Monograph:
Postharvest Innovations for the Heirloom Rices of the Cordillera Region, Philippines

This publication is a collaboration among the Philippine Department of Agriculture-Bureau of Agricultural Research (DA-BAR; funding agency), DA-Regional Field Office - Cordillera Administrative Region (DA-RFO CAR), the International Rice Research Institute (IRRI), and the Philippine Rice Research Institute (PhilRice).

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PREFACE

Heirloom Rice refers to the rice seeds that have been passed from generation to generation in the Cordilleras. They are part of the culture and heritage of its peoples, gaining value over time. They are the heart and essence of its rice terraces which is a testament to the hardiness and resilience of the rice grain. The Heirloom Rice Project (HRP) was motivated by the desire to conserve these precious seeds, cognizant of their inherent traits and qualities. Selected heirloom rice varieties are now known to be more nutrient-dense than the more prevalent varieties that are available. Recent interest in nutrition has elevated heirloom rice's status as a specialty rice, commanding higher prices in local and global markets. This contributes to the sustenance and productivity of the heirloom rice farmers, majority of whom are now female, providing a way for them to survive and thrive despite the harsh farming conditions in the Cordillera mountains.

Phase II of the HRP entitled, "*Conserving and Increasing Productivity and Value of Heirloom Rice in the Cordillera*" follows from Phase I's "*Raising Productivity and Enriching the Legacy of Heirloom Rice through Empowering Communities in Unfavorable Rice-Based Ecosystems"*. At the onset, the HRP primarily aimed to improve the livelihood of the indigenous peoples in the Cordilleras by significantly increasing the productivity of their desired rice varieties. This vision is shared among the partner institutions, namely the International Rice Research Institute (IRRI), the Department of Agriculture - Regional Field Office (DA-RFO) of the Cordillera Administrative Region, and the Philippine Rice Research Institute.

The strategies implemented to fulfill this vision are two-fold: 1) to increase farmers' income and 2) to sustain the heritage and food security in the rice terraces of the Cordillera region. The project's objectives are a) to ensure preservation and community registry of the characterized heirloom rices; b) to establish the inherent characteristics of at least 150 heirloom rices in the expansion sites; c) to increase the volume of quality milled heirloom rice by at least 10% through improved production and postharvest production management; d) to capacitate implementers and producers for improved productivity and product quality; and e) to increase the value of heirloom rice and ensure market competitiveness.

For HRP Phase II, IRRI was directly responsible for the 1) *in-situ* and *ex-situ* morpho-agronomic characterization and yield evaluation, genotyping, grain quality, and nutrient analyses; 2) field trials on pest management strategies; and 3) piloting of postharvest production technologies. In addition, the expanded heirloom rice value chain analysis is IRRI's contribution to maximize the full potential of heirloom rice as a prime commodity sold as either grain or as other rice by-products.

This monograph forms part of a set of HRP Phase II's research reports on the environmental, economic, social, and health aspects of heirloom rice cultivation in the Cordillera region. We hope that it will provide not just information but also inspiration for research managers, scientists, researchers, farmers, and all stakeholders to build on the lessons learned from the HRP and contribute to the sustainability and productivity of heirloom rice.

ACKNOWLEDGEMENT

The Heirloom Rice Project Phase II (HRP Phase II) is a multi-level and multi-disciplinary research collaboration among government, the academe, entrepreneurs, and the indigenous peoples of the Cordillera Administrative Region (CAR), together with scientists and researchers from national and international institutions. We would like to thank all the men and women who contributed to the project's fulfillment.

We are indebted to the Provincial Agricultural Offices (PAO) and the focal persons for their support and collaboration during our visits to their places. Their worthwhile assistance during meetings, field demonstrations, and training sessions for the postharvest machines/innovations in their respective locations contributed immensely to getting the work done successfully. Our thanks go to the PAO staff members, namely Mr. Derman Dalmo (Benguet), Mr. Joe Casibang (Kalinga), Mr. David Kimmayong (Ifugao), and Ms. Jovita Camso (Mountain Province). The focal persons, Mr. Felix Titiwa (Kibungan, Benguet), Ms. Meralyn Allama (Banaue, Ifugao), Mr. Alfonso Cayong (Hungduan, Ifugao), Mr. Charlie Osdeg (Lubuagan, Kalinga), Ms. Rowena Gonnay (Pasil, Kalinga), Ms. Melanie Lagasca (Bauko, Mountain Province), and Mr. Ceferino Oryan (Barlig, Mountain Province) likewise contributed greatly to the success of the project activities.

Our respect and appreciation is due to our partners from the DA-RFO CAR who graciously extended their work for the project: Dr. Magdalena Wanawan, Dr. Virginia Tapat, Dr. Veronica Fangasan, Mr. David Sumalag, Mr. Nestor Hummiwat, Ms. Jenny Dayao, Ms. Sarah Balloyan, Ms. May Ann Tuba-ang, Ms. Jean Mayos, and Ms. Daisy Caysoen.

We are grateful for the partnership with the Philippine Rice Research Institute, particularly to Dr. Glenn Ilar, Mr. Jerry Batcagan, Mr. Rheymark Credo, and Mr. Norwell Sabigan for their enthusiasm to participate in the testing of the machines and responding accordingly to the modification of the designs.

Our colleagues from the Mechanization and Postharvest Cluster, International Rice Research Institute, Engr. Martin Gummert and Mr. Eduardo Secretario, and former colleagues Mr. Alfred Schmidley and Engr. Christopher Cabardo for their invaluable support, encouragement, constructive comments and profound ideas for the improvement of the layout and design of the prototype machines.

We also extend our thanks to the private companies that helped in the fabrication of the prototypes of the machines as represented by Dr. Eulito Bautista of the JHT Micro Enterprises and Engr. Dexter Ona of the AXIS Machineries and Fabrication. Dealing with them was straightforward and without anxiety. An heirloom rice entrepreneur, Mr. Jimmy Lingayo of the Rice Terraces Farmers' Cooperative, is likewise acknowledged for generously introducing various heirloom rice varieties and walking us through the postharvest practices and machines currently in use in Cordillera.

This monograph was initiated and prepared by a research team with Engr. Joseph M. Sandro providing the technical information for the postharvest machines and processes and Ms. Joyce S. Luis contributing social and economic aspects. Drs. Ana E. Cope and Cecilia S. Acuin both gave invaluable guidance and feedback, and helpful coordination efforts among the members of the team throughout the preparation of this document.

We wish to express our gratitude to the DA-Bureau of Agricultural Research (DA-BAR) for the three-year grant, from 2017 to 2020, that made it possible for HRP Phase II to achieve its accomplishments. Likewise, we wish to express our appreciation to Dr. Alice Perdon of Kellogg's for generously funding the purchase of the postharvest machines.

This acknowledgement would not be complete without mentioning Dr. Casiana M. Vera Cruz who instigated the launching of the HRP project at IRRI in 2014 and led both HRP Phases I and II until her retirement in 2017. She paved the way for reaching out to the heirloom rice farmers and local partners. Though retired from IRRI, she maintains her solicitude for the Cordillera farmers and the people she talked to or worked with during the project. We wish to thank her for her enthusiasm, passion, and profound understanding.

We remember as well Dr. Gelia Castillo for her love for heirloom rice and deep concern for heirloom rice farmers. She once asked the HRP team "*I want to meet them (farmers) and ask, 'did you make money from heirloom rice?' If they say yes, I'll be very happy. But if no, I'll go after you".*

We dedicate this monograph, one of HRP Phase II's products, to the men and women farmers of the Cordilleras who live and protect the heirloom rices for the people of today and the children of tomorrow.

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INTRODUCTION

The Cordillera Administrative Region (CAR) maintains a diversity of heirloom rice varieties organically produced in its renowned terraces and manually processed using traditional practices. These heirloom rice varieties have been handed down across generations. Cordillera farmers are fully aware of the varieties' good eating qualities and adaptation to local agro-ecological conditions, as well as their single season growing behavior (e.g., late maturing), slow decomposition of biomass, and low yield potential (VCA HRP Phase II, 2020, Sajise et. al., 2012). Across time, these heirloom rice varieties have become popularly known and sought after by consumers in the urban lowland areas and rice-based small and medium businesses like the Mama Sita Holding Company. The varieties' nutritional value is one of the drivers for the change in preference of urban consumers to more nutritious pigmented rice – red or violet/black. It is also this same characteristic of heirloom rice that led the Mama Sita company to use the Balatinaw variety in its Heirloom Rice Champorado product. The company owner learned of heirloom rice varieties through promotional campaigns of the Heirloom Rice Project (HRP). The use of an heirloom rice variety in this champorado mix, which has been internationally launched, sits well with the company's thrust to use only natural ingredients in all their products. With this interest in producing heirloom rice for commercial consumption, a greater quantity of heirloom rice is therefore needed. Mama Sita alone requires about a hundred kilograms per order of a single variety as well as a steady supply for the year. Local consumers also require a minimum quantity of one kilogram per pack which they usually get from farmers, farmers' cooperatives, retailers, and on-line resellers.

To meet the demand for heirloom rice grains and to further preserve them, postharvest systems need to be given deeper attention as well. This monograph highlights the postharvest innovations introduced in HRP Phase II.

