properties are to be clarified, and the necessity of rubber roll-type milling functions and the details of milling parts are to be decided.

(3) When securing the design of measuring devices based on the volume to be milled, the area of space used for the provisional storage of paddy/white rice, and drying equipment/space, use this information when deciding on the information in "3.4.2 Size and layout of buildings".

3.4.2 Size and layout of buildings

As for the size of milling facility buildings, it is necessary to secure space of 1.0–1.5 m around the machines for checks and repair, in addition to the space for the machines themselves. In addition, many other matters should be examined, including: the installation of platforms for bringing in paddy; exhaust ducts for engines, etc.; the direction of hull-discharge pipes; receiving areas; paddy storage; and weigh stations. It is necessary to prepare well-built concrete floors resistant to vibrating machines for the mounting block where milling machines will be placed.

The building area layout will differ depending on the equipment to be installed. If there is leeway in the building budget, the following building layout should be examined for actual milling facilities.

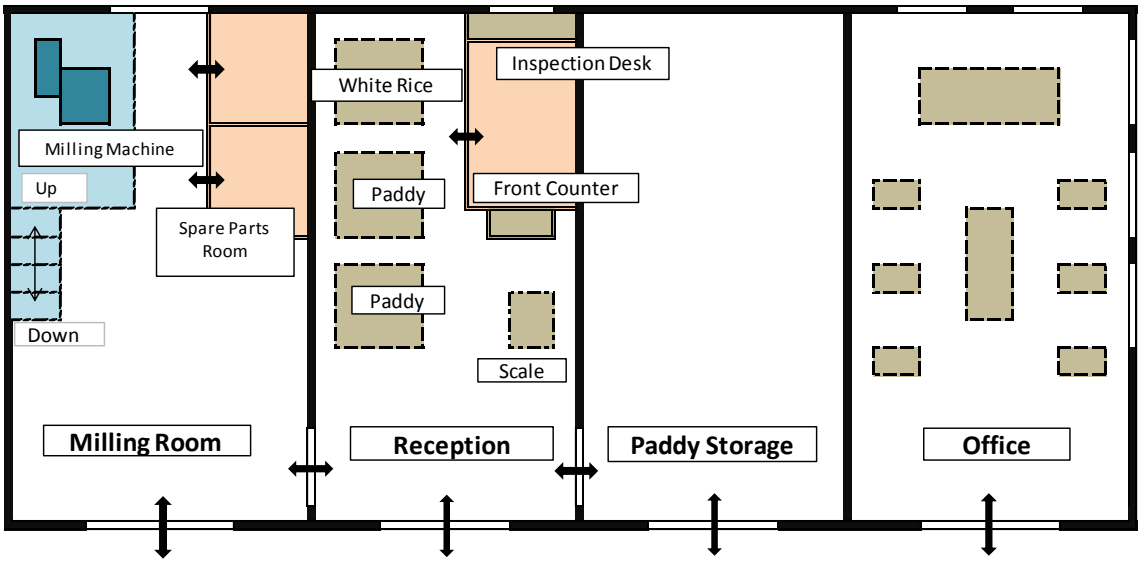

Figure 3: Example of a milling facility layout

3.4.3 Job category, number, and selection criterion of milling facility workers

The job category and number of milling facility workers differ depending on machine type, paddy processing volume, and operational style. For reference, job categories and necessary workers number in the case of the most popular milling machines in PNG, namely the Micro-mill (RM150) and Hercules (PS80), are shown below. In reality, numbers vary depending on milling volume, but in most cases, milling operation is done by one to three persons. In such a case, the manager of the facility sometimes serves as operator as well. The first person functions as operator, receiving clerk, and note-taker. The second and third are in charge of weighing,

paddy loading, white rice packaging, and white rice weighing. The manager is responsible for milling commission collection and white rice delivery.

(1) Manager of the milling facility: 1 person
(2) Machine operator(s): 1–2 persons
(3) Receiving clerk/note-taker: 1 person
(4) Persons in charge of weighing: 3 persons
(5) Persons in charge of paddy loading: 2–3 persons
(6) Person in charge of white rice packaging: 1 person
(7) Persons in charge of white rice weighing: 2 persons
(8) Person in charge of commission collection (accountant): 1 person
(9) Person in charge of white rice delivery: 1 person
(10) Person supporting farmers in drying/adjusting paddy: 1 person

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(Total: 13–16 people; average 3-5 people depending on facility size)

Regarding personnel selection criteria, the managers of milling facilities are chosen out of local responsible leaders, group members, or provincial government staff; while in the case of operators, it is necessary to define rough selection criteria in advance. One of the key necessities for operating a milling facility is finding an excellent manager; but the most important thing is to secure experienced and excellent operators with technical capabilities. Even if a facility is equipped with brand-new machines, in order to appropriately operate the machines and to produce quality white rice, operators with operational know-how that are capable of maintaining the machines are indispensable. The selection criteria of such operators are as follows.

(1) Can read, write, and calculate
(2) Have experience and know-how in repairing machines using tools
(3) Can start/stop engines and adjust speed in operation
(4) Have one-year or more of experience in operating milling machines or other farm machines with engines and motors
(5) At least know a basic production methods and have basic knowledge of post-harvesting
(6) Have received machine training (milling machines, in particular) or training in post-harvest treatment

As for the above (5) and (6), operators are expected to continuously learn by participating in training provided by the provincial governments.

However, the number of workers necessary at milling facilities differs depending on milling volume; and in PNG, at most milling facilities, milling operation is done by one to three workers. In such a case, as the content of the operation is the same, one person shoulders more than two functions. For instance, at a milling facility operated by three persons, the first functions as the manager, operator, and receiving clerk/note-taker. This person also shoulders the collection of milling commission and the delivery of white rice. The second and third persons are in charge of paddy weighing, paddy loading, white rice packaging, and white rice weighing, as well as farmer support for drying/adjusting paddy, etc. At milling facilities operated by just one person, needless to say, all of these operations are shouldered by that person.

3.4.4 Calculation of the estimated budget

When a milling facility construction plan has been made and when the planned site has almost been decided, the estimation of a necessary budget has to be calculated, considering the planned size of the milling facility operation. Estimated budgets for the building and for equipment (including spare parts, installation cost) are to be calculated roughly. When estimating budgets, it is necessary to calculate the estimated operational costs. It is also necessary to calculate taking into account the wages to be paid to the above workers, along with operational costs, etc. (See "4.4 Basic items for operation: Ensuring profit")

3.4.5 Utilizing funds and subsidies

In the case of private milling facilities, hefty funds have to be prepared for the construction of facilities. If the funds owned are not enough, it is necessary to consider an application for government subsidies and/or bank borrowing. In the case where provincial governments construct new public milling facilities by themselves, based on the estimated budget, procedures to secure a construction budget in advance are needed.

The public funds that the REU, provincial governments, district governments, and local governments (LLG) can utilize consist of development subsidies stipulated by PNG's contributions law for the economic and social development of the country. In order to develop milling service facilities, it is possible to obtaining public funds by closely approaching the PNG government's four sources of such funds, shown below.

(1) Subsidy of the provincial service improvement program (PSIP) (10 million kina/ province / year)
(2) Subsidy of the district service improvement program (DSIP) (5 million kina/district/year)
(3) Subsidy of the local government (LLG) service improvement program (100,000 kina/LLG/year)
(4) Subsidy of the National Agricultural Development Program (NADP)

Other government-supported or privately funded financial sources are as follows.

(1) National Development Bank (NDB) loans
(2) Farmers' savings loan societies (e.g., Sepik Farmers' Savings and Loan Society, East New Britain Farmers' Savings and Loan Society)
(3) South Pacific Bank/other commercial banks, ANZ, and Westpac

Other possible private funds usable for the development of rice include borrowings from relatives, private savings, rice producer cooperative funds, and many other fund sources.

4. Basic points regarding the sustainable operation of milling services

As mentioned in 2.1.2, the milling services provided at milling facilities are divided into two categories according to operational type; however, these two categories come with some identical important basic points toward ensuring sustainable operation, as follows.

1) It is necessary that milling facilities are able to continuously operate machines in an efficient manner with high yield at locations where adequate amounts of paddy are harvested.
2) It is necessary to operate milling facilities in a way that they can make a profit with their own funds without depending on any kind of financial support.
3) Milling machines should have the capabilities necessary for the milling volume expected at the location where the milling facility is located.
4) For the proper operation of milling machines, it is necessary to ensure experienced operators who are well-knowledgeable in milling or handling any machines.
5) Milling facility managers are required to have enough knowledge and experience in milling facility operation as well as to be capable of managing the facility in an appropriate and active manner, for moving toward their operational goals.
6) It is desirable to be able to ensure accounting by a person in charge of accounting, utilizing appropriate bookkeeping and recording methods. (Attachment 1)
7) In order to achieve high milling yield, the procurement of quality paddy is indispensable.
8) In addition to milling services, milling facilities are to take on the role of a base for information dissemination about cultivation/post-harvest techniques, and activities, etc., as well as for taking action so that users produce rice and use the milling facilities in a continuous manner.

4.1 Basic points regarding the operation of commissioned milling

The operation of commissioned milling in PNG is mainly characterized as follows:

1) As volume per milling is small, paddy are intermittently milled per lot, and work efficiency is low.
2) In order to make a profit, it is necessary to set milling fee (commission prices) matching the white rice prices in the market.
3) Initial investment is small because in most cases only one milling machine is utilized throughout the entire milling operation, from paddy to white rice.
4) As this type of milling is done for farmers' personal rice consumption, they rarely pay attention to milling yield.
5) In order for milling facilities to make a profit and to be operated in a sustainable manner, knowledge regarding reducing milling loss and improving the quality of rice is required.
6) Regardless of public or private milling facilities, currently no government staffs are knowledgeable in equipment maintenance techniques or in the ability to offer operational guidance for the facilities.

Based on the above characteristics, the major milling operations and operational procedures at commissioned milling facilities, as well as key points for appropriate operation, are shown below.

1) Receiving milling orders and checking paddy quality (Attachment 1)
   a) Users bring winnowed dry paddy into a milling facility by themselves and go through the reception desk.
   b) Firstly, the degree of purity (variety) is checked. It is desirable to keep the mix of different varieties at a mix rate of 5–10% or lower. This is because if the mix rate is high, it becomes difficult to adjust the milling machines, generating substantial amounts of broken rice.
   c) The mix rate of defective paddy, foreign substances, and other trash is checked. If the mix rate of such items is high, substantial amounts of broken rice are generated, lowering the milling yield. If pebbles, etc., are mixed in, they are prone to damage the metal mesh or wear it out earlier than usual; thus, users should remove such before bringing paddy into milling facilities. The mix rate of impurities including immature grains should be adjusted to 1% or lower (through cleaning/selecting).
   d) When measuring paddy moisture, do not take measurement by biting into paddy, and it is desirable to correctly take measurement using a moisture meter. This is because when moisture is kept at an appropriate rate of 14%w.b., less broken rice is generated, improving the milling yield.
   e) After confirming that paddy quality satisfies the standardized requirements, the paddy weight is measured using a precise scale, and milling orders are confirmed at the reception desk.

