Potential Greenhouse Gas Reduction from Using Rice Hull-fed Biomass Fuelled Flatbed Dryers

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Abbreviations

BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
DENR	Department of Environment and Natural Resources
DO	Department Order
DOE	Department of Energy
DPWH	Department of Public Works and Highways
FAO	Food and Agriculture Organisation of the United Nations
ForClim	Forest and Climate Protection Project Panay
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
IKI	International Climate Initiative
IRRI	International Rice Research Institute
NFA	National Food Authority
PIDS	Philippine Institute of Development Studies
PhilRice	Philippine Rice Research Institute
PHP	Philippine Pesos
PO	People's Organisation

Introduction

The Forest and Climate Protection Panay II Project (ForClim) supported the use of biomass to replace fossil fuel and reduce carbon emissions. The ForClim Project was funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) through its International Climate Initiative (IKI) and jointly implemented conducted by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH and the Department of Environment and Natural Resources (DENR) Philippines.

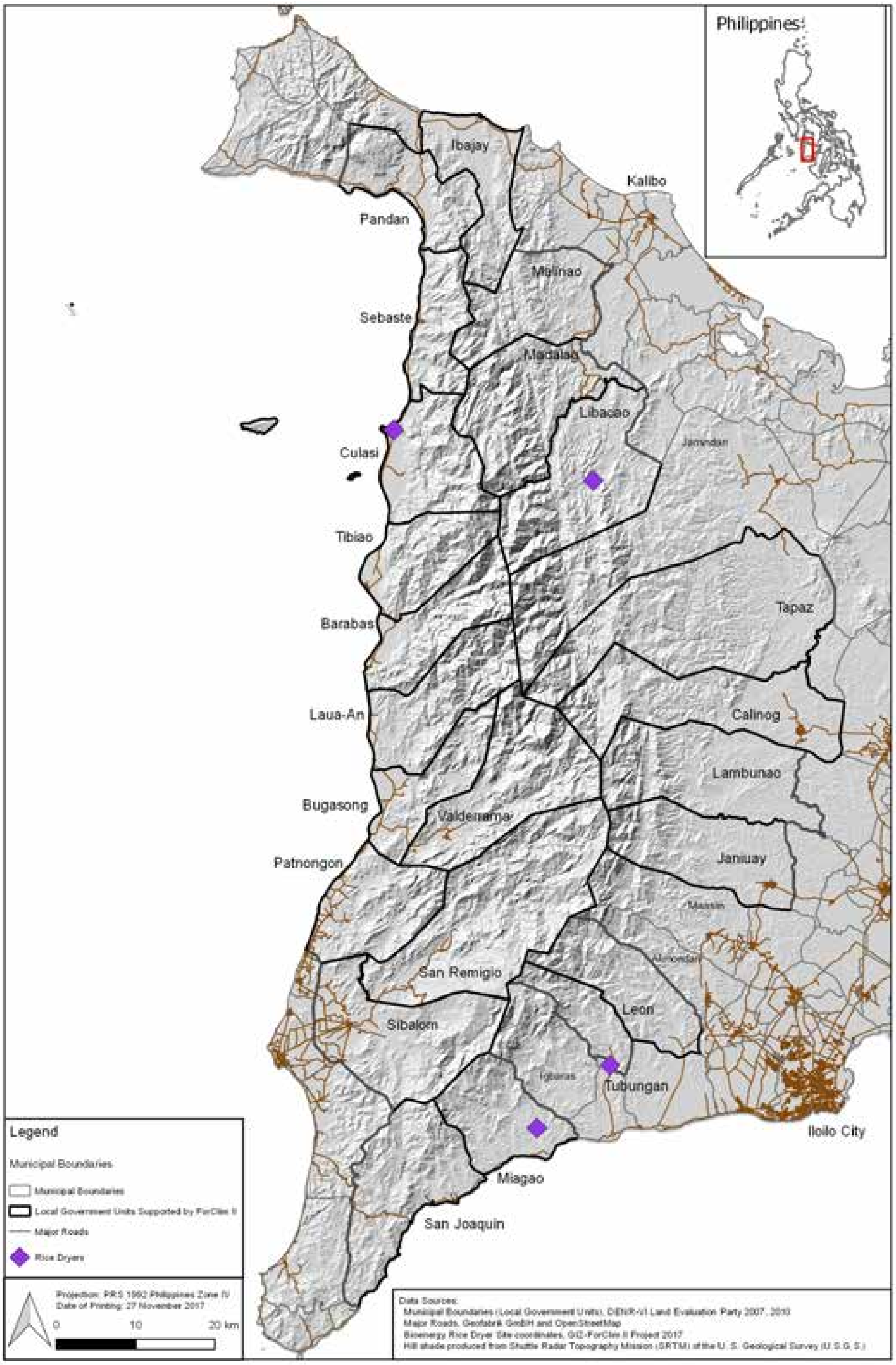


Figure 1. Map of Western Panay showing the location of the 4 rice dryers installed by the project.

In 2015, the project carried out a feasibility study on the potential of bio-energy (Ortwein and Militar 2015). Of special interest for this study was the potential of biomass (wood and agricultural residues) for the decentralised supply of communities and households with electricity, heat for drying rice (palay in the Philippines), coconut meat (Copra), abaca and lumber, and cooling.

The study did not make explicit feasibility considerations for rice drying by using rice husk as fuel because this technology is already implemented in flatbed and circulating dryers. However, the study concluded that cooperatives and associations should be supported by further information of the advantages of such systems compared to classical rice drying and mentioned that there was an average volume of 161,364 metric tonnes of rice husks available in Panay for the period 2009-2013.

The project supported 4 People's Organisations with the installation of flatbed rice dryers which use rice husk as energy source (Figures 1 and 2). These dryers reduce operating costs and greenhouse gas (GHG) emissions and can address the problem of lack of energy sources in off-grid areas. GHG emissions are not only reduced by substituting fossil fuel with rice husks, they are also reduced by preventing rice hulls from being left to decay and thereby producing methane.