Minimizing further deterioration and losses after harvesting, saving time in tedious postharvest activities, enhancing storage facilities, and improving the quality of the rice grains are some of the targets that postharvest systems intend to accomplish. The postharvest system consists of a set of operations which cover the period from harvest to consumption (Mejia, 2004). As expanded further by Spurgeon (1976 cited by Barsan, 2016), the postharvest system encompasses the delivery of a crop from the time and place of harvest to the time and place of consumption, with minimum loss, maximum efficiency, and maximum return for all involved. When losses from rice grains are minimized, both food security and income increase can be experienced by small and medium farmers, including the farmers in the Cordillera.

Postharvest losses in rice can be up to 20-30% from harvesting to milling (Gummert, 2020). On top of that, quality loss can reduce the price by 10–20%, hence total financial loss can be a lot higher (IRRI KB). In the Philippines, average postharvest losses of lowland rice had been estimated at 16%, compared with that of Vietnam and Thailand at 14% and 8%, respectively (Table 1). A large percentage of postharvest losses come from drying and milling, the most critical operations in both the Philippines and Vietnam, while relatively minimal losses are experienced in Thailand with milling having the highest percentage. Appropriate postharvest management practices and technologies are further done to improve the grain quality of lowland rice and lessen losses due to postharvest operations.

Table 1. Comparison of postharvest losses in rice.

Operation	Average Losses (%)		
	Philippines	Vietnam	Thailand
Harvesting	2.03	2.50	2.00
Distribution		0.90	0.40
Piling	0.08		
Threshing	2.18		
Drying	5.86	4.20	1.70
Storage	0.52	2.60	1.20
Milling	5.52	3.00	2.30
TOTAL	16.47	13.70	7.60

Sources of data: Philippines – PhilMech 2014;
Vietnam and Thailand – VIAEP 2016; VIAEP & FAO 2014

The challenge now with the HRP is how to keep these postharvest innovations in line with the aim of conserving and preserving the culture of rice farming in the Cordillera region. To get information on the current culture of rice farming in the Cordillera, heirloom rice farmers from four provinces of CAR (Kalinga, Ifugao, Mountain Province, and Benguet) were gathered for a focus group discussion (FGD) for the HRP. They were asked to enumerate the rice varieties they grow and to identify the varieties they sell (Table 2). Most of the varieties they grow are planted within the months of December to July of the following year and June to January of the next year. Most of these varieties mature within six to seven months. Farmers said that their preference on which varieties to sell is based on factors such as the natural color of the grains (e.g. Ominio and Balatinao) and the varieties' aromatic nature (e.g. Ladukan and Chor-chor-os), high price, high demand, and presence of a market. Heirloom rice varieties have their own innate attributes (color and aroma) while the price, demand, and market for heirloom rice can be enhanced more with improved postharvest innovations.

Table 2. Heirloom rice varieties grown and sold by province.

Province	Variety Grown				Variety Sold
	December to July		June to January		
Kalinga	• Alig • Chaykot • Chong-ak	• Linonaw • Ulikan • Waray	• Minukod • Oyak		• Oyak
Ifugao	• Bongkitan • Diket • Dolkitan	• Minaangan • Pingkitan	• Dona-al • Imbuucan • Inggulo • Inngyuho-yuho	• Innawi • Tinawon • Ong-ongon • Ugnah	• Diket • Minaangan
Mountain Province	• Akangan • Balatinao • Chor-chor-os • Dolyasi "red rice" • Gilgilang	• Intan "red" • Ladukan • Ominio • Pinawid • Waray	• Akangan • Awa • Ba-ay • Balatinao • Dolyasi "red rice" • Gilgilang	• Intan "red" • Laminad • Ominio • Pinawid • Saluyao • Waray	• Balatinaw • Cho-rchor-os • Ladukan • Ominio
Benguet	• Balatinaw • Bongkitan • Kabal • Red diket	• Balinsanga • Makanining • Lablabi	• Balatinaw • Bongkitan • Kabal	• Kintoman • Lasbakan	• Balatinaw • Bongkitan • Kabal • Lablabi • Lasbakan

Source: Varieties as mentioned by the participants in the FGD HRP II Value Chain Analysis

The need for postharvest interventions arose from the Participatory Needs and Opportunity Assessment (PNOA) conducted for the HRP. Through the PNOA, the heirloom rice farmers voiced out the need to improve and upgrade their postharvest operations which are time consuming and repetitive such as drying, winnowing, and sorting. Among the postharvest problems identified were the following: lack of postharvest facilities in general, which was identified in Benguet and Kalinga; lack of accessible or no customized rice mills in Kalinga and Mountain Province; lack of drying facilities or limited material for drying in Ifugao and Mountain Province; high cost of hauling or difficulty in hauling in Kalinga, Ifugao, and Mountain Province; and unavailability of thresher and rice mill in Mountain Province (Table 3).

Table 3. Postharvest-related problems from the Participatory Needs and Opportunity Assessment.

Benguet	Kalinga	Ifugao	Mountain Province
• lack of postharvest facilities	• lack of postharvest facilities • lack of accessible customized rice mill • high cost of hauling	• lack of drying facilities • high cost of hauling	• difficulty in threshing and hauling • no thresher and rice mill • limited materials for drying • no customized rice mill

Source: PNOA

To address these problems, prototypes for the postharvest innovations were manufactured and the machines were purchased with funding from the Kellogg Company collaborating with IRRI. The solar bubble dryer addressed constraints in drying the paddy threshed or in bundled form. The compact rice mill was introduced and provided to each provincial cooperative. Other postharvest innovations include carbon dioxide (CO_2) fumigation to address the problem of pest infestation during storage and the use of the length grader and vacuum packing machines to improve the quality of heirloom rice in local markets and, in the future, the global markets.

Field demonstrations and farmers' meetings were conducted to introduce these innovations to the heirloom rice farmers. One-page posters for each of the innovations (Annex 1 to 6) will be displayed in the offices of the project's research partners from the Department of Agriculture Regional Field Office (DA-RFO) - CAR and the local government unit of Mountain Province. The process flow of heirloom rice processing is presented first to give an overview of the innovations and to show in which step the innovations would facilitate the processes within the postharvest system. This is followed by the description and step-by-step procedure on how to use the innovations including the operating requirements, performance, and salient features.

Processing Center in Bontoc, Mountain Province

One of the outcomes of the HRP is the establishment of the heirloom rice processing center in Bontoc, Mountain Province funded by DA-RFO CAR. The model processing center is being operated by the Mountain Province Heirloom Rice Farmers Agricultural Cooperative (MPHRFAC). It houses the machines provided by the HRP through Kellogg which are aimed to improve the quality of heirloom rice by enabling more efficient milling, grading, and storage while minimizing rice weevil infestation.

Members of the Mountain Province Heirloom Rice Farmers' Agriculture Cooperative and staff of the HRP at the heirloom rice processing center in Bontoc

The posters will also be displayed here to increase the knowledge and awareness of farmers. These will also be distributed to three other cooperatives aside from the MPHRFAC.

Assessment and evaluation of the innovations

The HRP teams recognized the need to analyze the economic, social, and environmental impacts of these postharvest innovations. Specifically, economic matters cover the time and energy saved, accessibility and time flexibility to perform the operations, and other incurred savings e.g. transportation costs. Issues on the social and cultural implication of the introduced innovations include those along social acceptability and gender. Environmental impact can comprise the assessment of the beneficial or adverse effect to the environment as a result of using or performing the operations. The last part of this monograph suggests some evaluation methods of analysis to determine the extent of the benefits of the innovations to the heirloom rice farmers, especially that the innovations were introduced to minimize postharvest losses through improved handling of marketable heirloom rice varieties.

The IRRI-HRP team is confident that the teams of DA-Agribusiness and Marketing Assistance Division and the Research Division are the most appropriate bodies to conduct an impact assessment and/or evaluation analysis since they are highly visible in the area. This is also to lessen bias and would eventually increase the dissemination of the information widely to the public.

Process Flow of Heirloom Rice Processing

Figure 1 shows the flow of paddy heirloom rice production through different processes and using various equipment. It displays the relationship between processes and the equipment and the output from a single or combination of processes and equipment. A rectangle represents an equipment while the numbers stand for the processes and the letters are the outputs (see legend below the figure).