2) Preparation of order entry documents
   The order number, user name/address/phone number, paddy variety, weight, unit milling price, and milling commission are confirmed and attached to the order entry slip. The user then checks the details and puts their signature on the slip. (See Attachment 1)

3) Milling operation
   Milling operation is done in an appropriate manner in the order of order entry, and time spent for milling operation is recorded. When a machine failure or other trouble occurs, the situation is recorded in the maintenance record table and the record is stored. (See Attachment 3 & 4)

4) Collection of milling commission
   Milling facilities collect milling commission from users according to the order entry slip. After receiving the money, the accountant hands the stub (receipt) from the right side of the order entry slip to the user. Users bring the milled white rice home by themselves.

5) Role as an information base
   It is important for milling facilities to position themselves as a technical information dis-

semination base associated with rice, including not only milling services but also rice production, post-harvest techniques, and the release of a newsletter. In the future, they should obtain information related to rice production of user (feedback system), utilizing such information for continuous rice promotion planning and for increasing the number of repeaters utilizing milling facilities.

(1) Cultivation techniques (including soil preparation, fertilizer, weeding, transplanting, insect pest control, water management, post-harvest soil management)

(2) Post-harvest techniques (including cropping, drying, selection, adjustment, storing, selection of seeds)

(3) Explanatory meetings (sending out essential considerations and technical information to users)

4.2 Basic points for operating commercial milling

Next, the major characteristics and challenges related to operating commercial milling are as follows.

1) All of paddy to be polished at a milling facility is purchased by the milling facility. Milling facilities are required to procure quality paddy.
2) As the constantly uniform quality of the milled rice is required, milling facilities need to have material paddy storage space for pooling batches of paddy for bulk milling services.
3) It is indispensable to continuously operate milling machines in an efficient manner, focusing on milling yield.
4) As initial cost is high, it is required to continuously supply quality white rice so as to satisfy market demand.

Based on the above characteristics, the major milling operations and operational procedures at commercial milling facilities, as well as key points for appropriate operation, are shown below.

(1) Purchase of paddy

a) The quality of paddy brought in by farmers and brokers is checked, and weight is measured. In order to ensure a precise quality check, it is necessary to educate the checking staff.
b) Two to three paddy-purchasing prices are set for each class of paddy, and these are decided according to paddy quality and conceivable milling yield.
c) Paddy with more/less moisture than the appropriate moisture (14% w.b.) are purchased at lower prices.
d) As paddy with substantial amounts of foreign substances tend to cause broken rice, lowering milling yield, a lower price is set for such paddy. The ratio of foreign substances including immature paddy is adjusted to within 1%.

(2) Issuance of receipt

The amount payable is decided according to the quality and weight of the paddy. Upon receipt, the quality category, weight, unit price, and amount payable are added. The receipt is issued after booking down, and then the amount is paid to the farmer/broker.

(3) Storage of paddy to be polished

a) Paddy are sorted by variety and stored in tanks or silos after being divided into volumes for which continuous operation is possible. As for paddy that are too moist or too dry, moisture should be adjusted before storing such paddy in storage tanks by means of sun drying or by utilizing dryer machines.

b) Paddy should not be stored for long periods of time, in order to prevent insect pests.

(4) Milling operation

a) Paddy are polished to supply market demand, and white rice is stored in a product warehouse by brand name and weight of package.

b) While milling machines are in operation, samples are taken on a regular basis; and after being polished, the quality of the white rice is checked so that the uniform quality of the white rice can be ensured.

(5) Shipment of white rice

When an order is placed by a customer, a truck is arranged and the necessary amount of white rice is shipped.

4.3 Basic points regarding milling facility operation: Efficient use of machinery and equipment

In order for milling facilities to operate in the black, they must be able to produce white rice using installed milling machines that have appropriate capabilities meeting paddy production volume at the relevant area. However, regarding the lot size of paddy brought in by farmers, it is necessary to examine proper operating conditions suitable for the capabilities of the machines. If lot size is too small compared with the flow rate of the machines, it is difficult to adjust them to proper operational status within a short period of time due to small amounts of paddy, and efficient operation is not possible. Therefore, it is necessary to select proper milling machines meeting the expected volume of paddy to be brought in by farmers.

Further, it is also necessary to earn a profit margin by raising the selling price of white rice. However, as the selling price of white rice reflects the prices of rice in the market, there is a limit on raising the price of white rice. It is also difficult to reduce the fixed costs and operating costs of milling facilities as needed.

In order to avoid such a management situation, it is necessary to polish an adequate volume of paddy, meeting the ability of milling machines by dramatically increasing the production volume of paddy at the area where machines are installed, as well as to make a profit by efficiently

operating machinery and equipment without leaving them idle. (See “4.4.2 Outline of the break-even point” and “4.4.3 Setting the paddy purchase price and the white rice selling price”)

4.4 Basic items on operation: Ensuring profit

When operating milling facilities on a continuous basis with one’s own funds, it is of utmost importance to make profit from the actual operation of the facility. If machine operating costs can be paid from earnings ensured by milling services, it becomes possible for a milling facility to operate in the black [surplus finance] with its own funds without borrowing from others.

4.4.1 Profit of milling facilities

Spending (expenses) is necessary when milling facilities are operated. For instance, salaries are needed for managers, operators, and milling facility workers. In the case of motor-driven milling machines, electricity is indispensable. Electricity is also needed for lighting and using PCs for accounting. Also, when using engine-driven milling machines, it is necessary to prepare fuel, engine oil, and lubricant oil. Expenses for consumable parts and spare parts to be utilized at the time of machine failure are also needed to count.

On the other hand, commissioned milling facilities in PNG earn revenue by collecting milling commission according to the weight of the polished white rice that is processed. They can also earn revenue by selling bran and rice hulls, which are by-products generated in the milling process.

Subtracting the total amount of the above-mentioned expenses from the total amount of revenues, a resultant positive figure means profit, while a negative figure means loss.

4.4.2 Outline of the break-even point

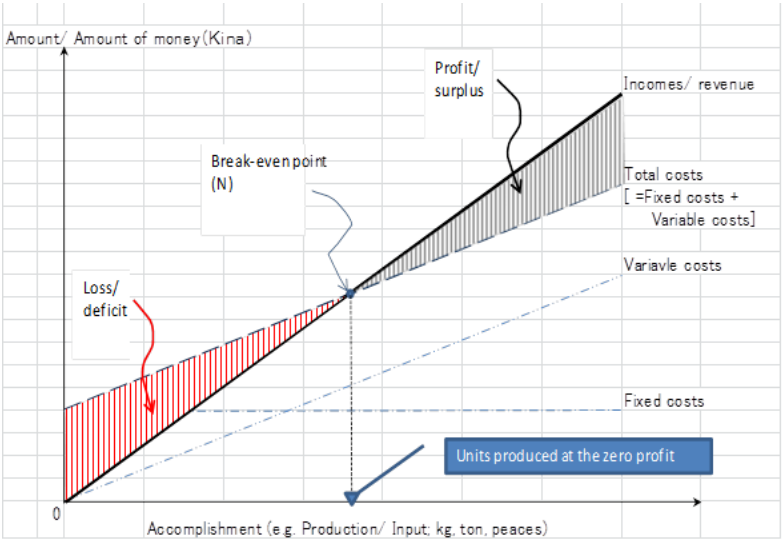


Figure 4: Chart of Break-even Point

Before calculating the revenues and expenses of milling facilities, it is necessary to understand the breakeven point. In the chart [Figure 4] above, the breakeven point is shown as an intersection of revenue and total cost, where both profit and loss are zero. The value of V, the intersection of the vertical line going down from the profit-even point with a horizontal line, is calculated as shown below.

Profit/loss is calculated using the following equation.

Calculation of profit and losses can normally produce as following equation:

Profit/loss = incomes – total costs; if answer is surplus, it is profit, if deficit, it is loss.

Break-even point (V) is units of values completed/ produced at the zero profit (loss); production units.

So, it is made as below:

Income – Total costs = 0, therefore, Incomes = Total costs

On the other hand, Total costs = Fixed costs + Variable costs x V

Applying the same thinking to Incomes calculation,

Income = Price per units x V

Price per units x V = Fixed costs + Variable costs x V

So, (Price per units – Variable costs) x V = Fixed costs

V = Fixed costs / (Price per units – Variable costs)

Calculation example:

In case that Fixed cost (Capital cost; building/ machines/ others) is 100,000Kina, Variable cost (mostly running cost for processing some materials; material purchase, fuel fee, spare parts etc.) is 1.5Kina/kg and Price per unit (selling price of processed one) is 2.8Kina/kg, so the **Break-even point (V)** is to be 76,923 kg [≒ 100,000Kina/ (2.8Kina/kg – 1.5Kina/kg)].

This means that over 76,923kg of production would be processed and sold out (beyond Break-even point (V)), hereafter, you might gain profit for conduct of a next business (preparation/ improvement). (See Table 3)

4.4.3 Setting the paddy purchase price and the white rice selling price

In commercial milling, naturally, the purchase price of paddy reflects the selling price of white rice. As the selling price of white rice reflects the market price, except when the quality of the white rice is extremely high or when it comes with extra value, the selling price should be set at the market price or lower than that. Therefore, it is inevitable that, considering operational cost, the purchase price of paddy is set to make a certain profit without running in the red (deficit operation).

4.4.4 Reference case: Breakeven point by difference in milling machine model

In order to recoup the initial investment put in as fixed cost, the necessary volume of paddy at the break-even point is calculated for each of the milling machine models, which are now being popularly utilized in PNG. These figures can be utilized for reference when reviewing paddy production volume at the area where relevant milling machines are installed. The operating cost is calculated utilizing a milling yield of 59.2%, which is the figure obtained by the recovery test conducted by JICA in June 2014; and as Table 3 indicates, the necessary volume of paddy at the break-even point for each of three models (RM150, PS80, YMM20) is as follows.

