Bridging agricultural livelihoods and energy access

Barriers and opportunities for rice and rice husk value chains in Labutta, Myanmar

MANCHESTER 1824 The University of Manchester

Tyndall°Centre for Climate Change Research

MERCY CORPS

REAM မြန်မာပြန်ပြည့်မြဲစွမ်းအင်အသင်း Renewable Energy Association Myanmar

Biomass Energy Association of Myanmar

Angela Mae Minas[1], San Yin Yin Tun[2], Wahyu Nugroho[2], Dipti Vaghela[3], Aung Myint[3], U Soe Tint Aung[3], Thet Su Mya[3], and Sarah Mander[1]

[1] Tyndall Centre for Climate Change Research, The University of Manchester
[2] Mercy Corps Myanmar
[3] Renewable Energy Association of Myanmar with Biomass Energy Association of Myanmar

Contents

Executive Summary

This report presents the results of a one-year collaborative research project between Mercy Corps Myanmar, Renewable Energy Association of Myanmar with Biomass Energy Association of Myanmar and the Tyndall Centre for Climate Change Research at the University of Manchester. The project explored the intersection between agricultural livelihoods and energy access through an investigation of social networks in rice and rice husk value chains in rural farming communities of Labutta in Myanmar's Lower Delta.


IRRI / Flickr

Rice production is an important agricultural activity in Myanmar, significantly contributing to its economy by providing income and employment to half of the country's population. However, because of lack of access to electricity in many rural areas, rice farmers have limited opportunities to increase their income. For many off-grid communities, heat and electricity for household lighting and livelihood activities are provided through steam and electricity produced from combustion or gasification of rice husk – a by product of rice milling. With an estimated over 3 million tonnes of rice husk produced every year, Myanmar has potential to utilise rice husk for income-generating activities and energy generation in order to support agricultural production and rural livelihoods.

Focusing on case study sites in Bi Tut and Kan Bet in Labutta, this research mapped social networks in rice production and rice husk value chains. This allowed us to identify actors and network structures that could play important roles in supporting energy access and increasing livelihood opportunities for smallholders. In addition to this, interviews and focus group discussions with farmers and millers also revealed important challenges and opportunities for rice husk bioenergy within rural farming communities.

Among the challenges identified are:

- Access to credit and financing. This is one of the most urgent requirements to enable smallholder farmers and millers to adopt value-adding activities such as access to high quality inputs (e.g., seeds and fertilisers) or mechanised drying, and so increase their income.

- Small-scale millers in off-grid areas offer an important service to smallholder farmers and need financial and technical support to upgrade their facilities.
- A rice husk market exists but mostly for traditional biomass uses, e.g., as briquettes or fuel sticks or direct burning for rice husk cook stoves; these can lead to pollution and negative impacts on health.
- Medium-scale millers are willing to participate in new or additional rice husk value added activities, but only if other actors or businesses can manage rice husk collection and transportation for them.

There are a number of opportunities for both farmers and millers that can address these challenges, including:

- Building or strengthening connections between medium-scale millers and local businesses that use rice husk
- Supporting market development for rice husk use in energy generation
- Empowering local partnerships within communities to manage husk-to-energy business models
- Linking groups of farmers to service providers in order to lower costs of production

Reflecting on these, results from this research suggest that in order to bridge agri-livelihods and energy access:

- Farmers and millers need access to credit under fair financing schemes. It is also particularly important to address issues in rice trading (e.g., differences in trading price) to increase farmers' income.
- Investments are needed to support facilities and activities that add value to rice husk, especially by using it for modern bioenergy. This requires financial support for millers, especially small-scale and husk-to-energy operators to allow them to invest in *zero-effluent husk-to-energy facilities*.
- Capacity building and partnerships strengthening initiatives are needed, which could be enabled by collaboration between local businesses, communities, and civil society organisations.
- More policy focus on rice husk bioenergy is needed to encourage investments and upscale existing initiatives. This includes a consideration of stricter implementation of rules preventing rice husk or wastewater disposal into river systems.

These findings draw on learnings from our case study sites and may not be applicable to other rice farming communities or regions. Nonethless, taken together they encourage thinking about the role of energy in poverty alleviation, particularly in consideration of *urgency* and *justice* – what is needed now and what is fair, especially for smallholders in rice production. Future work on this subject should undertake an economic analysis to further strengthen the case for value chain development for rice husk, including for *rice husk gasifiers* which have been valuable in powering off-grid farming communities, but are beyond the scope of this research.

Acronyms

BEAM	Biomass Energy Association of Myanmar
DOA	Department of Agriculture
DRD	Department of Rural Development
FAO	Food and Agriculture Organization of the United Nations
FPE	Farmer Producer Enterprise
MADB	Myanmar Agricultural Development Bank
MC	Mercy Corps
MMK	Myanmar Kyats
REAM	Renewable Energy Association of Myanmar
RHL	Royal Htoo Lin (Local name: Taw Win Htoo Lin)
ToT	Training of Trainer

Units of measurement

1 acre	0.4 ha
1 basket	24 kg (52.2 lbs)
1 bag (rice)	49 kg or 2 baskets
1 bag (husk)	14 kg or 30 lbs
1 Lakh	100,000
1 unit (of electricity)	1 kW

Operational definition of terms

Biomass
Biological material such as agricultural crops and residues, forestry crops and residues, animal residues, industrial residues, municipal solid waste, and sewage

Bioenergy
Energy produced from the chemical conversion of biomass in the form of:
(1) generated electricity and heat from burning or decomposing solid biomass,
(2) liquid fuels used to run vehicles and machines or
(3) gas which could also be used to run vehicles and machines, and generate electricity and heat

Feedstock
Biomass resources used for energy generation

Traditional biomass
Use of feedstock such as fuelwood, charcoal, manure and crop residues for household heating and cooking

- **Advantages**
  low technology, available, affordable
- **Disadvantages**
  inefficient use, high pollution, often very time intense to source (collecting)

Operational definition of terms

Modern bioenergy	Use of modern technologies to convert feedstock from crops and residues to electricity, heat or biofuels and biochemicals • **Advantages** more efficient use of resource, less polluting than traditional bioenergy • **Disadvantage** high cost compared to traditional uses
Combustion	Biomass conversion process where feedstock is burned in the presence of air, e.g., using boiler engines or furnace
Gasification	Biomass conversion process where feedstock is burned in an oxygen-deficient environment (partial oxidation of biomass)
Small-scale rice millers	Village-based millers whose milling facilities only have one or two step processes and capacity is only around 20 baskets of paddy per hour; Machines have high breakage with milling recovery of less than 60% (IRRI 2018)
Rice huller	A one-step milling machine used for small-scale production and milling of household rice; There are about 15,000 hullers in Myanmar (World Bank 2019)
Medium-scale rice millers	Village-based or commercial millerd whose milling machines have multi-step processes and has capacity to produce hundreds of baskets of paddy per hour
Farmer Producer Enterprises	Farmer groups in Labutta where members benefit from linkages to market actors, training on agricultural technologies and practices, and participation in outgrower schemes
Value chain	Framework used to understand the range of activities required to bring a product or service to consumers, starting from conception (e.g., preparation of inputs) to consumption (e.g., delivery to consumers)
Activities for value addition	Activities – such as improving processing, collection and transportation, storing, and producing food or non-food outputs – that create additional economic value to an agricultural product or by-product

1 Introduction

Rice production is the main agricultural activity in Myanmar, providing income and employment to almost half (49.69%) of the country's population (ILOSTAT 2019). Despite its economic importance, Myanmar's agriculture suffers from low productivity due to the lack of infrastructure, inadequate facilities, and largely manual farming practices (GRiSP 2013; World Bank 2016). These challenges are exacerbated by low access to electricity in rural areas which is vital to increase farm efficiency and productivity via mechanisation, better access to information, high-quality postproduction processes such as drying and milling, and value added processing of rice-based products. With only 60% of Myanmar's rural population having access to electricity, farmers have limited opportunities to improve their livelihoods and increase their incomes (UN SE4ALL 2016). It is within this context that this project sought to understand how access to energy could open opportunities for optimising rice production in Myanmar.

Biofuels and waste dominate energy use in the country (See Figure 1). However, the majority of this (82%) comes from use of traditional biomass, e.g., direct burning of fuelwood, which has negative environmental and health impacts (IEA 2018). Accordingly, only 18% of the population has access to clean fuels and modern bioenergy (UN SE4ALL 2016). Nonetheless, Myanmar's abundant biomass also present huge potential for energy generation.