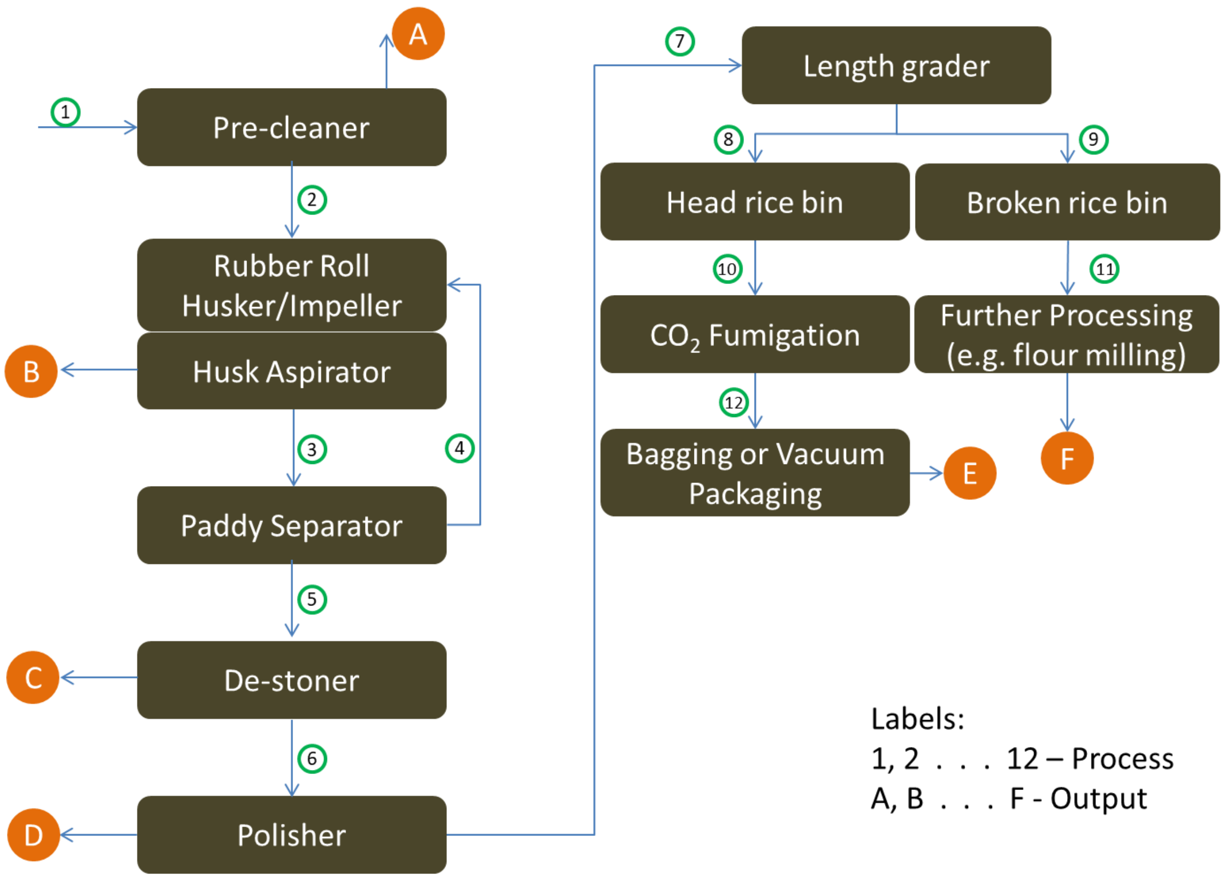


Figure 1. Process flow of heirloom rice production

Processes

- **1** – Paddy is put into pre-cleaner
- **2** – Pre-cleaned paddy moves to the rubber roll husker
- **3** – Mixture of brown rice and unhusked paddy moves to the separator
- **4** – Unhusked paddy is separated and returned to the rubber roll husker
- **5** – Brown rice moves to the de-stoner
- **6** – De-stoned brown rice moves to polisher
- **7** – Polished rice moves to length grader
- **8** – Head rice moves to head rice bin
- **9** – Broken rice moves to broken rice bin
- **10** – Head rice will be CO_2 fumigated for 12 days
- **11** – Broken rice will undergo further processing to make into other products like rice flour
- **12** – CO_2 fumigated rice will be vacuumed pack before it moves to market

Outputs

- **A** – Straw, chaff and empty grains
- **B** – Husk
- **C** – Small stones, mud balls etc.
- **D** – Bran
- **E** – Vacuum packed rice
- **F** – Other products likes rice flour

Postharvest Technologies

A. Solar Bubble Dryer

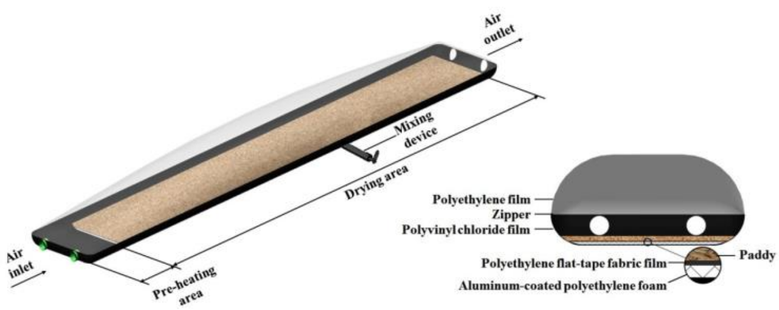
What is a Solar Bubble Dryer?

A Solar Bubble Dryer (SBD) is a mobile and cost-efficient drying technology that aims to provide a simple and flexible alternative to sun drying. Originally designed for threshed paddy, it improves the traditional sun drying process and eliminates all losses due to spillage, animals, and the weather without using power or fuel. The SBD comes in 0.5-ton and 1-ton capacity models.

Inside the SBD, drying happens in an enclosed space where the air is directly heated by solar radiation. In traditional sun drying, on the other hand, the paddy is laid on open mats or on pavements for direct exposure to solar radiation and wind. This also exposes the paddy to unpredictable occurrence of rain and rewetting during night time. In the Cordillera region, heirloom rice is usually dried using traditional sun drying by arranging the panicles like a trellis in front of houses or in the farms.

How does it work?

The SBD uses solar energy from the sun in two ways. First, the drying tunnel serves as a solar collector to convert energy from the sun's rays (entering through the transparent top of the drying tunnel) to heat, therefore increasing the temperature of the air for faster drying. Second, the SBD is equipped with a photovoltaic system that consists of solar panels for generating electricity — a rechargeable deep cycle battery for use at night and one or two small blowers to inflate the drying tunnel and move air through it. The air also removes water evaporating from the grains inside the tunnel. A simple roller with ropes attached to both of its ends is periodically dragged underneath to mix the grains without the need to open the tunnel. A rake for internal mixing is also available.



General guide for the use of the solar bubble dryer:

1. Preparing the area
   - Choose an open area with maximum solar radiation potential and is away from standing or running water.
   - Clear the area of sharp objects (stones, broken glass, nails, etc.) that may puncture the dryer.
   - Don't allow workers to smoke while preparing the dryer since the hot ashes from the cigar could damage the dryer materials.

2. Setting up of the drying tunnel

- Unfold the dryer, taking note of the unfolding pattern. It is highly recommended to follow this unfolding pattern in reverse when preparing the dryer for storage.
- Pull the other end of the dryer until the drying floor is properly stretched at two meters wide along the full length of the dryer.

3. Installing the ventilators and solar components

- For the complete instruction on the installation procedure, please refer to the instructional manual that came with the dryer.

4. Loading of paddy

- Unzip the top cover from the drying floor. Spread evenly the commodity like rice in the drying floor.
- Remember not to place any grain within 2 meters from the location of the ventilator.
- When the grains are already spread evenly on the drying floor, close the dryer by zipping the top cover and the drying floor.

Note: Refer to the instructional manual for the complete instruction procedures, care, and maintenance of all components of the dryer.

What are the benefits of SBD?

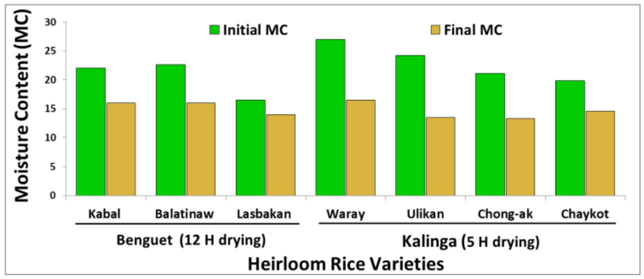
In Southeast Asia, the SBD can be used optimally in a two-hectare rice field with two croppings per year. However, in places where rice cropping is done just once a year, as in the case of Cordillera where farming is usually made in a 0.5-hectare field, farmers can still enjoy the following benefits of using the SBD:

- Paddy is safely dried and protected from unpredictable weather
- Timely drying of paddy and improved milled rice quality
- Better farmgate prices

It is recommended that introducing the SBD to farmers should be simultaneous with linking them to markets with premium price incentives. Since units of the SBD are already in-place in several HRP sites, partners from the DA-RFO CAR can provide assistance in the actual cost-benefit analysis and in the formulation of a contract – through the cooperatives – to act as service provider to the farmers.

How is its performance?

The drying time of paddy in the SBD is comparable to that of sun drying on a sunny day. A 500-kilogram batch of threshed paddies can be dried within a day. On cloudy or rainy days, drying time takes up to three days. Typical average drying rate is 0.5% moisture reduction per hour.



In the Cordillera region, an initial testing showed 0.4-1.8% moisture reduction per hour of freshly harvested paddy in bundled panicles. Variations in drying time are largely affected by the external environment (i.e. rain during drying operation in the case of Benguet varieties), grain size and shape, density of paddy in bundled panicles, and initial moisture content, among others.

What are the feedbacks from HRP farmer-partners?

Farmer-partners from the four HRP-assisted provincial cooperatives based in Mountain Province, Benguet, Kalinga, and Ifugao provinces in the Cordillera region attended the demonstrations and training sessions on the use of the SBD conducted in 2015-2018. They found SBD to be efficient and useful, which led to the purchase of 12 more units of SBD. They were also able to come up with suggestions on how to optimize the use of the SBD in the mountainous areas of the Cordilleras.

Comments from the HRP farmer-partners:

- *Can be transported by two farmers*
- *The existing available sizes in the market are still too big for our available space*
- *Doubtful if the components of the SBD are heavy duty*
- *Uneven drying since heirloom rice is usually dried in bundled panicles*
- *Training is still needed to increase familiarization of how to assemble the SBD*

Pictures taken during the promotion of the SBD in CAR:

https://rafiddacar.wixsite.com/agriinfo-cordillera/single-post/2016/07/28/DA-and-IRRI-Promotes-Solar-Bubble-Dryer-in-CAR

Training and demonstrating the SBD to the heirloom rice farmers with the DA-RFO CAR:

Banaue

Kibungan

Pasil

Barlig

Hungduan

Lubuagan

Bauko

Reference: GrainPro Solar Bubble Dryer 25 Instructional Manual MA4047RAD0315-1

B. Carbon Dioxide (CO_2) Fumigation

What is CO_2 fumigation?