Table 3: Necessary volume of paddy at the breakeven point for each of the three models

Machine Model			Unit	No.	Formula	RM150	PS80	YMM20	YMM20
Income		Milled rice selling price	Kina/kg	①		3.20	3.20	3.20	3.20
		Convert to paddy price	Kina/kg	②	①x0.592	1.89	1.89	1.89	1.89
Expenditure	Fixed cost	Building cost	Kina	③		1,500.00	100,000.00	200,000.00	200,000.00
		Machine purchasing cost	Kina	④		6,000.00	24,000.00	70,000.00	70,000.00
		Sub-total	Kina	⑤	③＋④	7,500.00	124,000.00	270,000.00	270,000.00
	Variable cost	Paddy purchasing price	Kina/kg	⑥		1.2000	1.2000	1.2000	1.2000
		Labor cost	Kina/kg	⑦		0.0200	0.0500	0.0500	0.0500
		Fuel cost	Kina/kg	⑧		0.0320	0.0390	0.0270	0.0270
		Lub.oil cost	Kina/kg	⑨		0.0004	0.0003	0.0003	0.0003
		Rubber rolls cost	Kina/kg	⑩		-	0.0120	0.0120	0.0120
		Screen, other parts cost	Kina/kg	⑪		0.00110	0.00090	0.00050	0.00050
		Transportation cost	Kina/kg	⑫		0.0150	0.0150	0.0150	0.0150
		Overhead	Kina/kg	⑬		0.2000	0.2000	0.2000	0.0000
		Sub-total	Kina/kg	⑭	⑥+⑦+⑧+⑨+⑩+⑪+⑫+⑬	1.4685	1.5172	1.5048	1.3048
Paddy quantity at break-even point			**kg**	**⑮**	**⑤/(②－⑭)**	**17,610**	**328,738**	**693,018**	**457,938**

Grounds for calculation in each number, ① to ⑮, as follows:

① Milled rice selling price: K3.20 Kina/kg

② Above conversion to paddy price: ①/0.592 （Milling recovery: 59.2%）

③ Building cost: (RM150) 1,500 Kina, (PS80) 100,000 Kina, (YMM20) 200,000 Kina

④ Machine purchasing price: (RM150) 6,000 Kina, (PS80) 24,000 Kina, (YMM20) 70,000 Kina

⑤ Sub-total of fixed cost = ③＋④

⑥ Paddy purchasing price: 1.20 Kina/kg

⑦ Labor cost: Operator's salary is 10% of milling fee. If the operator is the relative of owner, it is only 4% of milling fee.

⑧ Fuel cost: YMM20: 2.2 toea/kg, PS80: 3.3 toea/kg, RM150: 2.7 toea/kg

⑨ Lub. oil cost: (YMM20/PS80) 3 Lit x 18Kina/Lit x 100toea/Kina ÷ (300h x 700kg/h) = 0.03 toea/kg

⑩ Rubber roll cost: (YMM20/PS80) 360 Kina ÷(30ton x 1,000kg/ton) x 100 toea/Kina = 1.2 toea/kg

⑪ Screen & other parts cost: 180 Kina/set ÷(500h x 700kg/h) x 100 toea/kg = 0.05 toea/kg

⑫ Transportation cost: 6 Kina/Lit. x 1 Lit/10km x 10km x 100 toea/kg ÷400kg = 1.5 toea/kg

⑬ Overhead: Owner's overhead is 40% of milling fee. Then, 50 toea/kg x 0.40 = 20

toea/kg

⑭ Sub-total of variable cost = ⑥+⑦+⑧+⑨+⑩+⑪+⑫+⑬

⑮ Paddy quantity at break-even point = ⑤/ (②－⑭)

Note:

* ⑧ Calculation of fuel cost:
  (1) YMM20: 3.1 Lit/h x K6/Lit x 100 toea/Kina ÷ 700 kg/h = 2.7 toea/kg
  (2) PS80 : 2.3 Lit/h x K6/Lit x 100 toea/Kina ÷ 350 kg/h = 3.9 toea/kg
  (3) RM150: 0.8 LIt/h x K6/Lit x 100 toea/Kina ÷ 150 kg/h = 3.2 toea/kg

* ⑨ Calculation of lub.oil cost:
  (YMM20/PS80) 3 Lit x 18Kina/Lit x 100toea/Kina ÷ (300h x 700kg/h) = 0.03 toea/kg
  (RM150) 1 Lit x 18Kina/Lit x 100toea/Kina ÷ (300h x 150kg/h) = 0.04 toea/kg

* ⑪Calculation of screen/other parts:
  (YMM20) 180 Kina/set ÷ (500h x 700kg/h) x 100 toea/kg = 0.05 toea/kg
  (PS80) 150 Kina/set ÷ (500h x 350kg/h) x 100 toea/kg = 0.09 toea/kg
  (RM150) 85 Kina ÷ (500h x 150kg/h) x 100 toea/kg = 0.11 toea/kg

* ⑫ Calculation of transportation cost:
  Transportation cost of 10 km in case that pickup truck conveys 400kg-paddy.
  The fuel consumption of this truck is 1Lit./10km.
  6 Kina/Lit. x 1 Lit/10km x 10km x 100 toea/kg ÷400kg = 1.5 toea/kg

(1) According to the calculation results, the volume of paddy necessary for recouping initial investment is 10–30 tons for RM150; 200–400 tons for PS80; 600–800 tons for YMM20 at private facilities; and 400–600 tons for YMM20 at public facilities, where overhead costs are not needed for managers.
(2) Assuming that an adequate volume of paddy is supplied and where machines are operated five hours per day for 20 days per month, initial costs can be recovered in 2–3 months utilizing RM150; 1.0–1.5 months for PS80; and 7–9 months for YMM20 at public facilities; and profit can be expected thereafter.

This means that by milling more paddy than the calculated volume utilizing the above machines, facilities can make a profit.

4.5 Utilizing milling facilities as bases for information dissemination

The effective use of milling facilities is required in a way that public commissioned milling facilities serve as a base to promote smallholder rice production techniques and as a base to dis-

seminate information related to provincial government PR activities and technical support; for example, by actively promoting the key points of post-harvest techniques by pinning them up on bulletin boards. In other words, it is necessary to utilize public milling facilities/milling centers as a base for information dissemination for increasing the production of paddy, as well as for improving the quality of paddy and post-harvest techniques.

Specific examples of information include: 1) rice cultivation techniques, 2) methods for obtaining and keeping seeds, 3) post-harvest techniques including with sun drying methods, and other technical information, as well as relaying information and the successful cases of other regions in a newsletter.

For getting provincial governments to recognize the rice production activities of model farmers, milling facilities play an important role. Through the operational situation of milling facilities in each region, provincial governments can see production volume, rice production-related problems, and the tackled issues of each district/local government (LLG), and it is also possible for them to obtain information useful for future policy planning.

5. Accounting of milling facilities

The accounting of milling facilities is indispensable for operating such facilities in a sustainable manner. When it comes to the operation of milling facilities, in order to regularly check whether they are making a profit in real terms, in addition to bookkeeping, it is important to clearly recognize the financial situation, focusing on cash in terms of the cash flow of the milling facility.

The accounting method greatly differs depending on the operational type of milling facility in use. In the case of commissioned milling, it is necessary to process accounting by big volumes of paddy brought in by users. The weight of milled white rice is measured by weight of paddy, milling commission is calculated based on predetermined unit milling commission, and farmers pay the amount by paddy weight. On the other hand, in the case of commercial milling, milling facilities directly purchase paddy from farmers when receiving paddy. The unit purchase price of paddy is set by quality, and milling facilities pay the price according to paddy weight. In the case of commercial milling, paddy is pooled by variety until reaching a certain amount for collective milling. In the case of commercial milling, as the moisture of separately purchased paddy is not even, moisture is adjusted using drying machines; and after paddy moisture is adjusted to the proper level (14% w.b.), milling is usually done focusing on milling yield.

5.1 Setting and charging milling commission

Usually, at commissioned milling facilities in PNG, milling commission is paid by material paddy weight. Commission differs depending on facility equipment, regional circumstances, and fluctuation in the market prices of rice, etc.

In some provinces, there are milling facilities where milling commission is paid by polished white rice weight; however, depending on the mix rates of immature grains and foreign substances in paddy, as well as moisture and other qualities, the weight of polished white rice greatly differs. Further, if substantial amounts of foreign substances are mixed in, in addition to the fact that milling operation takes longer and that a lot of broken rice is generated, the risk of damaging machines is also high, thus verification tests have clearly shown that milling facilities incur heavy financial loss. Therefore, milling facilities collecting commission by polished white rice should change the commission-charging method as early as possible, in order to adopt, with the consent of users, a method of charging by weight of paddy.

5.2 Keeping and maintaining milling records

Average commissioned milling facilities in PNG do not keep milling records—or may simply have memorandum-like records. In order to operate milling facilities in an appropriate manner, it is necessary for milling facilities to ensure the recording of milling operations, as such records include figures, very useful for planning purposes, as well as for calculating machine operating

hours.

Operational records typically include the operating period of the facility, operating hours per day, idle period, halts/restarts due to machine failure, work hours and the assignment of operators, and operation shifts per day, storing various data reflecting the operational situation of the milling facility. In addition, it can be said that such records are valuable assets of the milling facility and are indispensable, as they include figures and materials useful as standards or references for the future planning of milling facilities and for annual planning. (See Attachment 3)

5.3 Methods for accounting records and verifications/audits

Regardless of being public or private, the accounting of milling facilities should be transparent. When storing accounting records, two or more persons who can attach their signature are needed when performing checks. If just one person is in charge, checking and auditing accounting figures is difficult; and if by chance, an error occurs, the very person in charge should take responsibility. For this reason, it is desirable to reduce bookkeeping documents when possible and to prepare/use an accounting format that helps prevent errors attributable to transcription. It is important to utilize a system for checking the paying/receiving of cash, not only by capable accountants but also by two or more bosses requiring their signatures. Also, for the accounting of milling facilities, it is desirable to adopt an annual audit system. (See "Attachment 1 for a format example of simplified milling order receipt slips/receipts")

6. Maintenance and troubleshooting of machinery and equipment

6.1 Basic points of maintenance

When operating milling facilities, it is very important to avoid machine failures and to make the most of milling facility machinery and equipment, especially regarding milling machines and power sources. Avoiding unreasonable operation and reducing damage to machines are also a good way to properly maintain equipment. It is necessary for operators not only to have knowledge and experience in mechanical operation but also to accumulate know-how to efficiently operate machines without causing machine failure. Maintenance methods that help milling machines improve their durability are also needed; thus, fully considering PNG-specific issues, the basic points that milling facility managers and operators should understand are shown below.

(1) Operating machines means to maintain them.

If machines are sitting idle, as is the case with automobiles, rust can appear and various malfunctions can occur, resulting in additional repair cost. In other words, it is necessary to understand that leaving milling machines idle for a long period of time can cause additional expenses.

(2) It is important to operate machines at least once or twice per month.
In PNG, many milling machines tend to sit idle without proper operation on a regular basis because not enough paddy is brought in to the facility and because operators are not knowledgeable. However, even if paddy is lacking, milling machines should be operated empty at least once a month. By operating machines empty once or twice a month, their operational condition can be checked, and if a defect is found, it can be repaired as soon as possible so that the machine is maintained and ready for operation.