In order to be able to quantify the effect of biomass powered flatbed rice dryers on GHG emission reduction and reduction of operating costs, the project commissioned a study, the results of which are summarized in the report.

Figure 2. Rice dryer in Miag-ao.

General information

Methods for rice Drying. Palay drying is an important part of the value chain for rice production. Palay usually has a moisture content of 28% (weight-based), while rice mills (where the rice husk is separated from the rice for food) require a moisture content of 13.5-14.0% for optimised operation (Ortwein and Militar 2015).

According to the International Rice Research Institute (IRRI), **traditional drying systems (sun drying)** of palay are still widely used primarily because it is easy to do and the costs are low (IRRI Rice Knowledge Bank http://www.knowledgebank.irri.org/). Sun drying palay involves putting it on mats or directly on the pavements, highways or municipal roads. The latter, most of the time, requires the use of one side of the road, which become impassable, while the palay is being dried. The Department of Public Works and Highways (DPWH) considers drying palay and other farm produce in national highways as a hazard for motorist and banned it in 2013 through the issuance of Department Order (DO) 41 Series of 2013. Violators of the DO are supposed to receive prison sentences of up to 6 months or pay a fine of PHP 1,000. This method is also dependent on the weather condition which makes it difficult to use especially during the rainy season. The National Food Authority (NFA) estimates that sun drying can result in 8 to 10% grain losses (Ortwein and Militar 2015). This is substantial and the government (past and present administrations) implemented mechanisation programmes, especially the distribution of flatbed palay dryers to cooperatives and farmer associations to minimise the losses in palay drying.

A dryer is a machine that removes the water from wet grains (corn, palay etc.) by forcing heated air through the grain bulk. In a flatbed dryer, the grain is kept stationary in a holding bin until drying is completed. A flat bed dryer consists of a drying bin, an air distribution system with a plenum chamber, a furnace or burner for heating the drying air, and a fan that blow the hot air into the chamber (Figure 3). Flatbed dryers can dry 10 tonnes of palay in 10 to 12 hours (FAO n.d.).