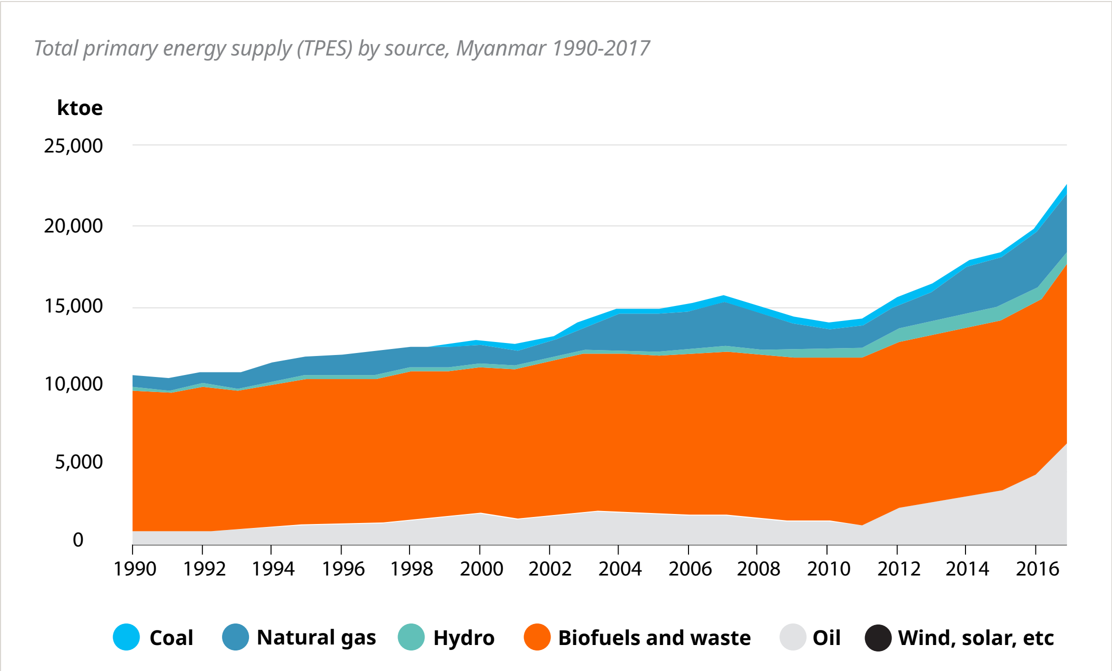


Figure 1. Sources of energy in Myanmar (IEA 2018)

One of its largest biomass resources is rice husk, a by-product of rice milling (Tun and Juchelková 2019). Each kilogram of milled white rice produ¬ces around 0.28 kg of rice husk. Based on current production, Myanmar produces over 3 million tonnes of rice husk every year (IRRI 2018). This is commonly used in rural farming communities as fuel for cooking and heating with 10% used as feedstock for steam and electricity generation using boiler or gasification engines, but with significant surplus left unused (Pode et al. 2016; Sovacool 2013). Among its energy applications, rice husk gasifiers have been an important source of power for Myanmar's off-grid communities in the last 30 years. Recent estimates show that as much as 10,000 rice mills and hullers, and more than 500 village electrification facilities in Myanmar use rice husk gasifiers. Progress in energy provision through husk-to-energy use in these areas is largely attributed to local expertise, self-financed investments from local entrepreneurs, and various forms of community collaboration, including initiatives led by cooperatives and village committees (Pode et al. 2016; Vaghela 2018; World Bank 2019).

Against this background, this project employed social network research to understand how local communities can be supported in order to optimise rice husk use – for improving access to energy, and enabling value-added activities to increase farmers' income. In doing so, it investigated local-level value chains to explore barriers and opportunities in linking access to energy to agricultural livelihoods.

This report presents findings from the project and draws insights from literature to reflect on implications for development planning and policy. Section 2 proceeds with a description of the case study sites in Labutta, as well as the data collection methods used in the research. Section 3 presents the resulting value chain maps from focus group discussions. Findings and key learnings are then presented in Sections 4 and 5. The last part, Section 6, outlines recommendations for future work to complement analysis from this research.

2 Case study

This research was conducted in Labutta township, in the lower delta of Ayeyarwady region where most (26%) of the country's rice production occurs (GRiSP 2013; World Bank 2019). Specifically, data were collected in two village tracts: Bi Tut and Kan Bet (See Figure 2). These villages – like others in the delta region of Myanmar – are located along the river streams and therefore, rely on water resources for their livelihoods, as well as transport. -However, farming communities in these areas may also risk endangering river health if excess rice husks are not managed properly (e.g., disposed in the river), which could consequently affect their livelihoods.

Figure 2. Case study sites

2.1 Agricultural activities

Labutta has over 300,000 acres (3.6 Lakh) of paddy growing area spread across its three farming zones: salty, brackish, and freshwater. Rice is mainly grown during monsoon season – from June to November; whilst only less than 10% of its total farmlands (mainly in freshwater zones) are used for paddy growing in the summer. Table 1 provides more specific information about agricultural activities in Bi Tut and Kan Bet, where the fieldwork was conducted.

Table 1. Socio-demographic and livelihood characteristics of Bi Tut and Kan Bet, Labutta

	Bi Tut	Kan Bet
Population	8,237	8,000 – 9,000
Households	1,983	1,745
Number of farming households	483	450
Number & scale of milling facilities	4 small-scale; 3 medium-scale	1 small-scale; 3 medium-scale
Livelihood activities	Paddy rice cultivation during monsoon season Pulse growing during summer	Paddy rice cultivation Livestock and poultry (i.e., duck, pigs) Shrimp farming

Source: Ministry of Labour Immigration and Population (2017), Fieldwork data

2.2. Energy sources

In terms of access to energy, only 10% of Labutta's households are connected to the grid and use electricity for lighting. Most residents use kerosene (38%), battery (28%), candle (11%), and diesel generator (8.7%), with a small percentage (3.6%) using solar power (Ministry of Labour Immigration and Population 2017). Accordingly, both Bi Tut and Kan Bet are not connected to the national grid, and therefore use off-grid energy sources for lighting and small household appliances (e.g., radio, tv, rice cooker) (See Table 2).

Table 2. Sources of energy in Bi Tut and Kan Bet

	Bi Tut	Kan Bet
Village tract	• Community-based rice husk gasifier	• Privately owned rice husk-to-energy facilities • Solar lamp posts for street lighting
Villages	• Solar panel for lights, mobile phone charging, television	• Battery for lighting and television • Solar panel for lights, mobile phone charging, television
	• Wood fuel for cooking • Diesel and petrol for boat and farm equipment (e.g., hand tractor and water pump)	• Wood fuel for cooking • Diesel and petrol for boat and farm equipment • Candle for lighting

Source: Fieldwork data

As shown in Table 2, rice husk is used in both communities as feedstock for energy production. In addition to this, other uses of rice husk include: as a cooking fuel (in briquette form as fuel stick or for husk-compatible cookstoves), particularly when fuelwood is difficult to source; and as material to cover muddy dirt roads during monsoon season.

Farmers use the ash produced from combustion of rice husk as fertilisers, and in combination with straw and animal waste. In Kan Bet, rice husk is also used as feedstock for a cremation facility operated by their villages' Social Service committee. Some millers also produce rice husk briquettes for use as a cooking fuel and as pellets for boiler engines.

2.3. Approach

To understand how local stakeholders are embedded in value chain systems, this research used qualitative approaches in social network research. This involves semi-structured interviews and focus group discussions combined with participatory visual network mapping – an interactive process where participants draw a map of their social network, following the value chain mapping canvas (See Figure 3).

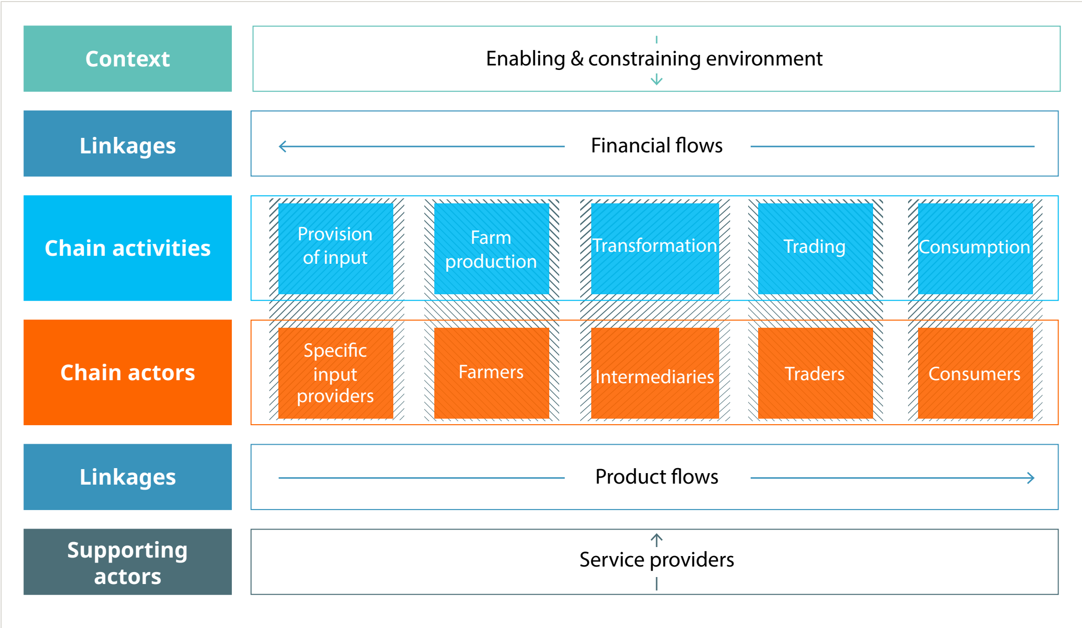


Figure 3. Value chain mapping canvas (Modified from Stein and Barron 2017)

In total, four semi-structured interviews and six sets of focus groups discussions were conducted (See Appendices E and F). Key informant interviewees include village leaders in Kan Bet and Bi Tut, an agricultural technician for Labutta and an energy facilities manager. Focus group participants include small- and medium-scale millers, and farmers who are members and non-members of Farmer Producer Enterprises (FPEs).

FPE is part of a Mercy Corps project in Labutta which aims to increase farmers' income by linking farmers to market actors and introducing new agricultural technologies and practices. The project incorporates different outgrower schemes – done in partnership with various local and international market actors, including local millers and traders, input companies, financial institutions, as well as Golden Sunland, a Singaporean hybrid seeds and rice trading company. It has 3,700 direct beneficiaries in 26 village tracts covering 200 villages.

Involving both members and non-members of FPEs allowed this research to get a balanced view from those who may have more connections to market vai FPE, and those who do not. The differences and similarities in their responses provided additional insights in the analysis of social network and value chain data.