Fumigants are effective against storage pests because, as gases, they can reach even the deepest and farthest hiding places of pests in an area. The range of safe fumigant chemicals that can be used is now restricted to CO_2 and phosphine. For organically labeled products like heirloom rice, CO_2 fumigation is the only accepted chemical method of eliminating storage pests.

Insects need oxygen for respiration. With CO_2 fumigation, much of the oxygen in the storage bin is replaced by CO_2 that suffocates and dehydrates the insects and also produces toxic chemicals in their blood. To be effective, elevated CO_2 levels must be maintained in a storage area until all insects die. The required exposure time depends on the percentage of CO_2 and the temperature of the grains.

Step by step guide for CO_2 fumigation

1. Preparing the area
   - The selected area should be indoor and clear of sharp objects (stones, broken glass, nails, etc.) that may puncture the cocoon.

2. Loading
    - Workers should not wear shoes with spikes that may damage the cocoon during loading. The moisture content of the paddy (threshed or in panicles) should be at most 14%.
    - Fumigation is done on paddy to be stored or on milled rice to be sold. For milled rice, fumigation should be done prior to packaging. Plastic crates can be used for ease of handling and stacking. Piling of the sacks/bundles/crates should start at the bottom section of the cocoon.

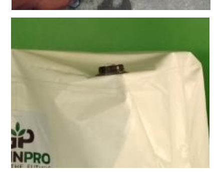

3. Positioning the top section and zipping
    - The top section or the bigger part of the cocoon should be unfolded over the stack; the top and bottom section arrows should be aligned and the tension straps should be outside.
    - The cocoon should be at full capacity so that sagging at the lower portion can be avoided. If there are portions where the cocoon is not fully stretched, gas leak may occur, thereby making the cocoon prone to rodent damage. Refer to the reference manual for the complete instruction on zipping. Zipping is easy but needs practice.



4. Purging CO_2 to the cocoon
    a. The amount of CO_2 to be purged into the cocoon is calculated using the formula (1-bulk density) x Volume x2 x 1.15. Every 2 kg of CO_2 replaces 1 cubic meter of air. For a 1-ton capacity cocoon, the amount of CO_2 to be purged is about 3 kg.

    b. The gas inlet port should be opened using the proper tools. Using snap-on standard high pressure, the CO_2 cylinder should be connected to the inlet port. The outlet at the top of the cocoon should be open so that air can escape once the CO_2 is being purged inside and should be closed after half of the CO_2 is purged.

    c. The amount of gas being flushed should be measured by putting the cylinder on a weighing scale. Once the connection is secure, the valve at the end of the hose near the inlet port should be slightly opened, followed by the cylinder tap to a point where the liquid gas could be heard passing through the hose. During this procedure, some ice may form around the gas inlet port and high pressure hose. If this happens, the PVC liner should not be touched because it becomes brittle, loses flexibility, and may crack. If the pressure hose or the inlet valve gets blocked with ice, it indicates that the CO_2 is being released too quickly. The cylinder tap should then be closed until the ice melts, and then reopened and adjusted to reduce the flow.



    d. Since CO_2 is heavier than air, the air inside the cocoon will be pushed upwards and out of the container through the outlet port. Complete displacement of oxygen is not possible as there is always some mixing at the interface between the air and the CO_2. However, if the final CO_2 concentration reaches 80%, the oxygen concentration in the remaining air amounts to 4%. This mixing of the CO_2 with the remaining air and

absorption of CO_2 by the paddy will take 12–24 hours depending on the temperature. This will also be the time to determine the initial concentration of CO_2.

5. Checking for leaks
   - The connection of the bottom and upper portions of the cocoon should be seamless to avoid gas leaks.

6. Checking for oxygen content of the cocoon
   - The initial CO_2 concentration of the cocoon after purging should be measured after 12–24 hours. The amount of oxygen should be measured with an oxygen meter and should not go above 10% in the period of 12 days.

References:
IRRI.2013.Grain Storage and Pest Management.
http://www.knowledgebank.irri.org/images/docs/training-manual-grain-storage.pdf
GrainPro Gas-Hermetic Fumigation/Self-Verifying Cocoon Instructional Manual MA2021TDB1199-18

Demonstration of the CO_2 fumigation, Benguet

C. Compact Rice Mill

What is a compact rice mill?

A compact rice mill is a two-stage mill which has separate processes for hulling and polishing. The commonly available compact rice mills in the market use rubber rollers but there are a few models that use polyurethane for the huller. Both rubber rollers and polyurethane remove the husk. The brown rice is then polished with a steel friction whitener. Two-stage mills reduce overheating of the grain and allow the operator to set individual settings for each step of the milling process. This feature ensures higher milling and head rice recoveries. The milling recovery of compact rice mills is normally above 60% which is way higher than that of a single-pass mill like the micro mill.

What are the features?

- Dockage sorter – Dockage refers to materials other than paddy and includes chaff, stone, weed seeds, soil, rice straw, stalks, etc.
- Rice husk/hull and bran separator – most commonly available two-stage mills have this feature in just one outlet.

- Adjustable polisher grade – the compact rice mill has settings for semi-polished to polished rice.
- Upgraded durability of wear and tear parts, leading to lower maintenance cost.
- Low temperature polishing, leading to higher head rice recovery.

How is its performance?*

- Milling Capacity 300kg/h
- Milling Recovery 68 %
- Headrice Recovery 77%
- Input Tank Capacity 40 kg
- Energy Consumption 4kW/h

**The values are based from the manufacturer's manual.*

How is a compact rice mill used?

a. Prepare the rice mill and make sure that all moving parts are well guarded and buckets are placed under all outlets.
b. Prepare the paddy to be milled. It should be clean from dockage and moisture content should be at most 14%. After making sure that the bin outlet at the bottom is closed, put the paddy in the bin tank.
c. Set the polishing degree knob **(5)** to the desired degree from 0-14, zero for brown rice and 14 for white rice.
d. Turn on the power switch button **(1)** and the rock screen/vibrator switch button **(2)**.
e. Open the bin lever **(3)** slowly to start the milling process.
f. Pull the polishing lever **(4)** to open the hopper where the brown rice is conveyed.
g. When milling is done, pull the vibrator lever **(6)** to empty the screen from the remaining polished rice.
h. Turn off the vibrator switch **(2)** and then the power switch **(1)**.

For the complete procedure and information on operation and maintenance, refer to the user's manual.

D. Length Grader

What is a length grader?

A length grader is a machine used to separate broken rice (large and small) from the whole kernel or head rice. In a high standard market where the proportion of head rice and broken rice is prescribed, length graders and blending machines are mostly used. The market of heirloom rice usually prescribes almost 100% head rice.

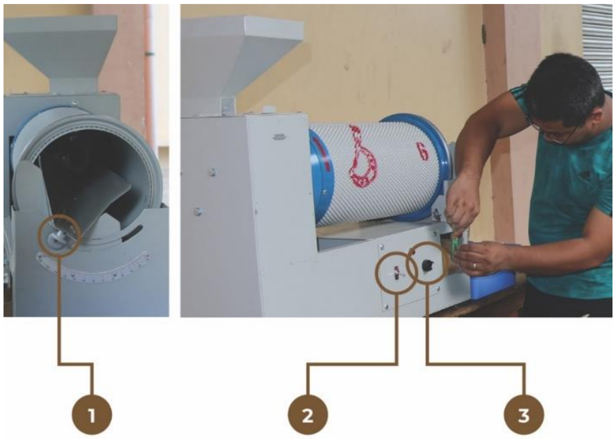
Prototype of redesigned rice length grader with manual option

What are the features?

- Lightweight
- Low power input (0.25 hp)
- 26 rpm cylinder speed
- Easy to adjust sieve angle
- Based on laboratory testing the capacity of the machine is 85 kg/h and its separation efficiency is 87%

How is the length grader used?

a. Prepare the length grader and make sure that all moving parts are well guarded and buckets are readied under all outlets.
b. Put the milled rice in the hopper, making sure that the bottom opening is closed.
c. Set the angle of the chute **(1)** to the appropriate position to get the desired percentage of whole grains. Usually, the size of the rice grain varies depending on the variety. Since the machine has only one size for the indented cylinder, the angle of the chute can be used to have a different percentage of head rice after separation. If a certain variety is to be used for the first time, several trial runs should be done to get the desired angle setting for the chute.
d. Turn on the power switch knob **(2)** then switch the START/ STOP knob **(3)** to Start.
e. Slowly pull the lever at the bottom of the hopper to release the rice to the indented cylinder. The small and large broken rice will fall on the chute while the whole grains will fall at the lower end of the cylinder to be collected later on using a pan or sack.
f. Separation is finished when no more rice is falling at the end of the cylinder.
g. Turn the START/STOP knob to STOP then turn off the power switch button.



Demo of the length grader

E. Vacuum Packing Machine

What is vacuum packaging?

Vacuum packaging is a process of packing where air is removed before sealing. For rice products, it reduces oxidation in unpolished rice which is how most heirloom rice varieties are sold. Vacuum packaging does not guarantee zero insect infestation that is why it is recommended to include an oxygen absorber inside the vacuumed plastic to lower the oxygen level to the amount that will prevent infestation.