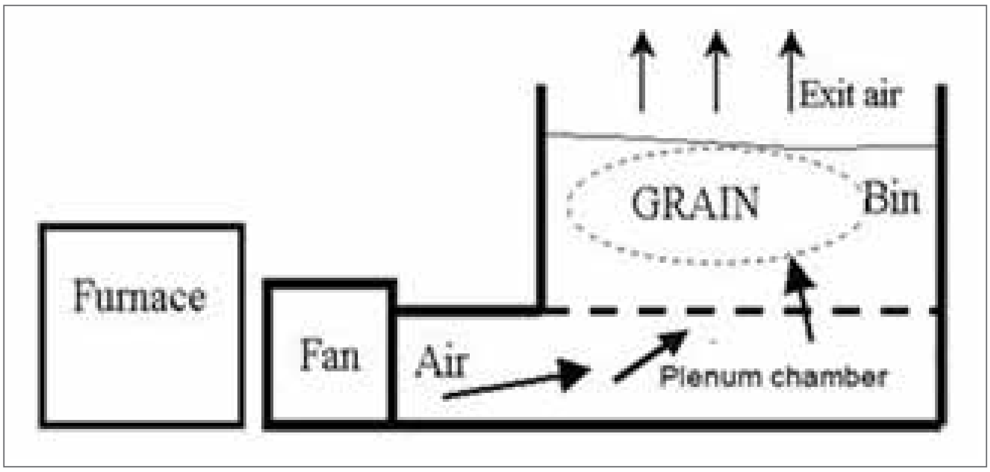


Figure 3. Typical schematic design of flatbed dryer
From: http://www.knowledgebank.irri.org/training/fact-sheets/postharvest-management/drying-fact-sheet-category/item/troubleshooting-a-flat-bed-dryer-fact-sheet

The benefits of drying palay mechanically include:

- production of better quality rice compared to traditional sun drying
- more uniform drying of grain
- higher milling yield and head rice (whole grains) recovery (less broken or crack grains)
- dependable as drying can be done even during inclement weather and anytime of the day
- eliminates the risk of grain deterioration during the rainy season (deterioration takes the form of stress cracking, mold development, grain fermentation and grain sprouting).

The **traditional flatbed dryer** uses diesel to power the fan and kerosene for the furnace. If not properly constructed, the soot and smell coming from kerosene and diesel will permeate the holding bin and pollute the palay. The heavy reliance on fossil fuels of this type of dryer results in higher greenhouse gas emission compared with the biomass alternative. Furthermore, the increasing fuel prices can drive up the cost for the drying of a sack palay.

The basic principle of **biomass fuelled flatbed dryer** is the combustion of rice husk (instead of burning kerosene) for the furnace and diesel to power the fan for the blower. In on-grid areas electricity can be used instead of a diesel engine. There was low adoption in the past of flatbed dryers, especially the biomass fuelled type, primarily due to technical and operational inefficiencies. Among the problems were that the furnace required constant user attention like shovelling the rice hulls into the furnace and mixing the palay, and difficulty in maintaining constant heat output (Manalili et al. 2015, Ragudo 2011). However, the designs have evolved over time and the latest flatbed dryers available have solved these problems. Jover Light Industries, based in Iloilo province, has successfully introduced a biomass flatbed dryer in Panay Island and other parts of the country.

ForClim II supported community organisations in Panay confirmed that 10-tonne biomass dryers from Jover are efficient, easy to use and produce better quality milled rice. The environmental benefits and cost savings were also emphasised by the association.

Market situation

Theoretically, the entire rice harvest of 1,613,636 tonnes in Panay island could be dried mechanically using biomass flatbed dryers. This would require the use of 56,447 tonnes of rice hulls as fuel or 35% of the estimated 161,364 tons[1] produced in the island, leaving a substantial amount of rice hulls that can be used for other purposes.