Figure 4. Photos from focus group discussions
(Top: with millers; Bottom: with farmers)

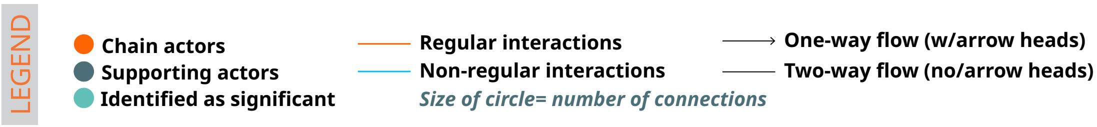
3 Value chain maps

This section presents the resulting value chain maps drawn during focus group discussions with farmers (FPE and non-FPE members in Bi Tut and Kan Bet) and millers (small-scale and medium-scale), with an analysis of social network data. In addition to identifying the actors and activities in the value chain, the maps presented here also visualise what participants believe to be the most important activity (pink badge) and most influential actors (teal colour) in the value chain, as outlined in the Tables 3 and 4. Furthermore, the context (top row) indicates the areas where participants identified challenges and constraints in the value chain. Explanations and implications of the connections between the actors and activities shown in the maps are further discussed in Section 4.

3.1. Rice value chains

Figures 5 – 8 show the rice value chain maps in Bi Tut and Kan Bet produced by FPE and non-FPE members. The maps indicate that FPE members in Bi Tut posess the largest (14 chain actors) and most connected network, suggesting that they are able to access and/or exchange resources for most of their activities. Whilst resource exchange is also indicative for Kan Bet farmers and non-FPE members in Bi Tut, these are only up until Trading.

However, problems related to resource access and quality (finance and credit, input, labour) are consistently identified by farmer groups as value chain contraints, indicating potential network differentials in terms of value (e.g., resources exchanged are low quality) and power (e.g., actors can access resources but only to a certain extent).



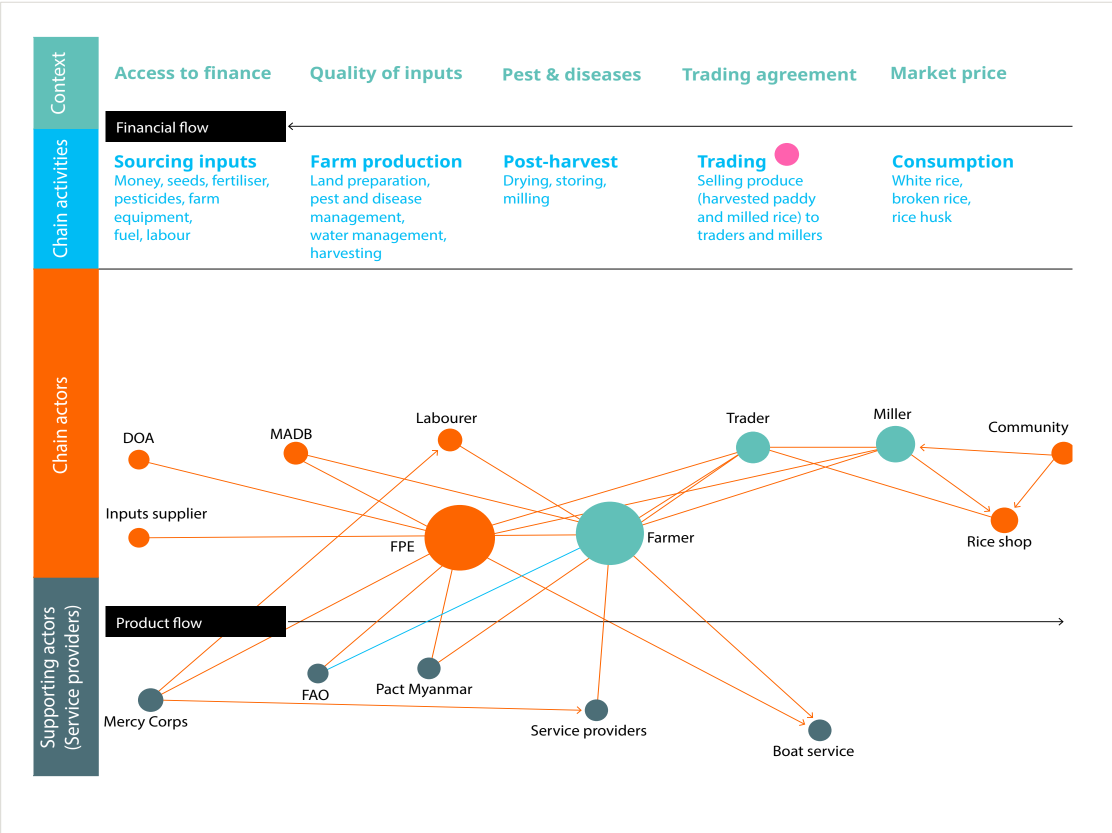


Figure 5. Rice value chain map in Bi Tut (FPE)

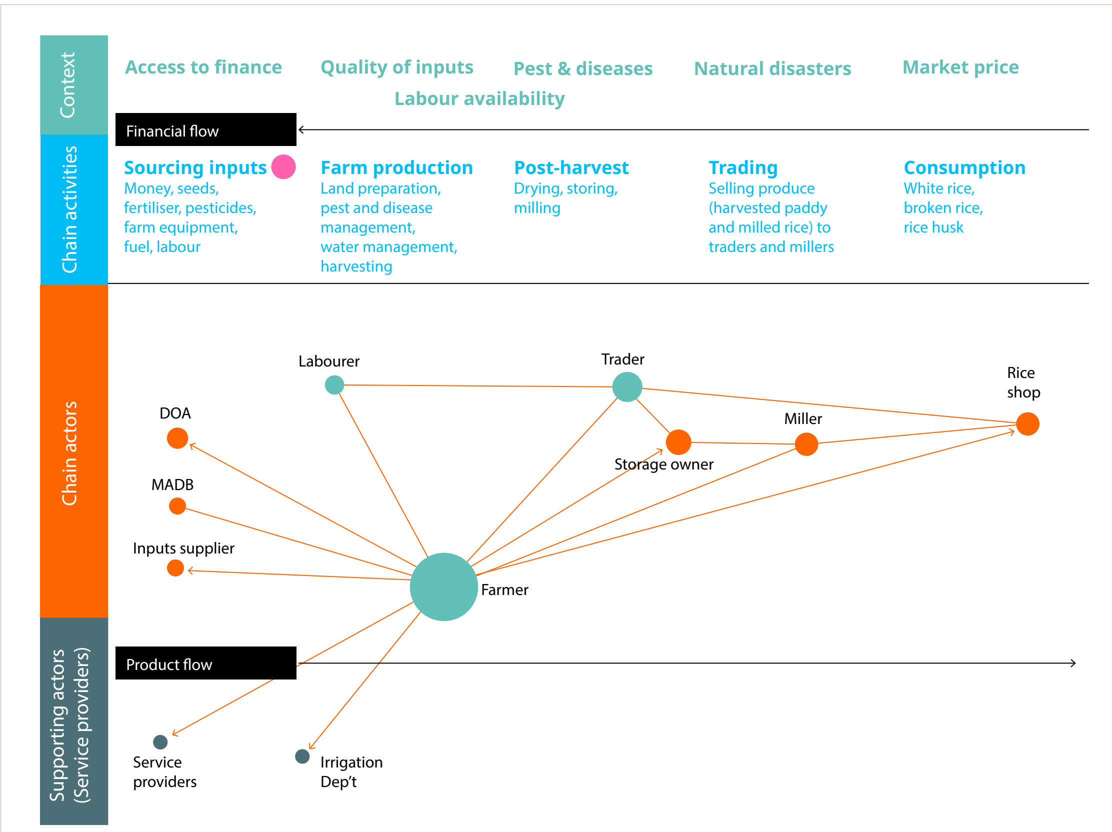


Figure 6. Rice value chain map in Bi Tut (Non-FPE)

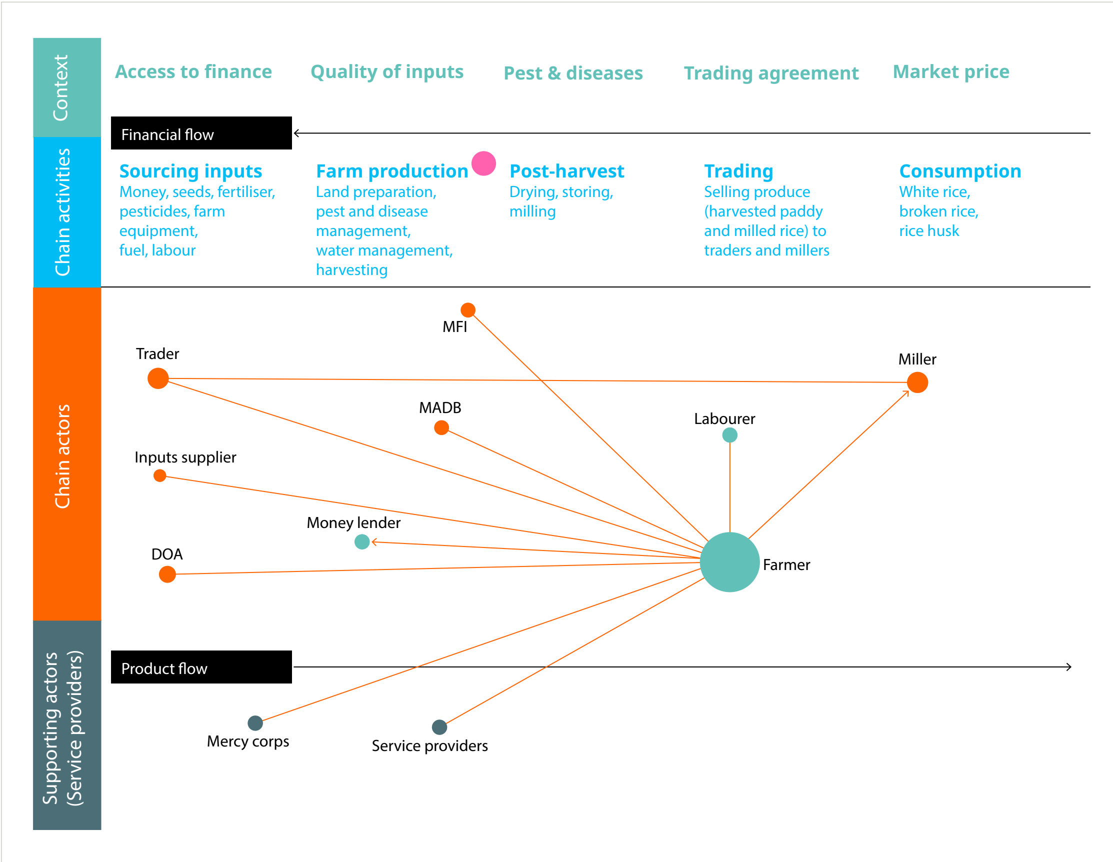


Figure 7. Rice value chain map in Kan Bet (FPE)