(3) It is important to clean machines after operation.
Cleaning machines after operation helps improve machine durability. If they are left without cleaning after operation, pest insects and rats might occur. Also, cleaning allows one to identify any defective parts in the machine, thus cleaning may contribute to maintenance.

(4) To check abnormal noise, trembling, heat, or odor, try to detect troubles at an early stage.
It is indispensable to perform these checks before starting milling operation, in order to avoid mechanical failure.

(5) Check the quality and quantity of lubricant oil, cooling water, and proper grease.
Impurities in lubricant oil should be removed utilizing a filter, etc., before operation.

(6) It is indispensable to ensure that lubricant oil, cooling water, and grease are checked before operating machines.
It is necessary to replace lubricant oil and cooling water with new oil/water and to add grease in a proper manner. If these are not done properly, premature damage to engines or overheating may result. Properly adding grease can lead to the prevention of mechanical damage.

(7) It is necessary to check tension/tightness not only of belts but also of nuts/bolts.
While machines are being cleaned, it is possible to check the tension/tightness of belts and nuts/bolts. For checking the tension of belts, if they are loose, it is necessary to properly adjust them for the efficient operation of the machines. If this is not done properly, fuel consumption will increase due to belt slippage, the breakage or damage of the belt may occur, or paddy may become clogged.

(8) It is important to replace consumable parts at the right time.
Any attrition of metal mesh and rubber belts can be found when cleaning machines. It is important to replace consumable parts with new ones at the right time.

6.2 Maintenance records

As mentioned above, keeping maintenance records is very important for operating milling facilities. The maintenance of milling machines and other equipment can be divided into two categories: maintenance implemented on a regular basis and maintenance implemented when mechanical failure or other unexpected incidences occur. In addition, by clearly recording the details of these maintenance operations, including the contents of checks, staff involved, hours needed for checking/repairing, replaced parts, estimated costs, etc., it is possible to: understand

the frequency of failure and the details of repair of each machine, to estimate mechanical life and part replacement intervals, and to have a reference when estimating operational cost. (See "Attachment 4 for an example of a format")

6.3 Inventory control of machine parts

The operation of milling facilities includes the inventory control of machine parts. Keeping maintenance records is very important for controlling the stock of machine parts. By recording maintenance, it becomes possible to calculate the stock of consumable parts and to estimate the items and number of spare parts.

In PNG, it takes time to obtain milling machine parts, and agents dealing with machines often do not stock parts. Therefore, if there is no stock of necessary parts when machines malfunction, operation stoppage is unavoidable, causing damage to milling facility operations. If the shut-down period is prolonged, even minimum profit might not be secured, and the sustainable operation of the milling facility might be put in danger. As such, the inventory control of machine parts is extremely important for operating milling facilities. Moreover, it is important to keep no more than the necessary amount on hand, thus, always keep a minimum amount of parts necessary for the operation of the facility, taking operational status into consideration. Also, if it is expected that the delivery of parts will take a long amount of time, it is necessary to place an order for necessary parts in advance at an earlier stage.

1) REU to provide for an agricultural engineer/mechanic to provide maintenance and service for machinery/equipment.
2) REU/PDAL to establish an understanding with supplier(s) of machinery/equipment to maintain a consistent supply of consumable and engine parts with parts catalogues.

6.4 Significance of maintenance for annual operational planning

For operating milling facilities, an annual operational plan is drawn up, examining annual milling volume by milling machine, annual operational budget, staff assignment plan, and the repair/renewal of buildings and machinery, etc., by item. In order to operate milling facilities with their own funds, both commissioned milling facilities and commercial milling facilities need to make a profit. For this purpose, it is necessary to reduce expenses as much as possible, as well as to come up with ideas to increase revenue, for which it is indispensable to properly maintain machines so that existing machines operate with less failure and with less shutdown period, enabling efficient and continuous operation. When calculating annual budgets, the level of the maintenance budget is an important factor. This is because if the maintenance budget is set too high, it becomes difficult to make a profit, hampering the operation of the milling facility.

When drawing up an annual operational plan for a milling facility, in order for the facility to make a profit, it is necessary to calculate the annual milling volume utilizing the milling records

of the previous year, as well as to properly operate milling facilities by keeping the stock of parts at an appropriate level, taking into consideration the remaining durable years of the milling machines, the necessary number of consumable parts, and the frequency of machine failure, by utilizing maintenance records. In other words, the maintenance of milling machines is an important factor that cannot be neglected when drawing up an annual operational plan for milling facilities.

6.5 Safety rules at milling facilities

The rules that workers should observe when operating milling facility machinery and equipment are shown below in reference to JIS (Japanese Industrial Standards) General requirement for safety (JIS: B9220).

(1) Check whether safety is secured: Alert others when starting machines.
(2) Check first whether the necessary maintenance has been done. (See “7.1 Maintenance”)
(3) Check the vicinity of machinery before operation: Never leave tools in the machine. Ensure that all nuts and bolts are fastened and adjust the tension of belts.
(4) Wear safe work clothes: Wear tight clothes that cannot be caught in machines.
(5) Wear a mask when working in dusty areas: This is to prevent lung damage.
(6) Wear earplugs when working in noisy areas: This is to prevent ear damage.
(7) Never operate a milling machine while listening to music through an iPhone or other devices. This is because when using such devices, it is difficult to notice abnormal noise, which could indicate that a serious accident is about to occur.
(8) Install protection devices for any dangerous movable parts of machines as much as possible: Use protection devices made of nets or grids that do not hinder the easy operation and maintenance of machines and that help secure a safe distance so that movable parts do not directly touch a worker’s body or clothes.

6.6 Troubleshooting

When milling machines are in operation, the failure, malfunction, or performance degradation of machines is inevitable. In the case where such events may occur, the basic measures that operators must take are as follows.

(1) Stop the machines immediately when any trouble occurs.
(2) Next, understand when, where, and how the event occurred.
(3) Look into the situation of the trouble exactly and identify suspected causes as well as measures to take.
(4) If cause cannot be identified by referring to the instruction manual, directly contact the manufacturer of the machine to identify the cause of the trouble and the measures to take. Standard troubleshooting associated with engines and milling machines is shown below Table 4 to 7.

Table 4: Troubleshooting diesel engines

Trouble		Suspected cause	Measures
Engine doesn't start	The starter motor doesn't rotate.	The starter motor is broken.	Repair the starter motor.
		The start signal doesn't work.	Perform repair on such malfunctions as when the control circuit is abnormal, the control power turns OFF, and when there is a disconnection in the control circuit, etc.
	The rotating speed of the starter motor is slow.	The battery is in a discharged state.	Charge the battery or replace it with new one.
	The starter motor rotates but doesn't start.	Fuel is not being supplied.	Open the fuel cock. Fill the tank with fuel. Repair a damaged fuel feed pump. Unclog the fuel filter.
		The ignition temperature of the fuel is too high.	Replace the fuel with one for which the ignition temperature is low.
		The governor/injection pump/nozzle is in poor condition.	Set the speed control lever to START. Adjust the fuel injection start timing.
		The compression pressure is low.	Replace the valve to resolve valve clearance failure/valve attrition.
			Replace the cylinder or piston ring to resolve cylinder/piston ring attrition.
			Replace the piston, as the piston head gap is too big.
Abnormal control system	Control power is lost.	The battery capacity has declined.	Solve such causes as the deterioration of the battery, a charger that generates no power, the power voltage of the charger being too low, and over discharge.
		The control system power fuse or breaker has been cut off.	Replace the power fuse or set the breaker to ON.
	The control operation is abnormal.	A malfunction occurred, caused by noise.	Solve problems in noise-generating parts.
		The PCB has short-circuited.	Repair short-circuited parts.
		The relay contact has poor conduction.	Repair poorly conducting relay parts.
		The terminal is loose.	Fasten terminals.
	Damage was caused by lightning strike.	The controlling component has been damaged.	Repair damaged parts, or replace parts.
Dramatic decrease in cooling water		Water is leaking due to a broken radiator.	Repair broken parts.
		The radiator cap is not properly tightened.	Tighten caps or replace them with new ones.
		The hopper gasket/seal is faulty.	Replace gaskets/seals with new ones.

Trouble		Suspected cause	Measures
Engine over-heating		Fan-cooling is faulty due to a loosened/broken (radiator type) fan belt.	Adjust the tension of the fan belt or replace it with a new one.
		The engine oil is faulty.	Replace the oil with regular oil (SAE30 or 40).
		The gap of the suc-tion/exhaust valve is not correct.	Make adjustment to ensure an appro-priate gap.
Abnormal decrease in engine oil		The gear case bolt or drain plug is loose.	Enlarge the tightening torque of bolts or drain plugs.
		The crankshaft oil seal is damaged.	Replace the oil seal with a new one.
		The cylinder head gasket packing is damaged.	Replace the gasket packing with new packing.
		The piston ring is worn out/broken.	Replace the piston ring with a new one.
		The piston cylinder liner is worn out.	Replace the worn-out piston cylinder liner with a new one.
Abnormal exhaust color	The exhaust smoke is black.	The air cleaner is dirty or clogged.	In the case of a dry air cleaner, blow off any clogging with compressed air, use a new air cleaner, or clean the air cleaner using neutral detergents.
			In the case of an oil-bath cleaner, clean it with light oil, or replace dirty oil with new oil.
		Inferior oil (containing wa-ter, filth, or old fuel) was being used.	Drain oil completely and use new clean fuel.
		Overloading has occurred.	Reduce the husked rice in the milling room.
		The engine oil is not at the proper level.	Resupply oil to necessary levels (when too low) or drain oil to necessary levels (when too high).
		Fueling is done too early or the fueling amount to the cylinder is too high.	Disassemble and adjust the fuel timing.
	The exhaust smoke is white.	The fuel timing is late.	Check and adjust the fuel timing.
		Water is mixed in with the fuel.	Disassemble and repair.
		The compression pressure is leaking.	Disassemble and repair.
		The engine oil is not at the proper level.	Resupply oil to necessary levels (when too low) or drain it to necessary levels (when too high).