What are the features?

- Cuboidal packaging
- Options for 0.5 kg and 1 kg cuboidal packaging containers
- Maximum of 12 kg commodity can be vacuum-packed in a single run

How is a vacuum packaging machine used?

a. Prepare the vacuum packaging machine. If the machine is to be used for the first time, make sure to read the instructional manual provided by the manufacturer.
b. Power off the machine while preparing the rice to be packed to save energy.
c. Weigh the rice before putting it inside the plastic, then place the plastic inside the molding container, making sure to press down the rice to avoid spaces.



d. Arrange the molding containers in the vacuum packaging machine.


e. Power on the machine and set the vacuum sealing and cooling time. This is usually set only once depending on the recommended value for the plastic to be used. The parameters may vary depending on the thickness and quality of the plastic.
f. Once all parameters are set, press down the top cover of the machine and lock it. In some machines, the vacuum chamber will automatically open when sealing is finished.
g. Remove the vacuum-packed plastic from the molding container.


Source for additional information

For additional information on the process flow and the five innovations visit the *Rice Knowledge Bank online at rkb.org* or contact the MPH (Mechanization and Postharvest Cluster) at postharvest@irri.org

Some suggestions on the impact assessment/evaluation of the innovations

To reiterate, these innovations were all demonstrated and tested in a specific province if not in all the four provinces of the HRP sites in CAR. A PNOA was conducted by a partner organization and one of the needs identified by the heirloom rice farmers was the improvement of their postharvest activities and facilities. IRRI's Mechanization and Postharvest Cluster spearheaded the technical work on these postharvest innovations and the funding for the purchase of equipment/machines was provided by the Kellogg Company.

Features of the innovations

Postharvest activities with introduced innovations include drying, storing, milling, sorting, and marketing (Table 4). Table 4 shows the salient features/attributes of the innovation which also represent the derived benefit or advantage of using the innovation. The quantitative aspects of the innovations can be used as a basis or threshold to contrast with the traditional practices. In order to do this, there is a need for baseline information on the use of traditional practices for these activities. For example, in drying a bundled paddy, the number of days and number of hours per day of sun drying in a concrete pavement or in a trellis, the specific amount of the paddy, and the number of persons doing sun drying need to be determined in order to compare it with SBD wherein a 500-kg paddy can be dried at most for 1 sunny day or up to 3 rainy days. Likewise, in seed storage, the percentage of viable and good seeds to be planted for the next season when seeds are traditionally kept in a jar versus the proper levels of CO_2 applied in storing the seeds need to be determined. The drudgery of hand pounding and manual sorting can be addressed with the introduced compact rice mill and length grader. These are just basic comparisons but the more important concern is the adaptation of the implied changes in the farmers' traditional practices.

Table 4. Postharvest activities and innovations with corresponding features and quantitative aspects.

Postharvest Activity	Innovation	Feature/Attribute	Quantitative Aspect
Drying	A. Solar Bubble Dryer	Sun drying of threshed/bundled paddy in an enclosed space with minimum of 0.5 ton or approximately 500 kg	Drying of 500-kilogram batch of threshed paddy is 1 day on a sunny day and up to 3 days on cloudy or rainy days
Storing	B. Carbon Dioxide (CO_2) Fumigation	Keeps away storage-pest infestation, thus making the rice seeds more viable for planting for the next season	All insects in the stored grains will die with proper levels of CO_2 applied
Milling	C. Compact Rice Mill	Two-stage mills that reduce overheating of the grain and ensure higher milling and head rice recoveries	Milling recovery is normally above 60%, higher than a single-pass mill like the micro mill
Sorting	D. Length Grader	Quicker in separating head rice from broken grains	Market for heirloom rice usually prescribes 90-100% head rice.PNS/BAFS 290:2019 prescribes 95% head rice for a premium grade rice
Marketing	E. Vacuum Packing Machine	Better product presentation for the market and preserves better quality of unpolished heirloom rice grains	Vacuum cuboid shape of the product and the machine can vacuum pack 12 kilos in one run.

These postharvest innovations have been demonstrated to the members of the cooperatives and were left to their care. Technically, they are capable of operating the machines but there should still be management protocols such as the choice of where the innovations should be kept, the person assigned as operator, and the person assigned for troubleshooting or repairing the machines. The members need to be aware of whether the innovation has been purchased or given and of the identity of the person/s involved in making the machine available to the farmers/cooperative. They must also feel ownership of the innovation to maximize its use and so in the future they can be key informants for feedback on the use of the innovation.

Impact assessment/evaluation studies

Most research studies that introduced interventions – based on needs assessment analysis – in rural areas are evaluated in terms of technical performance, economic viability, and social/gender acceptability (Paris et. al., 2011; Paris and Chi, 2005; Paris et. al., 2003; Diaz et. al., 1999). Field level testing/demonstration and the development of the prototype of these machines were conducted. To evaluate the interventions, information/data were collected using formal and informal interviews, FGD with the target group of farmers/users, and key informant interviews with individuals directly or indirectly affected in the introduction of the intervention. To cite, the micro rice mill was found to be socially acceptable in the area since it saves time for the women to travel to a mill; is economically viable since the cost of milling was jointly decided on by the users and the person maintaining the machine; and has a satisfactory technical performance.

A free web-base is provided by Bauer and Brown (2014) on the quantitative assessment of appropriate technologies. This can be used with the HRP innovations as well.

An evaluation of the interventions in the HRP sites helps to determine their appropriateness in addressing the needs of the people for specific postharvest activities, to serve as basis to scale out the interventions to other villages in and outside the region where similar rice varieties are grown, and to draw policies in agriculture on improving the lives of indigenous peoples. At the same time, it represents the reason for the existence of the provincial cooperative which can be strengthened more if there are proper management protocols for the interventions.

These interventions are in place in the HRP sites, hence an *ex post* evaluation is very suitable to assess whether the specific innovation/intervention justifies the need and whether it works (or is working) as expected in achieving its purpose (Haber, 2009). To differentiate it with the final project evaluations which is completed at the time of a project's conclusion to assess whether or not it has achieved its intended goals, an *ex post* evaluation is conducted in the years after a project's official end date – maybe one, three, or five years after. The *ex ante* analysis looks at future events based on possible predictions, while *ex post,* Latin for *after the event,* looks at results and events after they have occurred. There is no hard and fast rule on exactly when an *ex post* evaluation should be done but as the aim of an *ex post* evaluation is to assess the sustainability of results and impacts, usually some time will need to have passed to make this assessment (source: https://www.itad.com/article/lessons-from-an-ex-post-evaluation-and-why-we-should-do-more-of-them/).

Sample instruments

An example of an instrument used to assess impact or conduct evaluation of an innovation is attached as Annex 7. This was used in the context of the research objectives and targets of a research study on gender norms and innovation, hence these are simply to give ideas of methods that can be used to conduct impact assessment and evaluation of the innovations. In the study which explored the in-depth gender differences in the trajectory of individual experiences with a new agricultural or natural resource management practice or organization, informants (male and female) were selected based on their success story in adopting the innovation or how well they are known in the village to readily adopt an innovation.

The interventions were given to the assisted cooperatives, hence, an FGD among the members can be conducted to immediately know the consensus of the members on the impact of the innovation. Annex 8 gives 10-point criteria that can be used to evaluate an innovation.

References

Barsan, C. 2016. Potato Proteomics. Postharvest Systems collection from Science Direct. https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/postharvest-systems#:~:text=4.4%20Postharvest%20Proteomics,involved%20(Spurgeon%2C%201976).

Bauer, M.A. and A. Brown. 2014. Quantitative Assessment of Appropriate Technology. Procedia Engineering, Vol 78, pp 345-358. Access in the web https://www.sciencedirect.com/science/article/pii/S1877705814010637#:~:text=The%20most%20prevalent%20indicators%20were,Technology%20Assessment%20Tool%20(ATAT).

Diaz, C.P., M. Hossain and T.T. Paris. 1999. Appropriate Technology for Improving Women's Welfare: A Case Study of Farmer Participatory Evaluation of a Micro Rice Mill in Central Luzon, Philippines. **Philippine Sociological Review**, Vol 47, pp 68-80. https://www.jstor.org/stable/23898185?seq=1

Gummert, M., V.H. Nguyen, C. Cabardo, R. Quilloy, Yan Lin Aung, Myo Aung Thant, Myo Aung Kyaw, R. Labios, Nyo Me Htwe and R.S. Singleton. 2020. Assessment of post-harvest losses and carbon footprint in intensive lowland rice production in Myanmar. **Scientific Report (Nature Research),** Vol 10, 19797. https://doi.org/10.1038/s41598-020-76639-5

GrainPro Gas-Hermetic Fumigation/Self-Verifying Cocoon Instructional Manual MA2021TDB1199-18

GrainPro Solar Bubble Dryer 25 Instructional Manual MA4047RAD0315-1

Haber, A. 2009. Process of ex-post evaluation – conceptualization, operationalization, implementation of evaluation survey. https://docplayer.net/17723982-Process-of-ex-post-evaluation-conceptualisation-operationalisation-implementation-of-evaluation-survey.html; https://www.coursehero.com/file/34687598/text-2009-7604txt/

IRRI. https://www.irri.org/mechanization-and-postharvest

IRRI.2013.Grain Storage and Pest Management. http://www.knowledgebank.irri.org/images/docs/training-manual-grain-storage.pdf