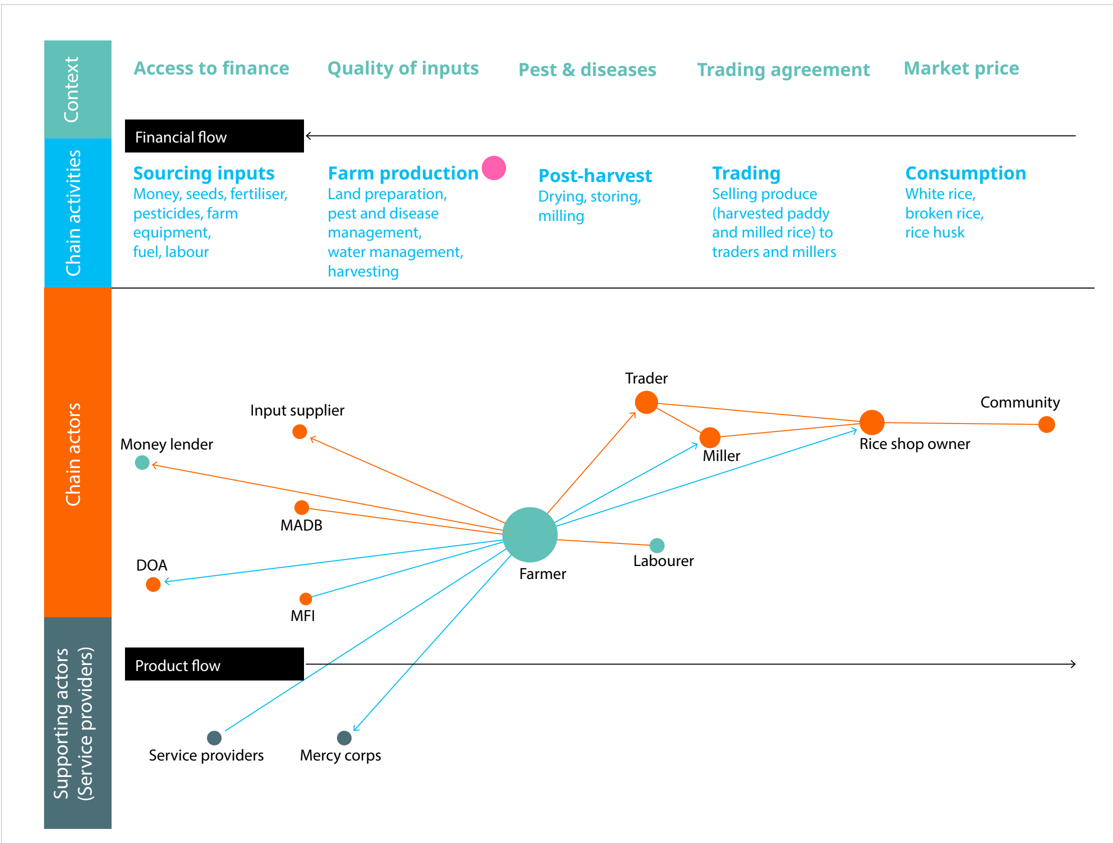


Figure 8. Rice value chain map in Kan Bet (Non-FPE)

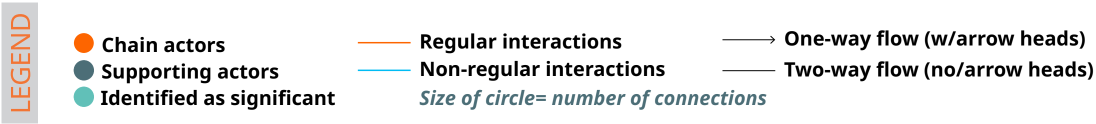
Table 3. Most important activity and actors in rice production

	Bi Tut FPE	Bi Tut Non-FPE	Kan Bet FPE	Kan Bet Non-FPE
Most important activity to reduce risk and increase income	Trading	Sourcing inputs	Farm production	Farm production
Most influential actor/s	Farmers, millers, traders	Farmers, labour group, traders	Farmer, neighbours, labourers*	Farmers, money lenders, labourers
Actor that benefits most	Millers	Traders and millers	Trader	Trader
Actor that loses most	Farmers	Farmers	Farmers	Farmer

* In Kan Bet, farmers access informal loan through their neighbours; because of land condition, not all agricultural machines are compatible to use in Kan Bet; thus, farmers hire about 220 labourers (twice per planting season for 10 acres) every rice production.

3.1. Rice husk value chains

Comparing the rice husk value chain maps of small and medium scale millers clearly indicates that small-scale millers have a denser and more highly connected network. Discussions during the network mapping process revealed that this because small-scale millers tend to work together and rely on other actors in their network to provide services for smallholder farmers. For example, small-scale millers mentioned sharing storage facilities and recommending other small-scale millers who have milling capacity to farmers; they also work with local collectors since they do not have the resources to collect and transport husks and other by-products on their own. Alternatively, medium-scale millers tend to have all required facilities and labour on-site to process rice husk briquettes and other value chain activities. Some local businesses also go directly to medium-scale millers to buy rice husk. Despite significant differences between the value chain networks of small- and medium-scale millers, there are opportunities to upgrade their value chains in ways that will benefit the rice husk market. This is discussed in Section 4.



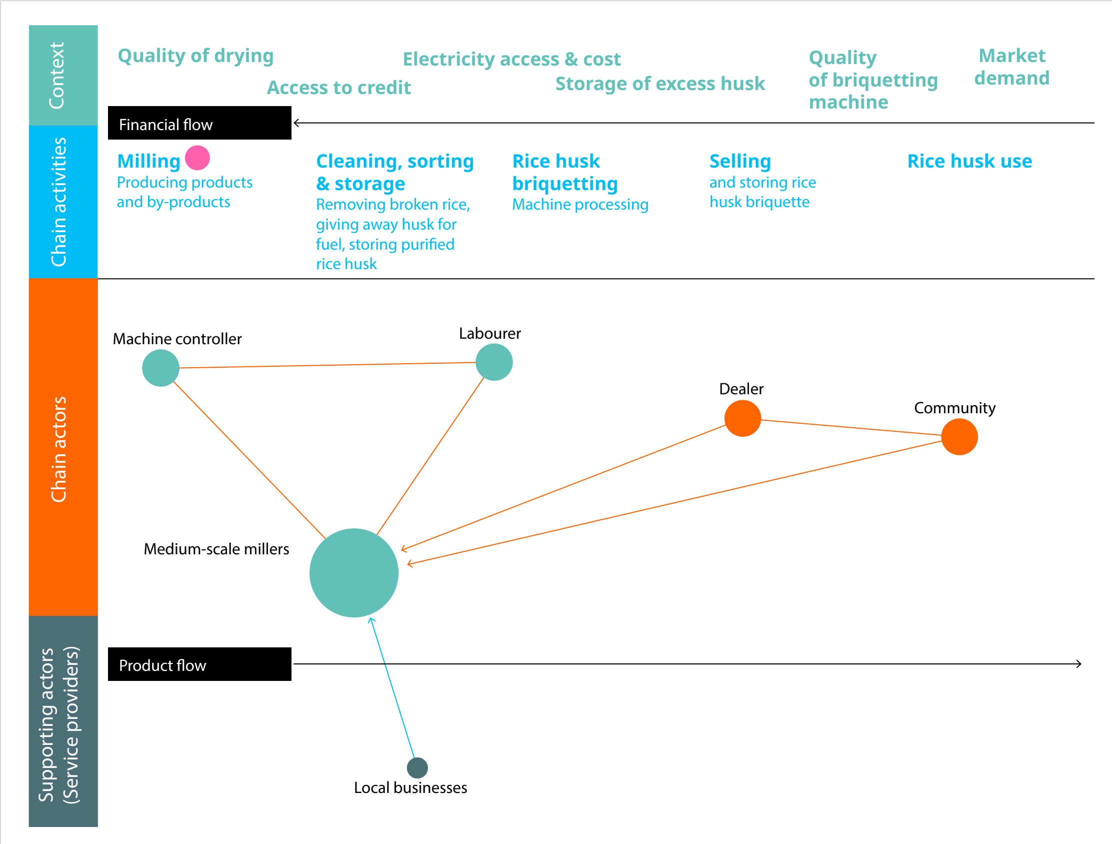


Figure 9. Rice husk value chain map (Medium-scale millers)