Table 5: Troubleshooting rubber roll-type milling machines

Trouble		Suspected cause	Measures
Husking part			
	Substantial broken paddy exist.	The rubber roll gap is too narrow.	Adjust the gap to meet the paddy variety (about 0.5–0.8 mm).
		The paddy is too dry.	Spread the paddy out in the shade and leave it until its moisture rises to 14%.
		The paddy is too moist.	Sun dry the paddy until its moisture declines to 14%.
		The rubber roll has been worn out.	Replace the rubber roll with a new one.
		A lot of immature grain has been mixed in.	Winnow the paddy before loading it into the hopper, in order to remove immature grain.
	The paddy flow is unstable.	Straw and rachis branches are mixed into the paddy.	Remove straw and rachis branches from the paddy before loading the hopper.
	The husked rice contains a lot of paddy.	The rubber roll gap is too wide.	Adjust the gap to meet the paddy variety (about 0.5–0.8 mm).
		The paddy is too dry.	Spread the paddy out in the shade and leave it until its moisture rises to 14%.
		The paddy is too moist.	Sun dry the paddy until its moisture declines to 14%.
		The slip ratio became too small due to rubber roll attrition.	According to the instruction manual, replace the location of the left and right rubber rolls.
		Different varieties of paddy are mixed in.	When packaging paddy, separate them by variety, and do not mix in different varieties.
		Paddy moisture is not even.	Do not mix moist and dry paddy together.
Milling part			
	The paddy is not milled.	The milling metal mesh is worn out.	Change the position of the mesh or replace it with a new one.
		The milling roll is worn out.	Replace the milling roll with a new one.
		Weight (milling pressure) is improperly added.	Adjust the weight to apply more friction.
		The milling roll rotation frequency is too low.	Make adjustment for proper regular rotation frequency.
		The paddy flow volume is not high enough.	Make adjustment to ensure proper flow volume.
	The bran is not adequately removed.	The metal mesh is clogged.	Take off the metal mesh and clean it with a brush.
		The blowing volume is not high enough.	Stretch the blowing fan belt properly and clean the fan and airway.
	The grain temperature is high.	The loading roll or milling roll is worn out.	Replace the worn-out roll with a new one.
		The blowing volume is not high enough.	Stretch the blowing fan belt properly and clean the fan and airway.
		The flow volume of the husked rice is not high enough.	Make adjustment to ensure proper flow volume.

Trouble		Suspected cause	Measures
	Abnormal noise is heard.	The main shaft pulley pin or bearing is worn out.	Remove the main shaft pulley and replace it with a new pin and bearing.
	A burning-like odor is present.	The drive-belt is loose and slipping.	Adjust the tension of the belt or replace the belt with a new one.
		The rubber roll rubs against the liner plate.	Remove the bracket, to displace the rubber roll back and forth, and adjust it so that it doesn't touch the liner plate.
		The rubber rolls rub violently against each other.	Adjust the rubber roll gap to meet the paddy variety (about 0.5–0.8 mm).

Table 6: Troubleshooting gasoline engines

Trouble		Suspected cause	Measure
Engine doesn't start		The recoil starter cannot be pulled on.	Repair the recoil starter.
		The engine has run out of fuel.	Fill the fuel tank.
		The fuel cock is not set to OPEN.	Turn the fuel cock to OPEN.
		The throttle lever is not set to START.	Set the throttle lever to START.
		The fuel doesn't reach the injection pump or the injection nozzle.	Remove the edge of the fuel pipe or fuel injection pipe, and tug on the recoil starter.
Engine overheating		The cooling fan's fins are clogged with dirt.	Remove dirt and clean the fins.
		The cylinder head's fins are clogged with dirt.	Remove dirt and clean the fins.
Abnormal decrease in engine oil		The gear case bolt or drain plug is loose.	Enlarge the tightening torque of the bolt/drain plug.
		The crankshaft oil seal is broken.	Replace the oil seal with a new one.
		The cylinder head/bonnet gasket packing is broken.	Replace the broken gasket packing with new packing.
		The piston ring is worn out/broken.	Replace the broken piston ring with a new one.
		The piston cylinder liner is worn out.	Replace the worn-out piston cylinder liner with a new one.

Trouble		Suspected cause	Measure
Abnormal exhaust color	The exhaust smoke is black.	The air cleaner is dirty or clogged.	In the case of a dry air cleaner, blow off any clogging with compressed air, replace the air cleaner with a new one, or clean the air cleaner with neutral detergent.
			In the case of an oil-bath cleaner, clean it with light oil, or replace dirty oil with new oil.
		Inferior oil (containing water, filth, or old fuel) is being used.	Drain the oil completely and add new clean fuel.
		Overloading has occurred.	Reduce the husked rice in the milling room.
		The engine oil is not at the proper level.	Resupply oil to necessary levels (when too low) and drain it to necessary levels (when too high).
		Fueling is being done too early or the fueling amount to the cylinder is too high.	Disassemble and adjust the fuel timing.
	The exhaust smoke is white.	The fuel timing is late.	Check and adjust the fuel timing.
		Water is mixed into the fuel.	Disassemble and repair.
		The compression pressure is leaking.	Disassemble and repair.
		The engine oil is not at the proper level.	Resupply oil to necessary levels (when too low) and drain it to necessary levels (when too high).

Table 7: Troubleshooting blade-type milling machines

Trouble		Suspected cause	Measures
Milling part			
	The paddy is not milled.	The milling metal mesh is worn out.	Change the position of the mesh or replace it with a new one.
		The milling roll is worn out.	Replace the milling roll with a new one.
		The discharge slide valve is opened too widely.	Adjust the slide valve opening so that the paddy stays in the milling room.
		The milling roll rotation frequency is too low.	Make adjustment for proper regular rotation frequency.
		The paddy flow volume is not high enough.	Make adjustment to ensure proper flow volume.
	The paddy is mixed in with white rice.	The gap between the blades is too wide.	Adjust the blades to ensure a proper gap (3–3 mm).
	Substantial broken rice is generated.	The gap between the blades is narrow.	Adjust the blades to ensure a proper gap (3– 4 mm).
		The metal mesh is worn out.	Replace the metal mesh with a new one.
		The metal mesh exhibits cracks.	Repair the metal mesh by welding the exterior.
		The metal mesh has holes.	Perform repair by welding small holes; and for repairing large holes, rivet tinplate to the outside of the metal mesh.
		The paddy is too dry.	Spread the paddy out in the shade and leave it until its moisture rises to 14%.
		The paddy is too moist.	Sun dry the paddy until its moisture declines to 14%.
		The gap between the slide valves at the discharging side is too narrow. That is, the volume of the loaded paddy is bigger than the volume of discharged rice.	Make the slide valves wide open on the discharging side or narrow the opening on the loading side.
	Noise is heard.	The bearing is worn out.	Replace the bearing with a new one.
	The bran is not adequately removed.	The metal mesh is clogged.	Take off the metal mesh and clean it with a brush.
		The blowing volume is not high enough.	Stretch the blowing fan belt properly.
	The fan doesn't properly suck in the paddy.	The airflow adjusting slide is blocking air.	Open the airflow adjusting slide.
	A burning-like odor is present.	The drive-belt is loose and slipping.	Adjust the tension of the belt or replace the belt with a new one.

(5) When problems are not resolved by making inquiries to the manufacturer, put in an official request for on-site inspection by technicians from the agent or manufacturer, in order to identify the cause and repair the machine.

Accompanying materials:

Attachment 1: Acceptance slip and receipt of commission milling

Attachment 2: Milling schedule chart

Attachment 3: Operation record

Attachment 4: Maintenance record

Attachment 5: Handbook on post-harvest technologies

Attachment 1: Acceptance slip and receipt of commission milling

ORDER: Order No. _____ _____ Milling Center #1

Customer's Name: _____

Address: _____

Phone: _____Signature: _____

REQUESTED WORK Work Date _____

□ Milling □ Grading □ □

Detail _____

_____

PAYMENT

Fees _____ Toea/kg Amount_____Kina_____Toea

Paid by the customer (Signature) _____Date_____

	Order Accepted	Work Started	Payment Received	Work Completed
Date				
Sign				

RECEIPT

Milling Center #1

Order No. _____

Name_____

For _____

_____

STAMP

_____

_____

Amount_____ Kina

_____ Toea

Date_____2015

Cashier: _____

Chief Acct_____

Attachment 2: Milling schedule chart

Milling schedule chart

Schedule Table: Operator: _____ Machine: _____ Month: July, 2014

Date			AM	PM
1	Tue	plan		
		actual		
2	Wed	plan		
		actual		
3	Thu	plan		
		actual		
4	Fri	plan		
		actual		
5	Sat	plan		
		actual		
6	Sun	plan		
		actual		
7	Mon	plan		
		actual		
8	Tue	plan		
		actual		
9	Wed	plan		
		actual		
10	Thu	plan		
		actual		
11	Fri	plan		
		actual		
12	Sat	plan		
		actual		
13	Sun	plan		
		actual		
14	Mon	plan		
		actual		
15	Tue	plan		
		actual		
16	Wed	plan		
		actual		
17	Thu	plan		
		actual		
18	Fri	plan		
		actual		
19	Sat	plan		
		actual		
20	Sun	plan		
		actual		
21	Mon	plan		
		actual		
22	Tue	plan		
		actual		
23	Wed	plan		
		actual		
24	Thu	plan		
		actual		
25	Fri	plan		
		actual		
26	Sat	plan		
		actual		
27	Sun	plan		
		actual		
28	Mon	plan		
		actual		
29	Tue	plan		
		actual		
30	Wed	plan		
		actual		
31	Thu	plan		
		actual		

Attachment 3: Operation record

Operation record

Work Sheet: Milling Machine _____ Operator _____ Month: July, 2014

Date	Order #	Start time	End time	Hours worked	Work description

Attachment 4: Maintenance record

Maintenance record

Maintenance Record: Milling Machine _____ Month: July, 2014

Date	Accumulated Hour	Description	Cost	Signature

Attachment 5:

Handbook on Rice Post-harvest Technologies

1. What is Post-Harvest Technology?

This Handbook is about rice post-harvest techniques, and unlike tuber and root crops that many farmers in PNG are familiar with such as taro, yams, cassava, sweet potato; rice is a grain and how it is handled at harvest and after harvest is quite different. It must be handled with a different techniques and this require learning from those who have grown and harvested rice over many years, both in PNG and in rice growing countries.

A post-harvest technology is a series of processes as a part of rice cultivation cycle (referring to figure 1) and any handling techniques or treatments applied to the economic part of a crop just harvested from the field for the purposes of transforming it into a form, condition, or composition that adds value, makes it storable or prolongs its shelf-life, and makes it useable or edible.