JICA. 2018. FY2018 Ex-Post Evaluation of Technical Cooperation Project "Laos Pilot Program for Narrowing the Development Gap towards ASEAN Integration (LPP):. https://www2.jica.go.jp/en/evaluation/pdf/2018_1002293_4.pdf

Mejía, D. J. 2004. An overview of rice post-harvest technology: use of small metallic silos for minimizing losses. http://www.fao.org/3/y4751e0o.htm

Paris, T.R., C.P. Diaz and I. Hossain. 2011. Participatory Evaluation of a Rice Flour Mill by Poor Rural Women: Lessons from Bangladesh. **Gender Technology and Development**, Vol. 15, Issue 2. https://www.tandfonline.com/doi/abs/10.1177/097185241101500205

Paris, T.R. and T.T.N. Chi. 2005. The Impact of Row Seeder Technology on Women Labor: A Case Study in the Mekong Delta, Vietnam. **Gender, Technology and Development**, https://journals.sagepub.com/doi/abs/10.1177/097185240500900201

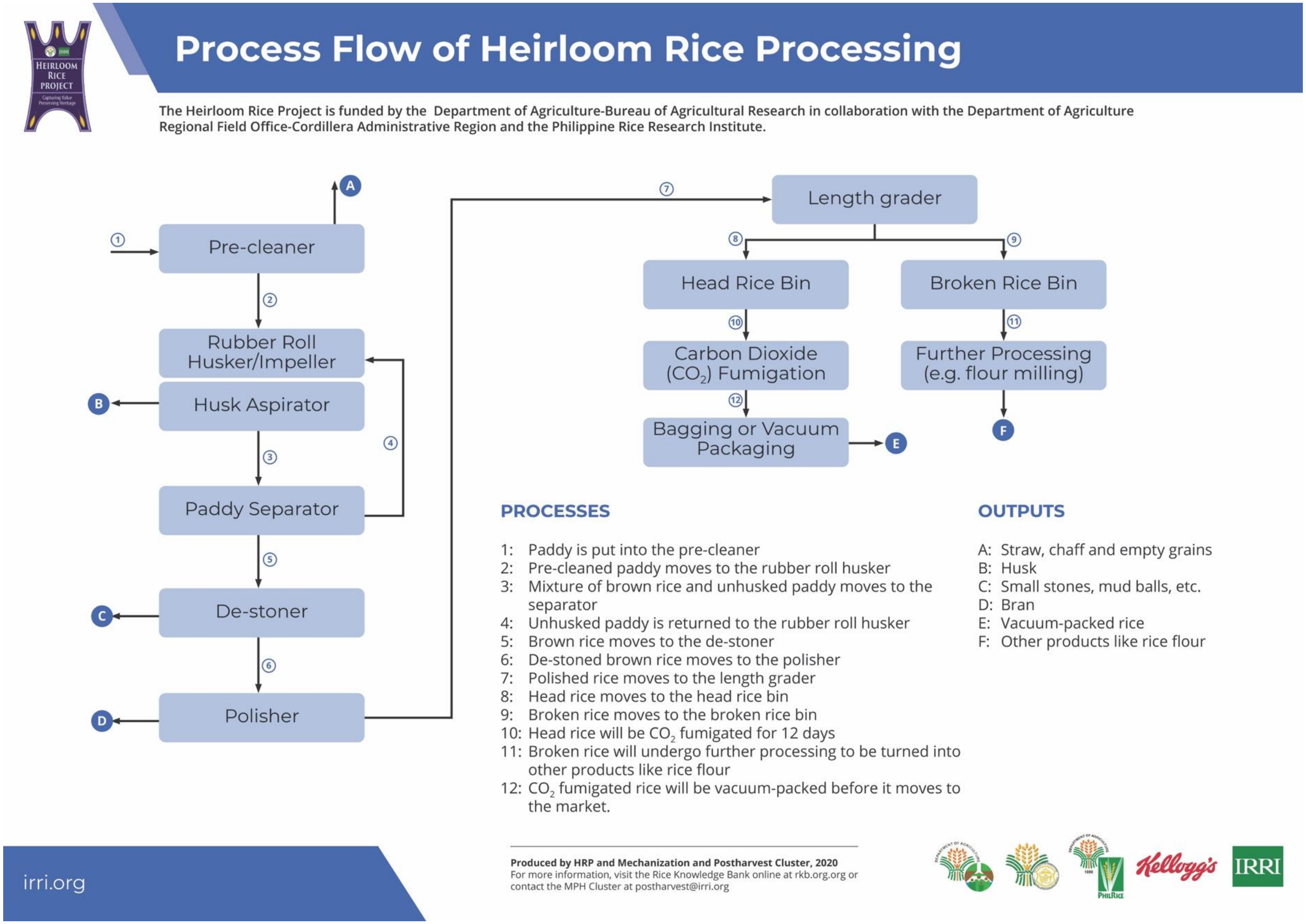
Paris, T.R., C.P. Diaz, E. Bautista and R. Orge. 2003. Adding value in rice production: a case study of women's participatory evaluation of a rice flour mill in Central Luzon, Philippines, **Philippine Journal of Crop Science**, Vol 28.

Philippine National Standard /Bureau of Agriculture and Fisheries Standards (PNS/BAFS) 290:2019. Grains-Grading and classification-Paddy and milled rice.

http://bafs.da.gov.ph/phocadownload/FinalPNS/PNS%20BAFS%20290%202019%20Grains-Paddy%20and%20Milled%20Rice-%20Grading%20and%20Specifications.pdf

Sajise, Edelweiss E., Teresita H. Borromeo, Nestor C. Altoveros and Sancho G. Bon. 2012. Traditional Rice in Central Cordillera, Philippines: Dynamics of On-Farm Management of Varietal Diversity Journal of Developments in Sustainable Agriculture 7: 75-88 (2012) July 23 2020 https://www.jstage.jst.go.jp/article/jdsa/7/1/7_1_75/_pdf

Annex 1. Heirloom Rice Project poster on postharvest intervention: process flow of heirloom rice processing



Annex 2. Heirloom Rice Project poster on postharvest intervention: solar bubble dryer

Solar Bubble Dryer: A Mobile and Economical Postharvest Drying Technology for Heirloom Rice

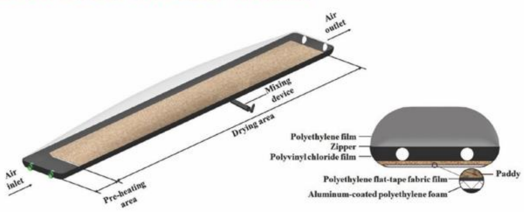
The Heirloom Rice Project is funded by the Department of Agriculture-Bureau of Agricultural Research in collaboration with the Department of Agriculture Regional Field Office-Cordillera Administrative Region and the Philippine Rice Research Institute.

WHAT IS A SOLAR BUBBLE DRYER?

A Solar Bubble Dryer (SBD) is a mobile and cost-efficient drying technology that aims to provide a simple and flexible alternative to sun drying. Originally designed for threshed paddies, it improves the traditional sun drying process and eliminates all losses due to spillage, animals, and the weather without using power or fuel.

The SBD has 0.5-ton and 1-ton capacity models. Using SBD, drying happens in an enclosed space where the air is directly heated by solar radiation. In traditional sun drying, on the other hand, the paddy is laid on open mats or on pavements for direct exposure to solar radiation and wind. It also exposes the paddy to unpredictable occurrence of rain and rewetting during night time. In the Cordillera region, heirloom rice is usually dried using traditional sun drying by arranging the panicles like a trellis in front of houses or farms.

HOW DOES THE SBD WORK?



WHAT ARE THE BENEFITS OF SBD?

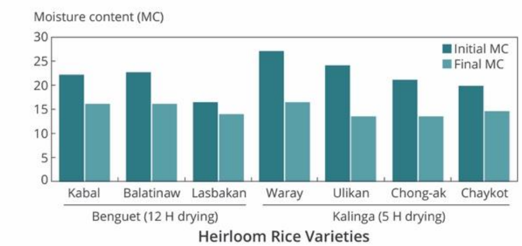
In Southeast Asia, SBD can be used optimally in a two-hectare rice field with two croppings per year. Farmers in the Cordilleras, where rice cropping is done just once a year in a 0.5-hectare field, can still enjoy the following benefits of SBD:

- Paddy is safely dried and protected from unpredictable weather
- Timely drying of paddies and improved milled quality
- Better farmgate prices

It is recommended that introducing SBD to farmers should be simultaneous with linking them to markets with premium price incentives. Since units of SBD are in-place in several HRP sites, partners from the DA-RFO-CAR can provide assistance in the actual cost-benefit analysis and in the formulation of a contract – through the cooperatives – to act as service provider to the farmers.

HOW IS ITS PERFORMANCE?

The drying time of paddies in an SBD is comparable to that of sun drying on a sunny day. A 500-kilogram batch of threshed paddies can be dried within a day. On cloudy or rainy days, drying time takes up to 3 days. Typical average drying rate is 0.5% moisture reduction per hour.



In the Cordillera region, an initial testing showed 0.4-1.8% moisture reduction per hour of freshly harvested paddy in bundled panicles. Variations in drying time are largely affected by the external environment (i.e. rain during drying operation in the case of Benguet varieties), grain size and shape, density of paddies in bundled panicles, and initial moisture content, among others.

WHAT ARE THE FEEDBACKS FROM HRP FARMER-PARTNERS?