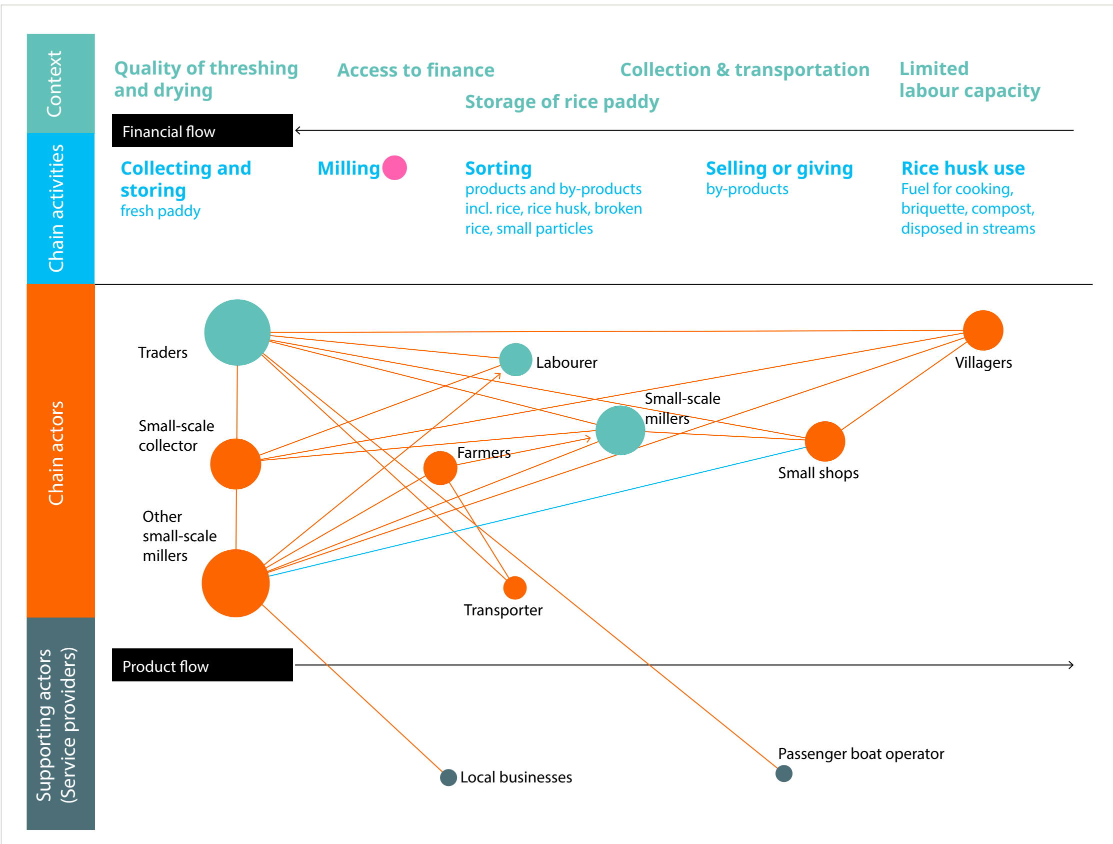


Figure 10. Rice husk value chain map (Small-scale millers)

Table 4. Most important activity and actors in rice husk processing

	Small-scale millers	Medium-scale millers
Most important activity to reduce risk and increase income	Milling	Milling
Most influential actor/s	Miller, Labourer, Trader	Miller, Machine controller, labourer
Actor that benefits most	Traders	
Actor that loses most	Labourers	


Rice husk briquetting machine


Rice husk briquettes

Products and by-products of rice milling

4 Key findings and lessons

Complementing the value chain maps presented above, this section highlights findings and key learnings from the project.

4.1. Access to credit and financing is the most urgent challenge of farmers and millers.

The lack of access to fair and affordable financing needs to be addressed so that farmers can improve their rice production and millers can consider value added activities from rice husk (See Tables 5 and 6). Challenges in relation to access to energy (i.e., electricity or farm machineries that require fuel), although regarded as important in rural development (Bellanca and Garside 2013), are only considered by farmers in the context of cost (i.e., 'better fuel for hand tractors is expensive, so we buy the fuel with the lower price but it has wax').

Farmers highlighted that due to financial constraints they have not been able to adopt the new farming practices they learn during training offered by NGOs, government, or private extension officers, see Figure 5, Bi Tut FPE). Furthermore, despite being able to access low-interest loans from MADB[1], delay in the release of money – one month after start of rice production – forces farmers to go through informal money lenders such as their neighbours and traders. These informal lenders, however, charge interest rates of up to 10% and with short repayment times[2]. When the MADB loan is released, farmers use the MADB money to repay informal loans. During harvesting, if farmers owe money to traders, their harvest is bought at a lower than market price otherwise they have to pay high interest rates. Any income from rice production is then re-invested for their next cropping season. Figure 11 provides an illustration of farmers' cash flow from formal and informal lenders during rice production. If these financing challenges are not addressed nuanced power structures between money lenders and farmers, will continue to limit income opportunities for farmers, and push them into a poverty trap (Yunus 2007).

[1] Different interest rates were given by farmers: 1.5% Bi Tut non-FPE, 0.8% in Kan Bet FPE

[2] MADB loan repayment is within 6 months; whilst informal lenders require repayment either after harvest for traders (4 months) or within 5 months

Table 5. Challenges and constraints in rice production

Bi Tut FPE	Bi Tut Non-FPE	Kan Bet FPE	Kan Bet Non-FPE
Access to finance[3]	**Access to finance**	**Access to finance**	**Access to credit**[4]
Quality of inputs	Quality of inputs	Quality of inputs	Farmer coordination
Pest and diseases	Labour availability	Labour availability	Labour availability
Trading agreement	Pest and diseases	Trading agreement	
Market price	Natural disasters	Market price	
	Market price		

Table 6. Challenges and constraints in rice husk utilisation

Small-scale millers	Medium-scale millers
Quality of threshing and drying	Quality of drying
Access to finance	**Access to finance**
Storage of paddy	Electricity access and cost
Collection and transportation	Storage of excess husk
Limited labour capacity	Quality of briquetting machine
	Market demand for husk

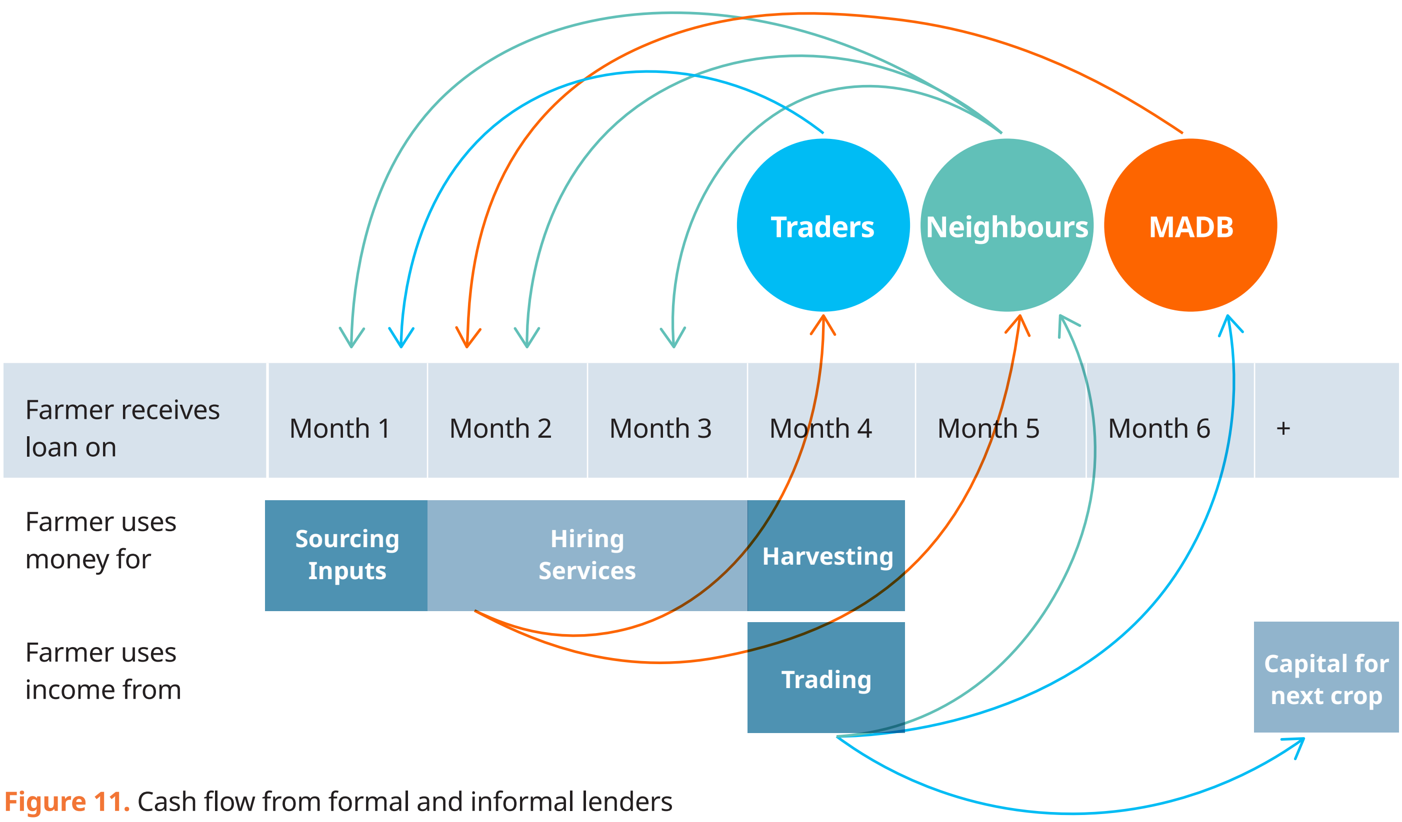


Figure 11. Cash flow from formal and informal lenders

[3] Access to finance refer to credit, cash and other financial services that participants claim to have difficulties accessing. This was described as 'problems in money'.

[4] Access to credit is particular to challenges that participants face with regards to applying and getting approved for loans. This includes providing a collateral and/or otheradministrative difficulties (e.g., lack of necessary documents) in applying for credit.

4.2. **There is an existing market for rice husk;** however, these operate at small scale and are mainly for products where rice husk is used as traditional biomass e.g., as briquettes or fuel sticks, for husk-compatible cook stoves. In both Kan Bet and Bi Tut, rice husk is used as fuel for cooking, especially when fuelwood is difficult to source during the monsoon season.

Small-scale millers sell rice husk to smallholder farmers in their village who also avail of their milling services; whilst medium-scale millers sell their husk briquettes to residents and local businesses. A participant claims that husk is cheaper than fuelwood which costs about 10,000 MMK per bag. Table 7 outlines the market price of rice husk per bag in Labutta area.