The use of biomass for the furnace will save 12,909,088 litres of kerosene consumption, which is equivalent to more than PHP 636 million using the August 2018 average price for kerosene in Panay Island. The calculation of the kerosene consumption of the furnace of the traditional dryer was based on a conservative estimate of 8 litres per hour or 80 litres for 10 hours drying of 10 tonnes of palay. In addition to the cost savings, the foul smell and black soot that are emitted by kerosene will also be avoided if biomass will be used instead. And there is also the impact on the climate, especially on GHG emission reduction.

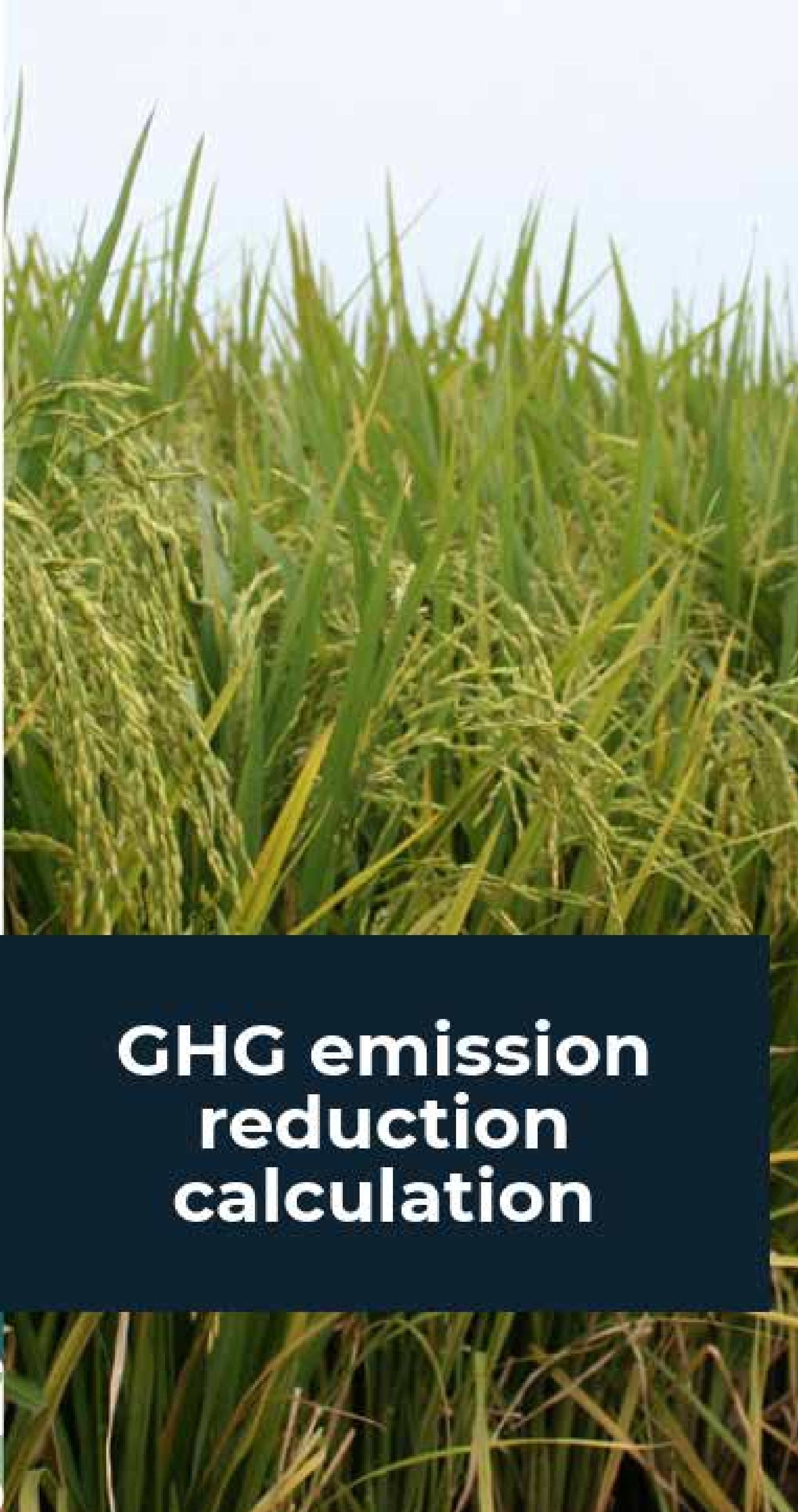
The key facts and figures about rice dryers are summarised in table 1.