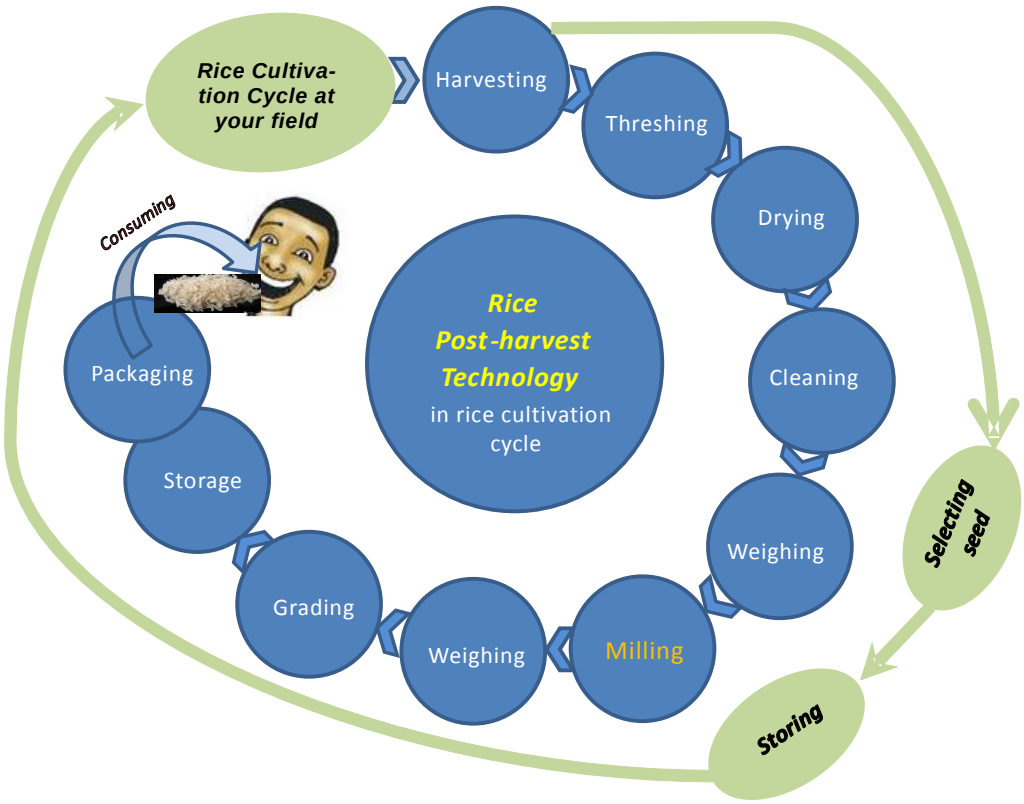


Figure 1: Illustration of different stages of rice post-harvest techniques and handling

Rice is a grain crop and is not immediately available for cooking at the harvest time. Belonging to the grass family, it needs to be field-dried after been separated from its straw and panicles, cleaned of its chaff and any foreign matter in it, and further dried to the required moisture content before it can processed for it to be edible or dried to be stored away for future processing. The Figure 1 illustrates the number of stages in which the post-harvest handling and techniques are associated with it.

Several stages of post-harvest handling of rice grains includes field-drying, threshing, shed-drying, cleaning, grading, storing, weighing, and milling before making it fit for human consumption. It is important to observe carefully all the stages of post-harvest handling as each stage will affect the other to determine the quality of grain, mill recovery rate and the minimizes

losses that can be controlled.

One important features of post-harvest handling is the harvest and treatment of selected grains for seeds to be used in the next cropping.

Check box for Confirmation:

Further Explanation:

(1) Producing good quality rice grains requires using appropriate post-harvest techniques and it helps reduce processing and grain-storage losses.

(2) Ensuring each stage of rice post-harvest processing is carefully managed is very important for producing high quality rice and seeds. Do not regard each stage as un-important and not necessary for your attention and management.

2. Harvesting

Harvesting is the process of obtaining plant parts or component of plant-parts that has reached its physiological maturity or at the stage of growth ideal for separating it from the stock plant. The act of harvesting can be picking, pulling, plucking, slashing, cutting, stripping and shaking the economic part of the plant that is of interest to the harvester. Time to harvest a crop is often determined by changes that takes place in the economic part of the crop and, in some cases, the entire plant. This change can be in the form of visual appearance, smell, colour, size, and the moisture content.

(1) For the rice crop, the harvest time is often determined by the visual appearance, colour, and moisture content of the grains. When the crop ripens, rice grains will be filled and tight, the grain colour change from green to olive-green to yellow and the moisture content drops between 18%w.b and 22%w.b. [on weight-basis].

(2) It is important to take note of the optimum harvesting time and crop maturity signs. Not taking note of the timing or missing the signs can cause the rice grains to remain in the field where the grain moisture content falls below 18%. When this occurs, any incidental wetting by rainfalls will cause the grains to absorb moisture and may germinate. Some rice varieties have shattering ability and any delay harvesting will cause yield losses through shattering. That is when ripen grains just fall to the ground when slight winds and rainfalls touch the crop; or when the farmer is moving through the field.

(3) Two main observations used to determine the correct harvest time for rice grains are:
Moisture content: Grain moisture content is ideally between 18 and 22%w.b. (wet basis). Grains should be firm but not crumbly when pressed between the teeth.

Ripe grains per panicle: The crop should be harvested when 80-85% of the grains on the field have changed colour from green to matured yellow.

(4) When harvesting the rice by sickle or knife, cut the rice straw 4-5 cm from the ground level and do not leave much bigger portion of its standing. (See Figure 2) Standing straws and straw stumps still remaining in the field can have stem-borer worms and adults to complete its life cycle. Always destroy the straw by cutting as low as possible to the ground and up-root and destroy the straw stumps and incorporate it into the soil by hoeing soon after the harvest and ready for the next season.

Figure 2: Grower harvesting rice with sickles at the plant height of 4-5 cm from the ground

(5) Do not allow the rice crop to extend its growing period by allowing secondary tillers with late panicles emerging when the main rice crop is about ripening. Overlap cropping allows the spreading of the flowering, grain-filling, grain ripening and harvesting period and timing, giving opportunity to pests like stem-borers and rice bugs to thrive.

(6) Overlap cropping will also result in harvest of immature and empty grains which can be the cause of extra volume and weight of rubbish, resulting in increased grain-fracture during milling when not winnowed and cleaned.

Check box for Confirmation:

Further Explanation:

(1) Some paddy can germinate in field crop before harvest if harvesting is delayed.

(2) In delayed harvest, standing crop's moisture content will fluctuate between drying and wetting period, causing the grains moisture content to fall below 18%w.b. and paddy might be eaten by birds;

(3) Transplanting is recommended because the crops will be uniform in its growth, flowing, and grains filling, giving little change for the lot of secondary panicles to emerge and not allowing the stem-borers to thrive.

3. Threshing

Threshing is the physical process of separating the grains from the rice straw and the panicles. Threshing of rice can be done by hand, foot, or simply by a swinging, beating and whipping actions against a framed object. Threshing can also be done with winnowing machines. In PNG agriculture, threshing grains is not a common practice, therefore, all new rice grower will need to learn the right operation and techniques for threshing. Threshed rice will contain a lot of chaff and foreign materials, therefore, after drying as shown above in Figure 6, cleaning needs to be carried out. The following steps are undertaking during the threshing:

(1) Harvested paddy should be threshed simultaneously on the day of harvest.

(2) Rice straws and panicles harvested that are wet from over-night rains or by the morning dew must be field-dried before threshing, often morning-half of the day is committed to harvesting and afternoon-half of the day is to do all the threshing.

(3) Use wide canvass or plastic sheets with the edges raised to catch all the grains being threshed through the beating-action as shown in Figure 4.

(4) Dry the paddy soon after threshing both in the outdoor and the in-door sheds to prevent grains from fermentation if the moisture remains in a heap or bag of grains for too long.

Figure 3: Wooden frame for threshing rice

Figure 4: Farmer threshing the rice, using wooden frame.

Figure 5: A grain threshing comb fixed on wooden frame.

Check box for Confirmation:

Further Explanation:
(1) Note that some rice varieties are easier to thresh requiring 2-3 beatings while others may require more than 4 beatings.
(2) Avoid heavy-handed actions or beating too strongly to prevent grains from cracking.
(3) Timing of drying: It is still good to thresh rice after drying if only panicles are dried.

4. Drying

Drying is the process that reduces the moisture content of the rice paddy down to a safe-level where rice can be properly milled and, importantly, put away safely for storage. Drying is the most critical operation after harvesting a rice crop. Any delay in the drying process, incomplete drying or ineffective drying will reduce the grain quality and result in post-harvest losses.

(1) Sun-dry the wet paddy by spreading the grains evenly on a plastic sheet or a canvass (see Figure 6) with the layer of about 4-5cm depth (see Figure 7). Turn-over the paddy every 30 minutes using a garden rake and by using hand and foot, tenderly spreading the grains as they dry. Slow-drying of the rice paddy will prevent cracking; and by contrast, quick and fast drying will cause the grains to crack and will result in lot of broken grains when milled.

(2) It is preferable to dry your paddy in a sheltered area (sheltered from direct sun-light and any sudden rain-fall) over three days, and occasionally bringing it out to direct sun drying for at least 30 minutes each day.

(3) Ensure that the surface temperature of rice paddy being dried does not rise above 36℃ or must be kept lower than 36℃. High grains temperature will destroy the grain embryo if one is to keep the grains for seeds. In a stored grains, both in sacks or canvass bags with inadequate drying, the paddy rice temperature can suddenly rises above 36℃, this may mean there is a high moisture content and the rice paddy may germinate under such condition. However, the germination will be short-lived as all the seeds that sprout will be smothered within the storage sack or canvass.

(4) When putting the high moisture paddy into the bags, keep the mouth of bags open to all the air movement and the release the heat and dampness from bag (see Figure 8)

Figure 6: Rice paddy evenly spread on a canvass for sun-drying.

Figure 7: Using finger to measure depth of rice paddy spread on canvass.

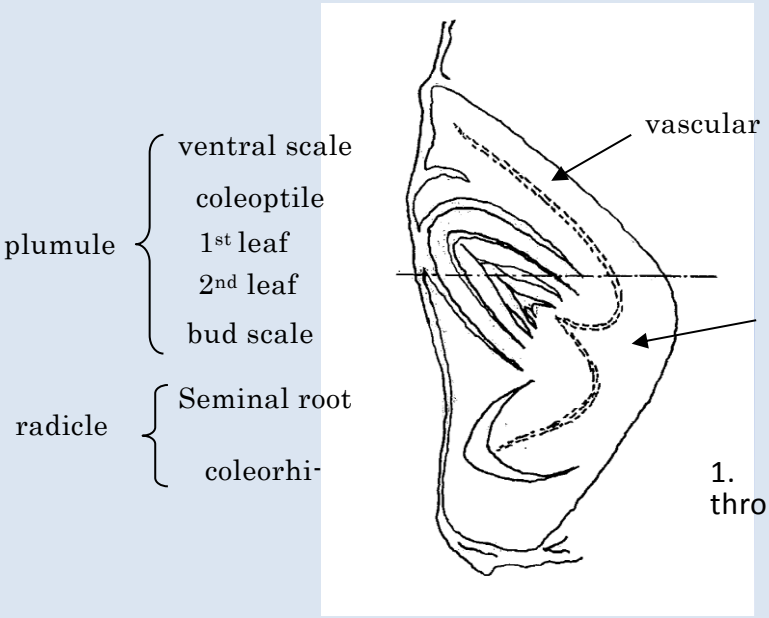
Figure 8. Rice paddy being stored away in poly-bags with the bag mouth left open to allow air movement.