Table 7. Price of rice husk by source and form

Source	Form of rice husk sold	Price per bag (30 lbs)
Small-scale milling facilities	Loose rice husk (for husk compatible stoves)	100 MMK[5]
Medium-scale milling facilities	Compacted rice husk (charcoal briquettes)	1,800 MMK for households 1,700 MMK for factories (wholesale price)

It is important to note, however, that although using rice husk for cooking is cheaper than fuelwood and lessens the risk of deforestation, its use remains traditional (i.e., direct burning). Traditional uses of biomass have negative impacts on health and also contribute to localised air pollution. It is therefore necessary that investments and support are offered towards developing facilities and activities that add value to rice husk by using it for modern bioenergy – one of which is electricity generation.

4.3. **Local partnerships have enabled new business models** for rice husk-to-energy facilities for communities in Labutta. In both Bi Tut and Kan Bet, electricity provision is facilitated by partnerships which formed specifically to address the increasing demand for electricity in the village. Before these partnerships, locals relied on electricity from either diesel generators operated by private business owners or rice husk-to-energy facilities operated by individual millers. Table 8 compares the characteristics of existing rice husk-to-energy business partnerships in the case study sites in Labutta.

[5] In Bi Tut, farmers estimate that they use 6 bags of husk per month for cooking

Table 8. Husk-to-energy business models existing in Labutta

	Community partnership	Private partnership	
Village	Bi Tut	Kan Bet	
Partners	Technology developer, Local community, Government (DRD)	Local miller	Private business person
Year operational	2019	2004	2017
Source of rice husk	Millers in Bi Tut and neighbouring villages, gathered by hired villagers and brokers	Own milling facility	Local millers in Kan Bet
Biomass conversion technology & engine[6]	Gasification	Gasification	Combustion via boiler engine
Electricity use	Households (lighting and small appliances) Streetlighting Public buildings (i.e., school, monasteries, police station, office)	Households (lighting and small appliances) Local businesses (e.g., agricultural supply shops, rice trading shops)	
Installation cost	200,000 MMK for meter box	3,000 – 5,000 MMK for line connection	
Supply schedule	Sole supplier in village tract	Two facilities take turns in supplying electricity to the village tract:	
	6am – 12 nn 6 pm – 11pm	7am – 3pm 5pm – 11pm	4pm – 11pm
Cost of electricity per unit	450 MMK Free 15 units for public buildings	800 MMK	
Payment system	Reloadable pre-paid electricity card	Monthly door-to-door collection, Cash payment based on usage	

[6] All energy facilities run diesel generators as back up when demand is high

Power generation from rice husk via small-scale gasification or combustion is common in many rural agricultural areas of Myanmar, offering a way to address the lack of access to electricity in off-grid areas like Bi Tut and Kan Bet with potential development co-benefits especially when environmental concerns are overcome (See Figures 12 and 13) (Hossain et al. 2018; Nguyen et al. 2015). Other researchers (e.g., Pode et al. 2016) also conclude that using rice husk for energy production is a self-sustainable option for rural electrification arguing that husk-to-energy facilities could be deployed easily without the need for government subsidy or grants.

Figure 12. A medium-scale milling facility drains wastewater into the river

Figure 13. Direct burning of rice husk produces smoke and ash

As observed in Bi Tut and Kan Bet, local partnerships (i.e., between community members, technology developers, government) play an important role in enabling this. A potential way forward, therefore, is to ensure that existing partnerships are supported via capacity building and financing. This could enable millers to adopt environmentally-friendly practices in managing rice husk waste by investing in more efficient zero-effluent gasifier facilites that integrate gas cleaning systems and waste water treatment plants (IEA Bioenergy 2012; Prabhansu et al. 2015; Abdoulmoumine et al. 2015; Woolcock and Brown 2013)

4.4. Small-scale millers are important to livelihood activities in off-grid areas

Social network analysis and statements from interviews reveal that smallholder farmers – especially those that live in areas that are not regularly visited by traders – mill their produce directly through small-scale millers. This suggests that small-scale millers play an important role in supporting rice production activities of smallholders.

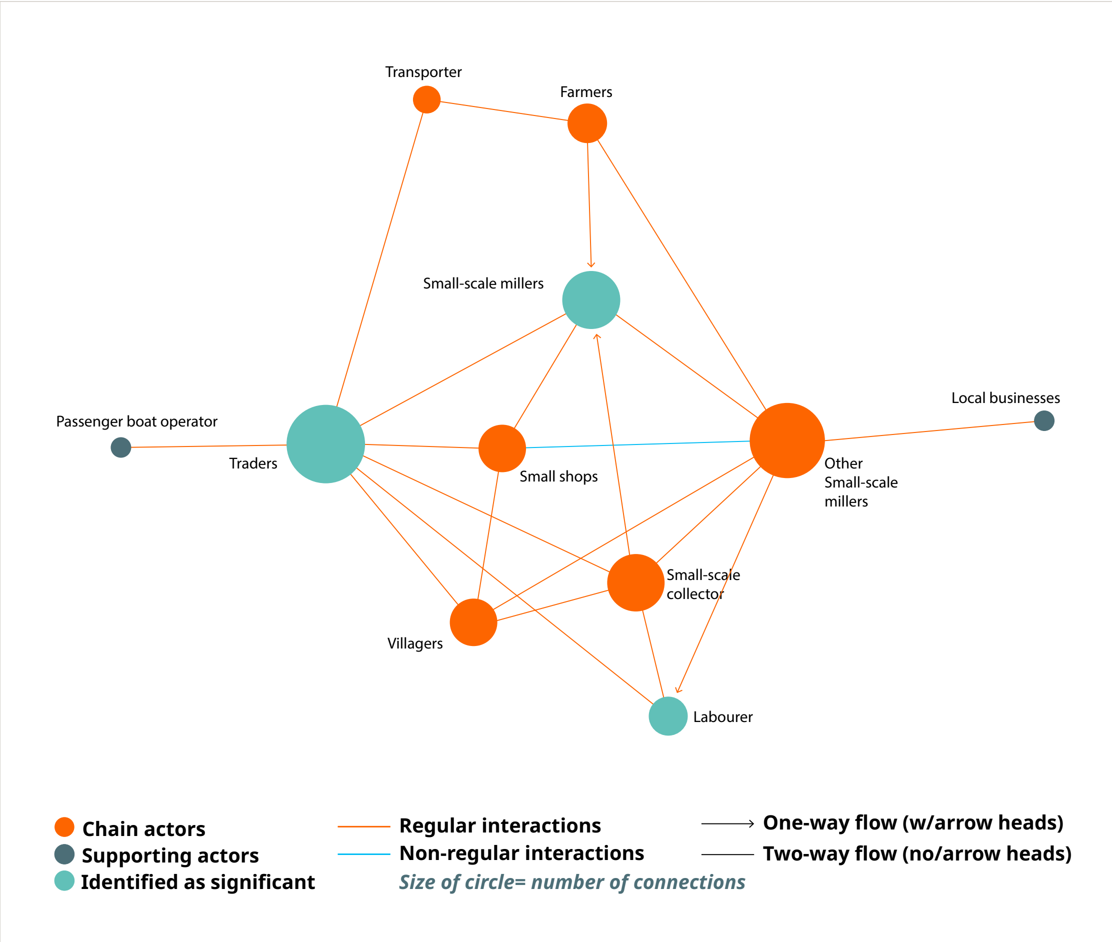


Figure 14. Social network map of small-scale millers

As visually presented in the social network map in Figure 14, small-scale millers work with other small-scale millers to provide milling services to farmers (e.g., referring farmers to other small-scale millers if they reach milling capacity, sharing storage facilities). They also have high number of connections (size of circle) and similar closeness centrality score to traders (0.71) (See Appendix A), which means small-scale millers and traders have an equal level of influence over milling activities in the villages. This finding provides a case for supporting small-scale millers who, according to participants, receive less support from the government than larger scale millers in terms of addressing their financial and technological needs.

Small-scale millers also often use diesel-powered and rice husk gasification engines for milling which can both be costly and have negative environmental impacts (Pode et al. 2016). As such, supporting millers through investments and financing for technological upgrading has the potential to not only benefit agricultural livelihoods in off-grid areas but also minimise environmental impacts. After technological upgrading, small-scale millers suggest that they could then consider adopting value-added activities for rice husk management (e.g., composting, briquettes, concrete (Kishore et al. 2011; Lim et al. 2012; Hossain et al. 2018; Sekifuji et al. 2019) if training is offered, for example, by civil society organisations.

Small-scale milling facility powered by diesel generator

4.5. Medium-scale millers are willing to participate in new or additional rice husk value added activities if other actors or businesses are facilitating these.

Focus group discussions revealed that medium-scale millers are more interested in improving the quality of their milled rice through investing in dryers which could help improve their milling quality instead of producing value-added products from husk. Although some millers are already making briquettes or fuel sticks from rice husk, they argue that this product has low market demand. Nonetheless, millers expressed interest in providing excess rice husk to local businesses and husk-to-energy facilities for a fee[7] and if they will not handle its collection and transportation.

In Labutta, local businesses that buy rice husk from medium-scale millers use it as feedstock for boiler engines in their production facilities (i.e., for noodle production and brick making). The rice husk value chain map in Figure 9 shows that local businesses are currently *supporting actors.* This means they are not directly involved in the activities related to producing value-added products from husk (Stein and Barron 2017) but have an important role in ensuring that rice husk is utilised.

To facilitate rice husk utilisation and increase income from it, it is necessary to improve *vertical coordination* between millers and local businesses. This means having longer term contractual agreements instead of one-off deals (see blue line on Figure 9). This would, however, require relationship and trust building between the actors in order to sustain product and financial flow (Mitchell et al. 2009).

[7] Statement from millers is "interested in more income from husk"

4.6. **In order for rice husk bioenergy to benefit farming households and agricultural livelihoods, a number of policy and market conditions will need to be met first.** These conditions also complement upgrading strategies[8] for rice and rice husk value chains:

- **Developing economies of scale to improve marketability of rice husk use in energy generation**.