Table 1. Key facts and figures about rice drying

Average annual rice production in off-grid areas (in tonnes)	1,613,636
Rice hull produced annually in off-grid (in tonnes)	161,346
Fuel prices/litre (average retail price in Panay urban centres)	PHP 49.32 (kerosene) / PHP 45.12 (diesel)
Flatbed dryer models	Jover Light Industries (biomass furnace); Maligaya Flatbed Dryer (PhilRice) – biomass or kerosene
• Flatbed capacity	Maligaya 2-6 tonnes; Jover 4-10 tonnes
• Drying time	Maligaya 4 to 12 hours per batch; Jover 8-10 hours for 10 tons load
• Fuel consumption (biomass in tonnes)	0.035 per hour
• Fuel consumption (diesel in litres)	2 per hour (Jover)
• Fuel consumption (kerosene in litres)	8 per hour
Projected operational lifetime of flatbed dryers	10 years
Total Number of Units Deployed	Maligaya: 1,000 units; Jover – 20 units

Source: DOE, FAO, GIZ, PIDS, PhilRice

1 Milling one metric tonne of rice produces about 200 kilograms of rice husk, but only about 50% are actually recoverable and thus available for utilisation as fuel.



GHG emission reduction calculation

The standard GHG emission calculation formula, see equations 1 – 4 below, was used to calculate the potential total reduction through the use of biomass fueled furnace flatbed dryers based on the figures listed in Table 2.

Table 2. Assumptions for GHG emission calculation

Average annual rice production in Panay (in tonnes)	1,613,636
Rice hull produced annually in Panay (in tonnes)	161,364
Number of batch dryings to mechanically process the entire harvest (10-tonne capacity/batch)	161,364
Drying time per batch	10 hours
Rice husk requirement for single batch drying (tonnes)	0.35
Biomass fuel (for the furnace): tons of rice hull required to dry the total rice produced	56,477
Kerosene fuel (for the furnace): litres required to dry the total rice produced using conventional flat-bed dryer	12,909,088
Diesel (for the blower): litres required to dry total rice produced	3,227,272

The following equations were used for the calculations:

Consumption (TJ) = Consumption (Gg) x Conversion Factor (TJ/unit) *Equation 1*
Where: Gg = gigagram; TJ – terajoule

CO_2 Emission (tCO_2) = Consumption (TJ) x CO_2 Emission Factor (kg CO_2/TJ)/1,000 *Equation 2*

CH_4 Emission (Gg CH_4) = (Consumption (TJ) x CH_4 Emission Factor ((kg CH_4/TJ)/1,000) x 21 *Equation 3*

N_2O Emission (Gg N_2O) = Consumption (TJ) x N_2O Emission Factor (kg N_2O/TJ)/1,000 *Equation 4*

The baseline emission comes from the calculation of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) from the combustion of kerosene and diesel in the traditional flatbed dryers. The baseline emission to dry the entire palay harvests in the off-grid is **42,525** tCO_2e (Table 3).

Table 3. Baseline emission

Kerosene	
Kerosene consumption (Gg)	10.74
Conversion Factor (TJ/Unit)	43.8
Consumption	470.43
CH_4 Emission Factor	3
N_2O Emission Factor	0.6
CO_2 Emission Factor	71,900
Kerosene CO_2 Emission (tCO_{2e})	33,941
Diesel	
Diesel consumption (Gg)	2.69
Conversion Factor (TJ/Unit)	43
Consumption	115.46
CH_4 Emission Factor	3
N_2O Emission Factor	0.6
CO_2 Emission Factor	74,100
Diesel CO_2 Emission (tCO_{2e})	8,584
Total Baseline Emission (tCO_{2e})	42,525

The project emission (Table 4) is from the combustion of rice hulls and diesel. The carbon emission from biomass is accounted for as part of the biogenic cycle, meaning the biomass combustion simply returns to the atmosphere the carbon which was absorbed as the plants grew (IEA Bioenergy). Thus, the project emission would only come from the diesel combustion amounting to 8,584 tCO_{2e} plus the methane and nitrogen oxide emitted by biomass amounting to 1,225 and resulting in a total of **9,809 tCO_{2e}**. By subtracting the project emission from the baseline, the estimated total GHG emission reduction will be **32,716 tCO_{2e}** per year.