Farmer-partners from the four HRP-assisted provincial cooperatives based in Mountain Province, Benguet, Kalinga, and Ifugao provinces in the Cordillera region attended the demonstrations and training sessions on the use of the SBD conducted in 2015-2018. They found SBD to be efficient and useful, which led to the purchase of 12 more units of SBD. They were also able to come up with suggestions for innovations to optimize the use of the SBD in the mountainous areas of the Cordilleras

Produced by HRP and Mechanization and Postharvest Cluster, 2020
For more information, visit the Rice Knowledge Bank online at rkb.org.org or contact the MPH Cluster at postharvest@irri.org

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Annex 3. Heirloom Rice Project poster on postharvest intervention: carbon dioxide fumigation

Carbon Dioxide (CO_2) Fumigation for Heirloom Rice

The Heirloom Rice Project is funded by the Department of Agriculture-Bureau of Agricultural Research in collaboration with the Department of Agriculture Regional Field Office-Cordillera Administrative Region and the Philippine Rice Research Institute.

WHAT IS CO_2 FUMIGATION?

Fumigants are effective against storage pests because, as gases, they can reach even the deepest and farthest hiding places of pests in an area. The range of safe fumigant chemicals that can be used is now restricted to CO_2 and phosphine. For organically labeled products like heirloom rice, CO_2 fumigation is the only accepted method of eliminating storage pests.

Insects need oxygen for respiration. With CO_2 fumigation, much of the oxygen in the storage bin is replaced by CO_2 that suffocates and dehydrates the insects and also produces toxic chemicals in their blood. To be effective, elevated CO_2 levels must be maintained in a storage area until all insects die. The required exposure time depends on the percentage of CO_2 and the temperature of the grains.

STEP BY STEP GUIDE FOR CO_2 FUMIGATION

1. Preparing the area

The selected area should be indoor and clear of sharp objects (stones, broken glass, nails, etc) that may puncture the cocoon.

2. Loading

Workers should not wear shoes with spikes that may damage the cocoon during loading. The moisture content of the paddy (threshed or in panicles) should be at most 14%.

Fumigation is done on paddy to be stored or on milled rice to be sold. For milled rice, fumigation should be done prior to packaging. Plastic crates can be used for ease of handling and stacking. Piling of the sacks / bundles / crates should start at the bottom section of the cocoon.

3. Positioning the top section and zipping

The top section or the bigger part of the cocoon should be unfolded over the stack; the top and bottom section arrows should be aligned and tension straps should be outside.

The cocoon should be at full capacity so that sagging at the lower portion can be avoided. If there are portions where the cocoon is not fully stretched, gas leak may occur, thereby making the cocoon prone to rodent damage. Refer to the reference manual for the complete instruction on zipping. Zipping is easy but needs practice.

Produced by HRP and Mechanization and Postharvest Cluster, 2020
For more information, visit the Rice Knowledge Bank online at rkb.org.org or contact the MPH Cluster at postharvest@irri.org

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Carbon Dioxide (CO_2) Fumigation for Heirloom Rice

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STEP BY STEP GUIDE FOR CO2 FUMIGATION

4. Purging CO_2 into the cocoon

a. The amount of CO_2 to be purged into the cocoon is calculated using the formula (1-bulk density) x Volume x2 x 1.15. Every 2 kg of CO_2 replaces 1 cubic meter of air. For a 1-ton capacity cocoon, the amount of CO_2 to be purged is about 3 kg.

b. The gas inlet port should be opened using proper tools. Using snap-on standard high pressure, the CO_2 cylinder should be connected to the inlet port. The outlet at the top of the cocoon should be open so that air can escape once the CO_2 is being purged inside and should be closed after half of the CO_2 is purged.

c. The amount of gas being flushed should be measured by putting the cylinder on a weighing scale. Once the connection is secure, the valve at the end of the hose near the inlet port should be slightly opened, followed by the cylinder tap to a point where the liquid gas could be heard passing through the hose. During this procedure, some ice may form around the gas inlet port and high pressure hose. If this happens, the PVC liner should not be touched because it becomes brittle, loses flexibility, and may crack. If the pressure hose or the inlet valve gets blocked with ice, it indicates that the CO_2 is being released too quickly. The cylinder tap should then be closed until the ice melts, and then re-opened and adjusted to reduce the flow.

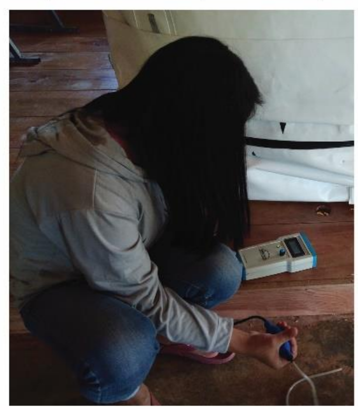
d. Since CO_2 is heavier than air, the air inside the cocoon will be pushed upwards and out of the container through the outlet port. Complete displacement of oxygen is not possible as there is always some mixing at the interface between the air and the CO_2. However, if the final CO_2 concentration reaches 80%, the oxygen concentration in the remaining air amounts to 4%. This mixing of the CO_2 with the remaining air and absorption of CO_2 by the paddy will take 12-24 hours depending on the temperature. This will also be the time to determine the initial concentration of CO_2.

5. Checking for leaks

The connection of the bottom and upper portions of the cocoon should be seamless to avoid gas leaks.

6. Checking for oxygen content of the cocoon

The initial CO_2 concentration of the cocoon after purging should be measured after 12-24 hours. The amount of oxygen should be measured with an oxygen meter and should not go above 10% in the period of 12 days.



REFERENCES:

IRRI.2013.Grain Storage and Pest Management. http://www.knowledgebank.irri.org/images/docs/training-manual-grain-storage.pdf
GrainPro Gas-Hermetic Fumigation/Self-Verifying Cocoon Instructional Manual MA2021TDB1199-18

Produced by HRP and Mechanization and Postharvest Cluster, 2020
For more information, visit the Rice Knowledge Bank online at rkb.org.org or contact the MPH Cluster at postharvest@irri.org

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Annex 4. Heirloom Rice Project poster on postharvest intervention: compact rice mill

Compact Rice Mill for Heirloom Rice

The Heirloom Rice Project is funded by the Department of Agriculture-Bureau of Agricultural Research in collaboration with the Department of Agriculture Regional Field Office-Cordillera Administrative Region and the Philippine Rice Research Institute.

WHAT IS A COMPACT RICE MILL?

A compact rice mill is a two-stage mill which has separate processes for hulling and polishing. The commonly available compact rice mills in the market use rubber rollers but there are a few models that use polyurethane for the huller. Both rubber rollers and polyurethane remove the husk. The brown rice is then polished with a steel friction whitener. Two-stage mills reduce overheating of the grain and allows the operator to set individual settings for each step of milling. This feature ensures higher milling and head rice recoveries. The milling recovery of compact rice mills is normally above 60% which is way higher than that of a single-pass mill like the micro mill.

WHAT ARE THE FEATURES?

- Dockage sorter – Dockage refers to materials other than paddy and includes chaff, stone, weed seeds, soil, rice straw, stalks, etc.
- Rice husk/hull and bran separator – most commonly available two-stage mills have this feature in just one outlet.
- Adjustable polisher grade – the compact rice mill has settings for semi-polished to polished rice.
- Upgraded durability of wear and tear parts, leading to lower maintenance cost.
- Low temperature polishing, leading to higher head rice recovery.

HOW IS ITS PERFORMANCE?*

Milling Capacity: 300 kg/h
Milling Recovery: 68%
Head Rice Recovery: 77%
Input Tank Capacity: 40 kg
Energy Consumption: 4 kW/h

**Values are based from the manufacturer's manual*

HOW IS A COMPACT RICE MILL USED?

1. Prepare the rice mill and make sure that all moving parts are well guarded and buckets are placed under all outlets.
2. Prepare the paddy to be milled. It should be clean from dockage and moisture content is at most 14%. After making sure that the bin outlet at the bottom is closed, put the paddy in the bin tank.
3. Set the polishing degree knob (5) to the desired degree from 0-14, zero for brown rice and 14 for white rice.
4. Turn on the power switch button (1) and the rock screen/vibrator switch button (2).
5. Open the bin lever (3) slowly to start the milling process.
6. Pull the polishing lever (4) to open the hopper where the brown rice is conveyed.
7. When milling is done, pull the vibrator lever (6) to empty the screen from the remaining polished rice.
8. Turn off the vibrator switch (2) and then the power switch (1).

For the complete procedure and information on operation and maintenance, refer to the user's manual.

Produced by HRP and Mechanization and Postharvest Cluster, 2020
For more information, visit the Rice Knowledge Bank online at rkb.org.org or contact the MPH Cluster at postharvest@irri.org

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Annex 5. Heirloom Rice Project poster on postharvest intervention: length grader

Length Grader for Heirloom Rice

The Heirloom Rice Project is funded by the Department of Agriculture-Bureau of Agricultural Research in collaboration with the Department of Agriculture Regional Field Office-Cordillera Administrative Region and the Philippine Rice Research Institute.

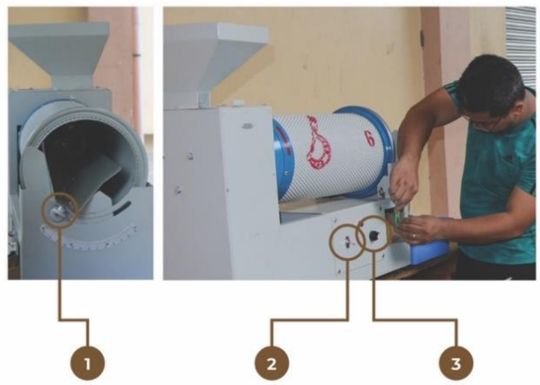
WHAT IS A LENGTH GRADER?