  There is potential to expand the rice husk market if issues (i.e., collection, transportation, storage) in husk production and processing are addressed (See Table 2, Challenges and Constraints and Figure 3, Context). One of the ways this can be done is if paddy collectors, transporters, and storage owners[9] also participate in the rice husk value chain by collecting, transporting and storing husk for local businesses or energy facilities that use it for power and heat generation (inter-chain upgrading).

- **Policy to encourage public-private research partnership for rice husk bioenergy technology development (e.g., gasification) and testing**

  Myanmar's National Energy Policy (The Republic of the Union of Myanmar 2014) includes a work programme[10] to develop biomass-to-energy for rural household cooking and electrification; however, the programme focuses less on generating electricity from rice husk compared to biogas from animal waste and biofuel production from crops. Policy and institutional support for rice husk bioenergy will be necessary to ensure that existing and future husk-to-energy facilities use improved technologies that do not contribute to negative environmental and health impacts (e.g., wastewater drained into the river, smoke and ash released from burning).

- **Financial support for millers, especially small-scale and husk-to-energy operators to enable investment in 'efficient rice husk-to-energy facilities'**

  Under fair financing schemes and/or cost-sharing through community partnerships, rice husk bioenergy can be instrumental in delivering access to electricity and in supporting agricultural production in off-grid communities (Bhattacharyya 2013). For millers without a grid connection, access to electricity via rice husk bioenergy can be an opportunity to adopt mechanised methods of drying and improve the quality of their milled rice (product upgrading). In doing so, millers can have more control over the quality of their product. At the same time, labour for drying will no longer be provided by smallholder farmers[11] giving them more time and opportunities to better participate in other areas of the rice value chain such as trading or sourcing better quality inputs.

[8] See Appendix E. Interpretation of upgrading strategies.

[9] *Collectors and transporters* are actors in small-scale milling value chain, while storage owner is an actor in the rice value chain for Bi Tut Non-FPE.

[10] Section 4B Work Program (iv).

[11] *Context of Bi Tut value chain:* Millers ask farmers to re-dry paddy if they do not meet moisture content requirements; However, it is possible that costs will be incurred or deducted from income from selling wet paddy

Fulfilling these conditions is prerequisite to sustainably linking access to energy from rice husk to agricultural livelihoods. Since these elements require long term planning and implementation, research results point to the need to address the more urgent value chain upgrading activities which that emerged from discussions with farmers. These are:

- **Addressing issues in rice trading to increase farmers' income**

  In Bi Tut, the FPE Committee can take a bigger role during trading, for example, by negotiating as a group to ensure that trading prices offered to farmers are fair *(functional upgrading)*. Their centrality in the value chain (See Figure 5 and Appendix C) suggest that their influence in the network can be useful in increasing farmers' income. For non-FPE members, discussions revealed that farmers can increase the value of their harvest and have more control during trading if they are able to access storage facilities. As presented in Figure 6, *storage owners* connect to both *millers* and *traders* signifying that it has an important role during trading.

- **Linking groups of farmers to service providers in order to lower cost of production**

  In Kan Bet, other than financing and trading issues, the limitation of the labour force (i.e., in terms of availability) emerged as one of the top constraints to increasing farmers' productivity (Table 1). According to farmers, they rely on groups of labourers to help in farm production since they are not always able to use agricultural machineries in their field because of their location and type of soil (i.e., soft). A potential value chain intervention to address this is for farm managers of neighbouring farms (who may not necessarily be village neighbours) to coordinate and hire labourer groups and agricultural machine services together *(horizontal coordination)*.

  The resulting network maps of Kan Bet FPE (Figure 7) and non-FPE (Figure 8) members show weaker social cohesion compared to farmers in Bi Tut (Appendices B and C) and therefore could benefit from more farmer-to-farmer interaction. Interactions such as hiring shared services can improve social cohesion by empowering farmers to cooperate and act together. Furthermore, it can also help farmers to lower their costs, increase income and reduce risks (Kilelu et al. 2017; Evers and Ewert 2015).

5 Concluding remarks

These results encourage thinking about the role of energy in poverty alleviation, vis-à-vis urgency and justice – what is needed now and what is fair, especially to smallholders in rice production. Results from our case study sites in Labutta provide evidence that there are more urgent needs to be addressed before *using rice husk as feedstock for energy production* can improve agricultural livelihoods. Addresing these needs should start with providing access to finance to both farmers and millers, ensuring that locals have access to bioenergy technologies that do not have negative environmental and health impacts, and then supporting the development of the rice husk market – all of which will benefit from policy and institutional support.

Whilst locals shared sentiments in favour of accessing support (especially finance) from civil society organisations (i.e., NGOs such as Mercy Corps – but this may be unsustainable for the long term and unscalable), support is also seen to be available within communities and from market-based financial institutions. In particular, strong FPE groups and local partnerships (e.g., community-partnered husk-to-energy facility in Bi Tut and private business partnerships in Kan Bet) show how future business models of rice husk bioenergy might be shaped in ways that involves local people and businesses.

Access to energy therefore can genuinely serve agricultural livelihoods and contribute to poverty alleviation if solutions are offered in ways that build upon (1) addressing communities' immediate needs (2) and use and enhance existing capacities within the communities. The value chain upgrading strategies proposed in this report offer some ways to do this.

6 Future work

This project used value chain analysis to understand the current state of rice production and rice husk use in Bi Tut and Kan Bet in Labutta. Whilst a number of upgrading strategies and recommendations have been identified, additional research will be useful to understand the feasibility of deploying rice husk gasification facilities in off-grid areas in Myanmar:

- Economic assessment to understand financial feasibility of investing in rice husk gasification versus other existing renewable energy technologies in off-grid areas (e.g., solar panels, rice husk boiler, diesel engines)

- Research taking a development financing lens to explore challenges, opportunities and multi-actor solutions that could enable local banks and other financiers to lend to smallholders, as well as to explore the role of local and international development partners

- For Labutta-based millers who have access to the grid, financial feasibility of investing in rice husk bioenergy to power their dryers and milling machines versus connection to the grid

- Agricultural economic analysis to understand how small-scale rice producers can achieve return of investment in husk bioenergy solutions, e.g., financial gain from reducing rice breakage through mechanised drying

7 References

Abdoulmoumine, N. et al. (2015). A review on biomass gasification syngas cleanup. *Applied Energy*, 155, pp.294–307.

Bellanca, R. and Garside, B. (2013). *An approach to designing energy delivery models that work for people living in poverty*. London. [online]. Available from: http://pubs.iied.org/pdfs/16551IIED.pdf [Accessed November 8, 2018].

Bhattacharyya, S.C. (2013). Financing energy access and off-grid electrification: A review of status, options and challenges. *Renewable and Sustainable Energy Reviews*, 20, pp.462–472. [online]. Available from: https://linkinghub.elsevier.com/retrieve/pii/S1364032112007046 [Accessed November 26, 2018].

Evers, A. and Ewert, B. (2015). Social innovation for social cohesion. In *New Frontiers in Social Innovation Research*. Springer, pp. 107–127.

GRiSP. (2013). *Rice Almanac: Source Book for One of the Most Important Economic Activities on Earth*. 4th editio. J. Maclean, B. Hardy, & G. Hettel, eds. Los Baños (Philippines): IRRI.

Hossain, S.S., Mathur, L. and Roy, P.K. (2018). Rice husk/rice husk ash as an alternative source of silica in ceramics: A review. *Journal of Asian Ceramic Societies*, 6(4), pp.299–313. [online]. Available from: https://www.tandfonline.com/doi/full/10.1080/21870764.2018.1539210 [Accessed February 4, 2020].

IEA. (2018). Myanmar: Total Primary Energy Supply (TPES) by source (chart). *IEA Statistics*. [online]. Available from: https://www.iea.org/statistics/?country=MYANMAR&year=2016&category=Key indicators&indicator=TPESbySource&mode=chart&categoryBrowse=false&dataTable=BALANCES&showDataTable=true.

IEA Bioenergy. (2012). *Technology Roadmap: Bioenergy for Heat and Power*. [online]. Available from: www.iea.org/about/copyright.asp [Accessed January 31, 2020].

ILOSTAT. (2019). Employment in agriculture (% of total employment) - Myanmar. [online]. Available from: https://data.worldbank.org/indicator/SL.AGR.EMPL.ZS?locations=MM [Accessed January 20, 2020].

IRRI. (2018). Myanmar: Milled Rice Production 2018. *World Rice Statistics*. [online]. Available from: http://ricestat.irri.org:8080/wrsv3/entrypoint.htm [Accessed March 22, 2020].

Kilelu, C. et al. (2017). Value Chain Upgrading and the Inclusion of Smallholders in Markets: Reflections on Contributions of Multi-Stakeholder Processes in Dairy Development in Tanzania. *The European Journal of Development Research*, 29, pp.1102–1121. [online]. Available from: www.palgrave.com/journals [Accessed November 7, 2019].

Kishore, R., Bhikshma, V. and Jeevana Prakash, P. (2011). Study on strength characteristics of high strength Rice Husk Ash concrete. In *Procedia Engineering*. pp. 2666–2672.

Lim, S.L. et al. (2012). Biotransformation of rice husk into organic fertilizer through vermicomposting. *Ecological Engineering*, 41, pp.60–64.

Ministry of Labour Immigration and Population. (2017). *2014 Myanmar Population and Housing Census: Labutta Township Report*.

Mitchell, J., Coles, C. and Keane, J. (2009). *Upgrading along Value Chains: Strategies for poverty reduction in Latin America*.

Nguyen, H.N., Ha-Duong, M. and Van de Steene, L. (2015). A critical look at rice husk gasification in Cambodia: Technology and sustainability. *Journal of Science and Technology*, 53(3A).

Pode, R., Pode, G. and Diouf, B. (2016). Solution to sustainable rural electrification in Myanmar. *Renewable and Sustainable Energy Reviews*, 59, pp.107–118. [online]. Available from: https://www.sciencedirect.com/science/article/pii/S1364032115017037 [Accessed April 18, 2019].