Table 4. Project emission

Diesel	
Diesel consumption (Gg)	2.69
Conversion Factor (TJ/Unit)	43
Consumption	115.46
CH_4 Emission Factor	3
N_2O Emission Factor	0.6
CO_2 Emission Factor	74,100
CH_4 Emission	**413**
N_2O Emission	**812**
Diesel CO2 Emission (tCO2e)	**8,584**
Total Project Emission (tCO_{2e})	**8,463.83**

There can be less emission if the diesel engine used for the blower will be replaced by solar photovoltaic or small-scale biomass systems. The former is more likely to happen as there has been a lot of technical and cost improvement with solar photovoltaic systems. There are still limited working models of small-scale biomass systems for use in powering machineries and electronic equipment.

GHG emission and cost savings in Panay

ForClim provided funding to 4 people's organisations (PO) in Panay for the acquisition of one unit each of a Jover flat-bed biomass dryer for their respective post-harvest operations. So far, the collective experience of the POs is that the Jover dryer is functioning well and effective in drying palay, especially in terms of uniform drying of grain and in the production of better-quality rice. The drying process is neither tedious or labour intensive nor does it require constant attention. In addition, the ashes of the rice husks provide excellent fertiliser.

The 4 POs will utilise the dryers for an estimated total of 60 10-tonne batches per year processing an aggregated 600 tonnes of palay. This results in a GHG emission reduction of 181.8 tCO_{2e} annually. In addition, it provides a cost saving of PHP 236,736 from the avoidance of kerosene use, or about 3,850 Euro based on the average exchange rate for August 2018 of PHP 61.46 for 1 Euro.

The 4 dryers are already serving the needs of the farmers in the areas where the POs are operating and it is expected that over time there will be an increase in their utilisation. Other POs and farmers can see the effectiveness and usefulness of the biomass flatbed dryers and this will hopefully result in more and more farmers and POs using biomass instead of Kerosene or electricity.

If the entire rice harvest in Panay would be dried using biomass, the total GHG emission reduction would be about 9,800 tCO_{2e} per year. The total cost savings would be over 636 million PHP or about 10,350,000 Euro based on the average exchange rate for August 2018.

References

DPWH (2013) Department Order 41, Series of 2013. Banning of drying palay and other farm produce along national highways. http://www.dpwh.gov.ph/dpwh/sites/default/files/issuances/DO_041_S2013_1.pdf last accessed 25 September 2018.

FAO (n.d.) Post-Harvesting Processing. http://www.fao.org/3/a-au104e.pdf last accessed 31 August 2018.

IEA Bioenergy: Fossil VS Biogenic CO_2 Emissions. http://www.ieabioenergy.com/iea-publications/faq/woodybiomass/biogenic-co2/ last accessed 31 August 2018.

Manalili, N.M., Yaptenco, K.F. and Manilay, A.A. (2015) Rapid Appraisal of the Postharvest Facilities Projects in the Philippines. Philippine Institute of Development Studies, Discussion Paper Series, No. 2015-31. https://dirp3.pids.gov.ph/webportal/CDN/PUBLICATIONS/pidsdps1531.pdf last accessed 31 August 2018.

Ortwein, A. and Militar, J.G. (2015) Use of Biomass as Renewable Energy. Quezon City, Philippines: Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. http://faspselib.denr.gov.ph/node/1366 last accessed 31 August 2018.

Ragudo, T.F. (2011) Status of Adoption of UPLB Flat Dryer. J. ISSAAS 17(2):168-180. https://www.issaas.org/journal/v17/02/journal-issaas-v17n2-15-ragudo.pdf last accessed 31 August 2018.

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