A length grader is a machine used to separate broken rice (large and small) from the whole kernel or head rice. In a high standard market where the proportion of head rice and broken rice is prescribed, length graders and blending machines are mostly used. The market of heirloom rice usually prescribes almost 100% head rice.

Prototype of redesigned rice length grader with manual option.

WHAT ARE THE FEATURES?

- Lightweight
- Low power input (0.25 hp)
- 26 rpm cylinder speed
- Easy to adjust sieve angle
- Based on laboratory testing, the capacity of the machine is 85 kg/h and its separation efficiency is 87%



HOW IS A LENGTH GRADER USED?

1. Prepare the length grader and make sure that all moving parts are well guarded and buckets are readied under all outlets.
2. Put the milled rice in the hopper, making sure that the bottom opening is closed.
3. Set the angle of the chute (1) to the appropriate position to get the desired percentage of whole grains. Usually, the size of the rice grain varies depending on the variety. Since the machine has only one size for the indented cylinder, the angle of the chute can be used to have a different percentage of head rice after separation. If a certain variety is to be used for the first time, several trial runs should be done to get the desired angle setting for the chute.
4. Turn on the power switch knob (2) then switch the START/STOP knob (3) to Start.
5. Slowly pull the lever at the bottom of the hopper to release the rice to the indented cylinder. The small and large broken rice will fall on the chute while the whole grains will fall at the lower end of the cylinder to be collected later on using a pan or sack.
6. Separation is finished when no more rice is falling at the end of the cylinder.
7. Turn the START/STOP knob to STOP then turn off the power switch button.

Produced by HRP and Mechanization and Postharvest Cluster, 2020
For more information, visit the Rice Knowledge Bank online at rkb.org.org or contact the MPH Cluster at postharvest@irri.org

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Annex 6. Heirloom Rice Project poster on postharvest intervention: vacuum packaging machine

Vaccum Packaging Machine for Heirloom Rice

The Heirloom Rice Project is funded by the Department of Agriculture-Bureau of Agricultural Research in collaboration with the Department of Agriculture Regional Field Office-Cordillera Administrative Region and the Philippine Rice Research Institute.

WHAT IS VACUUM PACKAGING?

Vacuum packaging is a process of packing where air is removed before sealing. For rice products, it reduces oxidation in unpolished rice which is how most heirloom rice varieties are sold. Vacuum packaging does not guarantee zero insect infestation that is why it is recommended to include an oxygen absorber inside the vacuumed plastic to lower the oxygen level to the amount that will prevent infestation.

WHAT ARE THE FEATURES?

- Cuboidal packaging
- Options for 0.5 kg and 1 kg cuboidal packaging containers
- Maximum of 12 kg commodity can be vacuum-packed in a single run.

HOW IS A VACUUM PACKAGING MACHINE USED?

1. Prepare the vacuum packaging machine. If the machine is to be used for the first time, make sure to read the instructional manual provided by the manufacturer.
2. Power off the machine while preparing the rice to be packed to save energy.
3. Weigh the rice before putting it inside the plastic, then place the plastic inside the molding container, making sure to press down the rice to avoid void spaces.
4. Arrange the molding containers in the vacuum packaging machine.
5. Power on the machine and set the vacuum sealing and cooling time. This is usually set only once depending on the recommended value for the plastic to be used. The parameters may vary depending on the thickness and quality of the plastic.
6. Once all parameters are set, press down the top cover of the machine and lock it. In some machines, the vacuum chamber will automatically open when sealing is finished.
7. Remove the vacuum-packed plastic from the molding container.

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Annex 7. Semi-Structured Individual Interview: Innovation Pathways (GENNOVATE)

1. Place of study.
2. Socio-demographic information
3. Now I would like to turn to [the innovation]. Can you please tell me a little bit about it? What is new about it?
4. How has [the innovation] changed the way you do things? [Pause.] What were you doing before you got involved with [the innovation]?
5. Are you the type of person who likes to try out new things? Why? Or Why not?
6. Besides [the **innovation], what other new kinds of [agricultural practices or technologies / NRM practices] have you** tried out?
LEARNING PHASE
7. Okay, now let's back up to the very beginning – the time when you first heard about [the innovation] and before you decided to try it out. How did you first learn about [the innovation]?
8. When was this?
9. Did someone encourage you to try out [the innovation]? Who was that?
10. Do you recall the factors you considered when you were deciding to give [the innovation] a try?
11. What different places could you turn to in order to get more information about [the innovation] or possibly some material support? Did you take advantage of these? What were these places?
12. What does someone need to know or learn about in order to get started with [the innovation]?
13. How skilled do you need to be try out [the innovation]?
14. What else do you need to try it out?
15. Did you talk about trying out [the innovation] with anyone in your family? [If so] How did they respond? What was their role in the decision to try it?
16. Did you mention [the innovation] to anyone else besides your family? [If so,] who? What were their reactions? What was their role in your decision to try it?
TESTING/ADAPTATION PHASE
17. Now, let's jump ahead to that moment when you began trying out [the innovation]. When was this? Was there a long period between knowing about [the innovation] and trying it out? [If so,] Why? What was the delay?
18. Did you take out a loan or borrow cash for [the innovation]? [If so], Please tell me about this?
19. How did other family members react when you first tried out [the innovation]? Did they encourage or discourage you
20. What about other people in your life, how did they react? [Pause for response.] Did they make suggestions about changes in the innovation? [If so,] Please tell me about these.
21. Tell me about your early experiences with [the innovation]. What went well?
22. And what didn't go as well with [the innovation] as you had hoped? What were the biggest defects that you identified?
23. Did you try out different things to make [the innovation] work better? [If so,] Tell me about this?
24. Did they make improvements? What were they?
25. Did you communicate these changes back to the source of information about [the innovation]?
26. In the early days of trying out [the innovation], do you recall what you were telling people about trying out [the innovation]? [Pause] [If so,] What was their response?
27. What important changes have resulted from [the innovation] for you?
28. Of the changes you just mentioned *[it may be helpful to repeat them back to the respondent*], which ones have been the most significant for you? Why?
29. Did members of your family, or neighbors or other people in your village also try out [the innovation]? Who?
30. Did they do that as a result of your testing of it, or for other reasons?
31. If others tried it out, why did some continue with [the innovation] and why did others drop it?
32. What are the important changes from [the innovation] for your village?
33. Have any problems emerged with use of [the innovation]?
34. Did these problems increase or decrease as you became more familiar with [the innovation]? Why?
35. Has anything that you have learned from your involvement with [the innovation] been useful to you in other ways besides with [the innovation]?
36. Has [the innovation] affected any of your other activities – either at work or in your household? [If so], How?
37. What about the most important relationships in your life? Do you think these have been affected in some way by your experiences with [the innovation]?
38. What about important decisions in your household? Have any of these been affected by your involvement in [the innovation]?
39. Do you think the respect which you receive within your family has increased or decreased because of the innovation? [If so], what led to this?
40. Now I'd like to move outside your home. Have your relationships with your friends or neighbors been affected at all by your involvement with [the innovation]?
41. Has your participation in any groups inside or outside the village been affected by your involvement with [the innovation]?
42. Are there other ways perhaps that [the innovation] has affected your life that we have not yet discussed?
43. Now, looking back on all that we have talked about, what do you think helped you the most to be successful with [the innovation]?
44. Is there anything that you would have liked to have done differently with [the innovation]?
45. What do you think would make it easier for you to try out other new practices or organizations that are involved in similar [innovations]?

Annex 8. Ten (10) Criteria to evaluate when choosing a new technology

Question 1: To what extent will this technology meet our needs today?

1.	Features:	Does the technology provide out-of-the-box features that meet your requirements? If not, can the gaps be filled through configuration?
2.	User-friendliness:	How intuitive and easy-to-understand is the technology's user-interface and user-experience?
3.	Security:	Can you trust that your data are safe on the technology?

Question 2: To what extent will the technology meet our future needs?

4.	Flexibility:	How easily can the solution evolve as your organization and your requirements evolve? Try to picture 5 years from now – is the technology propelling new ideas and ways of working or is it struggling to keep up as the organization changes and matures?
5.	Interoperability:	How well does the technology 'speak' to other technologies your organization uses? How easily can data flow from this tool to other tools or vice-versa? How nicely does it play with other tools staff use and will continue to day-to-day (e.g. for email, documents, analytics, etc)?
6.	Innovation:	How much investment and effort is going into improving the technology and its adoption? How many releases does the technology have per year and how helpful are the new releases?
7.	Ecosystem:	How strong and connected is the community of users and partners around the technology? How widely available is information that will help you troubleshoot or improve your implementation of the technology?

Question 3: To what extent does the technology work within your budget?

8.	Setup Costs:	How much will it cost us–directly and indirectly–to design, configure, and rollout this tool?
9.	License Costs:	What do we need to pay each year to license this technology?
10.	Maintenance Costs:	What will it take and what will it cost to support this technology?

Source: VeraSolution. 10 Criteria to Evaluate When Choosing a New Technology.
https://www.verasolutions.org/10-criteria-to-evaluate-when-choosing-a-new-technology/