Check box for Confirmation:

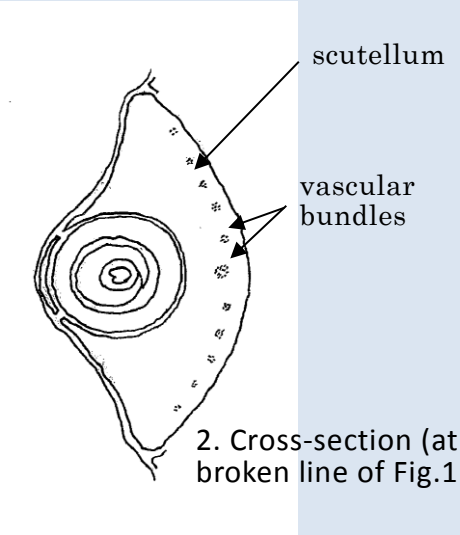
Further Explanation:

(1) Slow drying is preferable to avoid the cracking of rice grain.

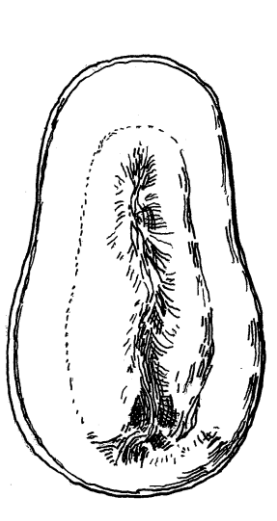
(2) Below are the rice embryo's figures. Baby leafs and root already exist in it. The enzyme activity to use starch of endosperm loses by high temperature over 36℃. [Adapted from 'THE GROWING RICE PLANT', Hoshikawa, NOBUNKYO]



1. Vertical Section through the embryo.



2. Cross-section (at the broken line of Fig.1)



3. Front view of the embryo.

a: Germinated seeds

(b) . Seeds exposed to high temperature will not germinate

(3) Don't mix the paddy with 5%-different moisture content because it causes the production of fermentation and mold. Also, it is difficult to make the moisture of paddy evenly before milling.
(4) Equilibrium moisture content of paddy is related with air temperature and relative humidity.
(5) When drying paddy under the sun, it is necessary to spread them and turnover continuously and evenly, maintaining a certain thickness (4–5 cm thick), and it is important to spread them evenly. It depends on the weather, but it is very important that the crop temperature doesn't rise to or above 36℃ (roughly the human body temperature). For this purpose, though it depends on weather, it is necessary to watch crop temperature and to repeatedly turn paddy upside down (every 20–30 minutes). By doing so, paddy can be dried evenly without generating cracked or damaged rice.

5. Cleaning

Cleaning is the process to remove rice straw chaff, foreign matters and immature/empty grains within paddy after threshing and drying. High percentage of chaff, foreign matters include the soil piece, sand, small stones, metal debris, plastic or paper pieces, twig and branches, wood piece, weed seed, other grains, chemical and poisonous matters, etc., will unnecessarily increase the number of sack of rice and weight of paddy, which may cost the grower avoidable transport fees and milling fees paid the mill operator; and for the rice mill operator the cost of wear-and-tear and spoilage to his machine.

(1) The importance of cleaning is as follows:
① To remove foreign matter, broken and immature grains to gain high milling recovery rate [to reduce broken rice amount].
② To increase the milling efficiency [to reduce fuel consumption].
③ To decrease the damage of machine.
④ To decrease running cost due to less wear of consumable parts.
⑤ To increase more than 5% of mechanical efficiency and energy consumption if percentage of foreign matter, broken and immature grains is less than 1%.
⑥ To decrease post-harvest loss.

(2) Prevent broken rice. 5% broken rice decrease 10% on milling recovery.

(3) The immature grains are classified into impurity. Immature grains decrease the milling recovery rate and the mechanical efficiency of the rice milling unit and is the cause of broken rice grains.

(4) Use winnowing tray/ basket and mechanical cleaners such as manual winnower, oscillating sieves and aspirator. Small stone and sand that cannot be removed by winnowing can be removed hand picking.

Figure 9: Winnowing of grains using weaved bamboo-strip round tray.

Figure 10: Winnowing using drop-and-wind technique.

Figure 11: Hand-operators wooden-framed mechanical winnower.

Check box for Confirmation:

Further Explanation:

(1) Never feed the immature and empty grains into milling machine because of above reasons in the item of 3. (1).

Broken rice makes another broken rice as well as immature rice. Below data evidently show that milled rice, milling recovery and flow rate are all increased by winnowing paddy, both are 15kg of same quality paddy at first.

	Material process	Paddy (kg)	M/rice (kg)	Recovery(%)	Flow Rate(kg/h)
Test-1	No winnowing	15.000	5.954	39.7	47.2
Test-2	After winnowing	14.416	6.890	47.8	75.2

(2) Broken rice makes another broken; broken rice and immature grains give unnecessary higher milling pressure to the whole grains that will cause more broken because broken and immature grains get into the space between whole grains. Furthermore, this situation is quite an additional work for the milling unit to polish the surface area of broken rice grains, especially, its cross-sectional area, resulting in more mechanical load on the milling unit during operation.

6. Milling

Rice milling is the next important stage in the post-harvest chain of techniques. In here the good grain is milled through mechanical means to remove the outer skin, hull, and bran to reveal the white kernel and endosperm of the grain that is utilized as food product for human consumption. The by-products such as the germ and the brans can also be collected and utilized as a compo-

nent to the formulation of stock feeds for poultry, other livestocks and aquaculture.

(1) When utilizing the rice milling units, feed only good, clean and fairly well dried rice grains into the machine. Avoid using paddy rice that is not cleaned, having lot of empty grains, panicle parts, and straw chaffs; especially, grit and sand-stones.

(2) The three common milling units used, sold and distributed, and possessed by communities in PNG are the following units in Figure 12 to 14.

Figure 12: Eagle RM150 Milling unit.

Figure 13: Impro: PS-80 (a copy of Satake SB10D).

Figure 14: Yanmar YMM20 milling unit.

Check box for Confirmation:

Further Explanation:

❖ **General cares for milling**

(1) The milling charges should applied on the quantity of paddy and not on milled rice.
(2) In case of the contamination of more than 3 - 5% immature grains, the milling recovery decreases suddenly and lowers the mechanical efficiency.
(3) The cost of both transporting paddy to the mills and fees charged for milling, together with the operational load on machines will be higher, if paddy rice are not cleaned.
(4) In case of Japanese milling center, they make effort to increase milling recovery by 0.5%. If their milling recovery decreases 2-3%, the center will make a loss and go into bankruptcy.
(5) Milling recovery is very important at commercial-based mill service and business.
(6) If clean paddy is fed into milling machine, the milling load, fuel consumption and lubrication oil use will be low or are decreased. This will ensure the mechanical efficiency is maintained and the consumable parts such as rubber rolls, screens and milling rollers can be used for a longer time.
(7) Only friction type milling machine is usually used in Papua New Guinea. There are two categories of its milling machine; blade type and rubber roll type.
(8) Micro Mill: RM150 is commonly suitable for milling a small lot of carry-in paddy.
(9) Note the difference of manual and mechanical milling as stated below:

	Manual Mill		Mechanical Mill
1	Uneven milling is ocurred.	1	Even milling can be done.
2	Milled rice quality is not uniform and constant.	2	Can produce uniform milled rice quality anytime.
3	It takes a long time for milling due to bad efficiency of equipment.	3	High efficiency and short milling time due to high capacity.
4	Equipment cost is cheap.	4	Initial cost is expensive compared with manual mill.
5	Anybody can use equipment because of easy mechanism.	5	Skillful engineer is needed to operate and maintain rice mill.
6	Can install anywhere and need a small space.	6	Need proper installation space depending on machine size.
7	No running cost and maintenance cost due to manual operation.	7	Running cost such as fuel, oil, consumable parts is expensive.
8	Can use by one person.	8	Operation can be made by plural persons.

❖ Understand completely the following difference between commissioned mill and commercial mill.

No	Point	Commissioned milling	Commercial milling
1	Operation efficiency	Milling amount per unit time small; operation intermittent; operation inefficient	Milling amount per unit time high; operation continuous; operation very efficient
2	Milling quality	As paddy quality varies from time to time, the quality of milled rice is not even.	Quality always even; stable quality of white rice can be produced
3	Milling yield	Milling quality not regarded important	Milling quality is regarded as important; possible to produce milled white rice meeting the market-required quality.
4	Degree of milling quality	Milling recovery not regarded important; paddy milled in line with customer's demand (or meeting machine capability)	As milling is done for profit, yield is regarded as important.
5	Operators' technical capabilities	As the fine-tuned adjustment of machines is not necessary, operators are not required to have high technical capability.	Machines require fine-tuned operational adjustment. Therefore, experienced operators are needed.
6	Initial investment	Initial investment not costly	Initial investment and running cost are likely to be expensive.
7	Composition of machines	Consisting mainly of small-scale milling machines	Consisting of more than two machines; for instance: Winnower → hulling machine → milling machine → pre-cleaning machine → gravel remover → measuring machine → packaging machine
8	Quality of paddy	Paddy brought into milling facilities differ in moisture content; some contain lots of foreign substances; the adjustment of milling is difficult.	Procurement of quality paddy material is needed. (Necessary to procure one variety of paddy; less damaged grain, less cracked rice, less foreign substances mixed in; paddy with a stable 14% of moisture)

❖ Fundamental of maintaining the soundness of the milling and post-harvest equipment that has transmission mechanism and many moving parts and gears:

1. Operate at least once or twice per month.
2. Clean machine inside and outside completely after operation at once.
3. Check abnormal noise, vibration, heat and odor.
4. Check bolts and nuts as well as belts.
5. Check lubrication oil, cooling water and grease.
6. Replace consumable parts at proper timing.
7. Keep a maintenance record by simplified format.

7. Grading

Grading is the process of sorting the milled rice grains into categories based on the visual observation and moisture content measurements. Visual observations will indicate whole grains, broken grains, off-types (grains of other variety), coloured grains, and presence of the un-milled paddy.

(1) The following are factors used for sorting and grading milled grains into several categories depending on the operator's end-use.
   ① Moisture content;
   ② Head rice and broken percentage;
   ③ Defectives;
   ④ Impurities [Foreign matters, vain paddy and immature grains]; and
   ⑤ Presence of un-milled paddy.

(2) Take care of moisture content of milled rice. If the moisture content of milled rice is high, the product gets mouldy.

(3) If rice is not consumed soon after milling, and rice is requiring long shelf-life or storage would need high milling degree for removing all the bran.

Check box for Confirmation:

Further Explanation:

(1) In case of commercial-based mill, the uniformity of milled rice (especially physical quality) at any production base is highly recommended and is required to meet market expectation.
(2) When packaging for retail sales, removal of small broken rice can upgrade the quality.
(3) The quality standard for the individual mill must be developed to keep the uniformity and quality control of rice, when you plan to sell as an original brand.
(4) If milling degree is low, some bran is still remained on rice kernel. Bran contains fatty acids and easy to oxidize. Then, the fatty acid of bran increases and reduces the fresh taste of rice.
(5) Avoid the sudden change of moisture and temperature of rice grains, because it results in the cracking even after milling.
(6) Packed samples of milled rice produced in East Sepik and Madang.

Figure 15: Packaged milled rice from Maprik, ESP

Figure 16: Packaged milled rice by farmers in Madang province

(7) Use of by-product of rice:

There are some differences of market prices;

- Husk: charcoal husk, underground drain, fuel
- Bran: chicken feed, fertilizer (Bokashi)
- Fine broken grains can be fed to fish/ chicken feed

8. Storage

The purpose of grain storage facility is to provide safe storage conditions for rice grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi as shown in Figure 17.

(1) Grain moisture content should be maintained at 14%w.b. or less.

(2) Don't put rice bags directly on the floor. Those bags should be laid on the rack above 20cm above the floor;

(3) The longer the grain needs to be stored, the lower the required moisture content will need to be.

(4) Grain and paddy seed stored at moisture contents above 14%w.b. may experience the growth of molds, rapid loss of viability and a reduction in eating quality.

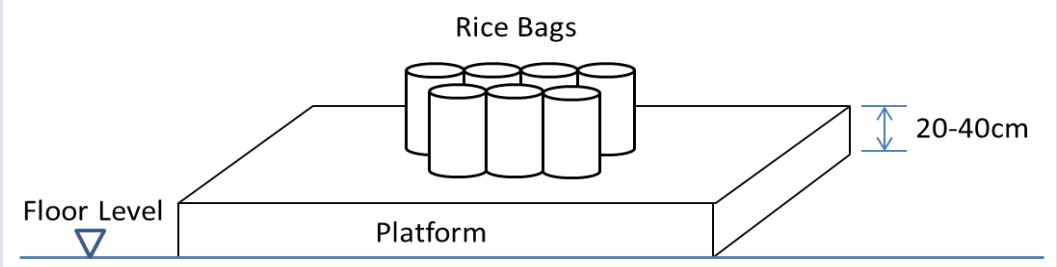
(5) If the moisture content of paddy inside bag is high, open all mouths of bags to release vapor and heat coming from the paddy itself. It's better to spread such paddy of high moisture content on plastic sheet for room conditions drying.

Figure 17: Village style rice storage house.

Check box for Confirmation:

Further Explanation:

(1) Adequate air ventilation is required in store rooms to prevent the moisture from floor or ground reaching the rice bags store on the floor.



(2) Losses from insects, rodents, birds and moisture uptake are usually high in bulk storage systems. Also, some shrinkage occurs by long term storage.

(3) Grain is protected from re-absorbing by rain or absorbing moisture from the surrounding air.

9. Weighing

Weighing is the method of determining the mass of the rice paddy produce and mass of the white or milled rice processed.

(1) The measurement of rice weight must be correct and precise. The platform scale is needed for measurement of paddy/white rice weight to calculate the correct milling recovery.

(2) Conduct the zero-adjustment of spring scale or table scale before starting the measurement of weight.

(3) Conduct the measurement of weight by putting paddy/rice on the scale. Read the weight graduation after the indicator is stable. Read the weight kg by round off to one decimal place by 100g.

(4) After measurement, don't forget to deduct the tare, which is the weight of bag/vessel.

Figure 18: Platform type of weighing scale.

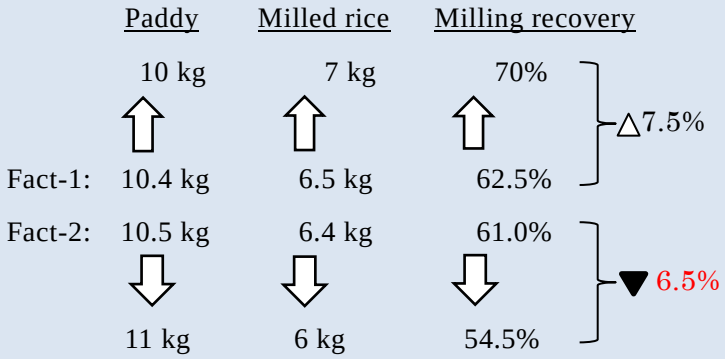
Figure 19: Reading mechanism for the platform type weighing scale.

Figure 20: Hanging type of scale 100Kg capacity.

Check box for Confirmation:

Further Explanation:

(1) Never round off /up to the closest whole number.



(2) Differences among each two milling recoveries are +7.5% and -6.5%. These differences are quite big when the performance of milling machine is evaluated.
(3) To know the percentage, it is important to read to 3 decimal places; i.e.
(4) Consider the above Fact-1. If 0.4kg is disregarded from 10.4kg, it becomes 10kg.
(5) Can you also disregard 40 kg in case of 1,040kg? Therefore, we need to read all whole numbers and if possible read to 3 or 4 decimal places for accuracy and when dealing with lots of individuals of values and measurements as cumulatively they will add up.
(6) The Hanging-type spring scale is not recommended because the inside spring becomes extended after continuous use and years of operation and the measured reading may give incorrect and reading errors.

10. Seed Selection

High quality seeds come from proper maintenance of genetic purity and good growing conditions. Appropriate timing and method of harvesting and proper processing during threshing, cleaning, drying and storage would ensure sustainable and continuous cropping successes.

(1) Be careful on gradual drying process for seed paddy. Do not exposed seed grains to high temperatures over 36℃ [degree Centigrade].

(2) Select only sound and fully mature paddy for seed from rice panicle. Select clean grains free from insect and disease damage.

(3) Do not exceed over 30-40% of seeds per panicle when selecting grains for seed.

(4) Don't keep paddy seed over 36℃.

(5) Paddy seeds can be dried by hanging at string under shed as shown in Figure 21.

Figure 21: Rice seed being hang onto the ceiling for safe-keeping

(6) Procure only grains of the center portion in an ear of rice, where will be the highest germination ratio. As shown in Figure 22, the circled parts (such as the ear tips or near the root) tend to exhibit deformed grain or immature rice, which should be removed when selecting seeds. As a rough standard, 30–40% should be selected and used for seeds. Then, the germination rate will exceed 90%,

equalizing the growth of seedlings at rice nurseries.

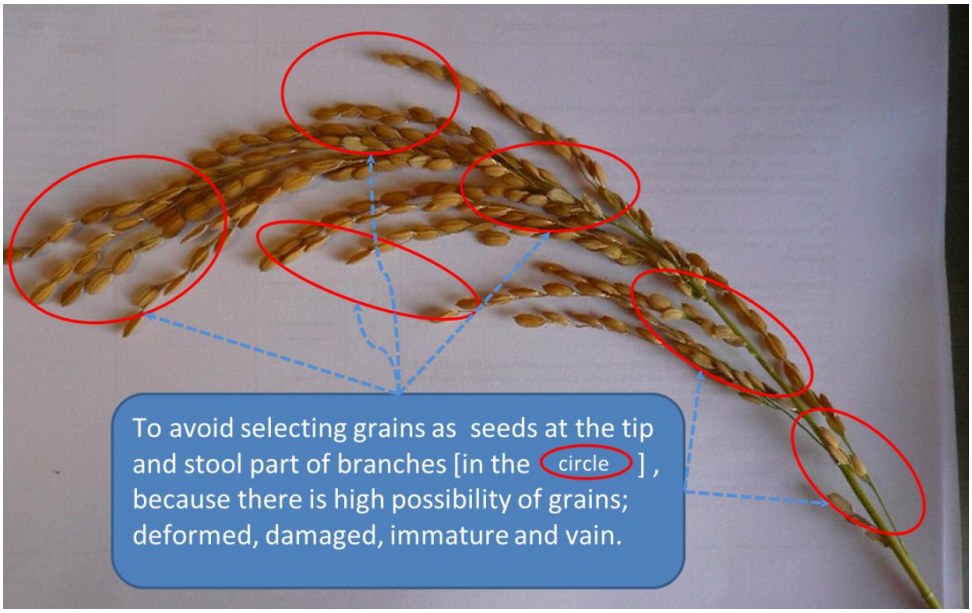


Figure 22: Part of panicle where grains are selected as seeds.

Check box for Confirmation:

Further Explanation:

(1) Deterioration in seed quality may begin at any point in the plant's development stage.

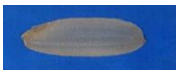
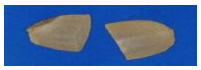
(2) Seed quality depends on the physical conditions that rice plant is exposed to during its growth stages, as well as at harvesting, processing, storage and planting.

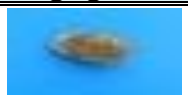
(3) Temperature, nutrients and other environmental factors can affect seed development and later influences on the seed quality.

(4) The use of superior grains for rice seed will results in high quality milled rice eventually.

ANNEX

List of Damaged Rice Kernel

Name	Whole grain	Large brokens	Small brokens (fine rice)	Poor ripening/ empty grain
Paddy				
Brown rice				Nil
Milled rice				Nil
Feature	Milled rice with length greater or equal to three quarters of the average length of whole grain.	Milled rice with length less or equal to three quarters but more than one quarter of the average length of whole grain.	Milled rice with length less than one quarter of the length of whole grain.	Poor ripening paddy which has empty or very poor kernel inside.

Name	Damaged grain				
	Disease grain	**Insect damage grain**	**Spotted grain**	**Deformed grain**	**Rusty grain**
Paddy					
Brown rice					
Milled rice					
Feature	A kernel which is damaged by fungus or virus, etc.	A kernel which is bitten or sucked by insect	After milling, kernel has discolored portion of less than Dia.1mm.	Embryo has a notch length is more than one quarter of the kernel width.	Kernel surface is brownish-red color.

Name	Cracked grain	Dead grain	Discolored grain	Immature grain (1)	Immature grain (2)
Paddy					
Brown rice					
Milled rice					
Feature	One or plural vertical/ horizontal cracks have on surface of kernel.	Most portion of kernel is chalky, matte and unripened.	In spite of shading, discolored portion is at kernel surface.	Totally poor and unripened kernel (milky-white kernel)	Green unripened kernel