Prabhansu et al. (2015). A review on the fuel gas cleaning technologies in gasification process. *Journal of Environmental Chemical Engineering*, 3(2), pp.689–702.

Sekifuji, R., Chieu, L. Van and Tateda, M. (2019). Investigation of negative effects of rice husk silica on komatsuna growth using three experiments. *International Journal of Recycling of Organic Waste in Agriculture 2019 8:1*, 8(1), pp.311–319. [online]. Available from: http://link.springer.com/10.1007/s40093-019-00303-w.

Sovacool, B.K. (2013). Confronting energy poverty behind the bamboo curtain: A review of challenges and solutions for Myanmar (Burma). *Energy for Sustainable Development*, 17(4), pp.305–314.

Stein, C. and Barron, J. (2017). *Mapping actors along value chains: integrating visual network research and participatory statistics into value chain analysis*. Colombo, Sri Lanka: CGIAR Research Program on Water, Land and Ecosystems (WLE). [online]. Available from: http://www.iwmi.cgiar.org/publications/other-publication-types/books-monographs/iwmi-jointly-published/research-for-development-learning-series-issue-5/ [Accessed August 17, 2018].

The Republic of the Union of Myanmar. (2014). *National Energy Policy*.

Tun, M.M. and Juchelková, D. (2019). Biomass Sources and Energy Potential for Energy Sector in Myanmar: An Outlook. *Resources*, 8(2), p.102. [online]. Available from: https://www.mdpi.com/2079-9276/8/2/102 [Accessed March 22, 2020].

UN SE4ALL. (2016). *Data Catalog*. [online]. Available from: https://datacatalog.worldbank.org/dataset/sustainable-energy-all [Accessed October 1, 2018].

Vaghela, D. (2018). Financing Economically Viable Decentralized Renewable Energy: Biomass Gasifiers and Micro/Mini Hydropower in Myanmar . In *Low Carbon Energy For Development Network 7th Annual Conference*.

Woolcock, P.J. and Brown, R.C. (2013). A review of cleaning technologies for biomass-derived syngas. *Biomass and Bioenergy*.

World Bank. (2016). *Myanmar: Analysis of Farm Production Economics*.

World Bank. (2019). *Myanmar Rice and Pulses: Farm Production Economics and Value Chain Dynamics*.

Yunus, M. (2007). *Creating a world without poverty: Social business and the future of capitalism*. New York: PublicAffairs.

8 Appendices

A. Network characteristics of social network of small-scale and medium-scale millers

Characteristics	Interpretation	Small-scale millers	Medium scale millers
Nodes and edges			
Number of nodes	Count of actors in the network	11 nodes	6 nodes
Number of edges	Count of all connections	21 edges	7 edges
Centrality measures			
Betweenness centrality	Actors with the highest scores that act as bridges and can control the flow of resources	• Trader, 15.1 • Other millers, 13.7	• Medium-scale millers, 8.0
Closeness centrality	Actors with the highest scores that have the ability to influence the entire network	• Trader, 0.71 • Other millers, 0.7 • Small-scale millers, 0.67 • Small-scale collectors, 0.67	• Medium-scale millers, 1.0
Cohesion			
Density	Higher density, higher social cohesion	0.38	0.30
Average degree	Higher degree, more connectivity	3.82	2.33
Path length	Lower path length, quicker resource sharing	1.72	1.53
Modularity	Higher value means more significant internal grouping	0.118	0.122

B. Network characteristics of FPE and Non-FPE Groups in Kan Bet

Characteristics	Interpretation	Small-scale millers	Medium scale millers
Nodes and edges			
Number of nodes	Count of actors in the network	11 nodes	13 nodes
Number of edges	Count of all connections	11 edges	15 edges
Centrality measures			
Betweenness centrality	Actors with the highest scores that act as bridges and can control the flow of resources	• Farmer, 44.0	• Farmer, 60.0 • Rice shop owner, 11.0
Closeness centrality	Actors with the highest scores that have the ability to influence the entire network	• Farmer, 1.0 • Miller, 0.55 • Trader, 0.55	• Farmer, 0.92 • Rice shop owner, 0.6 • Miller, 0.57 • Trader, 0.57
Cohesion			
Density	Higher density, higher social cohesion	0.20	0.19
Average degree	Higher degree, more connectivity	2.0	2.31
Path length	Lower path length, quicker resource sharing	1.8	1.91
Modularity	Higher value means more significant internal grouping	0.116	0.264

C. Network characteristics of FPE and Non-FPE Groups in Bi Tut

Characteristics	Interpretation	Small-scale millers	Medium scale millers
Nodes and edges			
Number of nodes	Count of actors in the network	15 nodes	11 nodes
Number of edges	Count of all connections	25 edges	15 edges
Centrality measures			
Betweenness centrality	Actors with the highest scores that act as bridges and can control the flow of resources	• FPE, 44.3 • Farmer, 30.5 • Miller, 17.0	• Farmer, 37.7 • Trader, 1.3
Closeness centrality	Actors with the highest scores that have the ability to influence the entire network	• FPE, 0.77 • Farmer, 0.73 • Miller, 0.61	• Farmer, 1.0 • Trader, 0.62 • Inputs supplier, 0.52 • DOA, 0.52 • Service provider, 0.52 • MADB, 0.52
Cohesion			
Density	Higher density, higher social cohesion	0.23	0.27
Average degree	Higher degree, more connectivity	3.33	2.73
Path length	Lower path length, quicker resource sharing	1.97	1.73
Modularity	Higher value means more significant internal grouping	0.29	0

D. Comparison of influence scores based on farmers' statements and centrality measures

High-scoring influential actors based on			
	Participants' statements	**Betweenness centrality**	**Closeness centrality**
top actors that	*are important in value chain*	*controls flow of resources*	*influences the network*
small-scale	miller trader labourer	trader other millers	trader other millers
medium-scale	miller machine controller labourer	miller	miller
Kan Bet FPE	farmer money lender labourer	farmer	farmer miller trader
Kan Bet non-FPE	farmer money lender labourer	farmer rice shop owner	farmer rice shop owner miller trader
Bi Tut FPE	farmer trader labourer	FPE farmer miller	FPE farmer miller
Bi Tut non-FPE	farmer trader labourer	farmer trader	farmer trader inputs supplier DOA service provider MADB

E. Anonymised list of farmer participants (part 1)

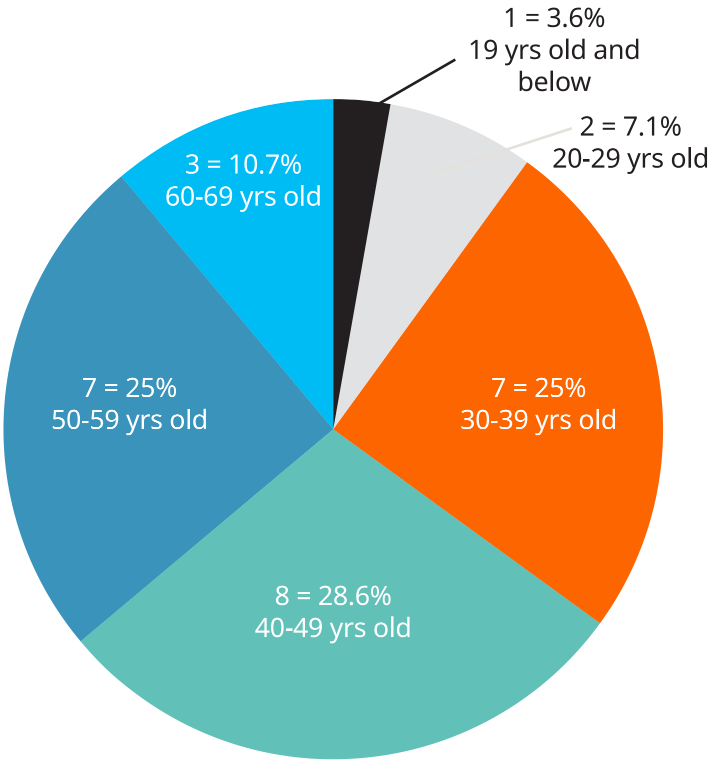
No.	Code	Village	Membership	Role	Age	Age group	Gender
1	BF-1	Bi Tut	FPE	farm manager	36	30-39	M
2	BF-2	Bi Tut	FPE	farm manager	48	40-49	M
3	BF-3	Bi Tut	FPE	farm manager	40	40-49	M
4	BF-4	Bi Tut	FPE	farm manager	47	40-49	M
5	BF-5	Bi Tut	FPE	farm manager	36	30-39	M
6	BN-1	Bi Tut	Non-FPE	farm manager	56	50-59	M
7	BN-2	Bi Tut	Non-FPE	labourer	45	40-49	M
8	BN-3	Bi Tut	Non-FPE	farm manager	36	30-39	M
9	BN-4	Bi Tut	Non-FPE	farm manager	39	30-39	F
10	KF-1	Kan Bet	FPE	farm manager	43	40-49	M
11	KF-2	Kan Bet	FPE	farm manager	44	40-49	F
12	KF-3	Kan Bet	FPE	farm manager	37	30-39	M
13	KF-4	Kan Bet	FPE	farm manager	66	60-69	M
14	KF-5	Kan Bet	FPE	farm manager	51	50-59	F
15	KN-1	Kan Bet	Non-FPE	farm manager	46	40-49	M
16	KN-2	Kan Bet	Non-FPE	farm manager	19	10-19	M
17	KN-3	Kan Bet	Non-FPE	farm manager	58	50-59	F
18	KN-4	Kan Bet	Non-FPE	farm manager	24	20-29	M
19	KN-5	Kan Bet	Non-FPE	labourer	51	50-59	M

E. Anonymised list of farmer participants (part 2)

No.	Code	Village	Member of milling org'n?	Role	Age	Age group	Gender	Milling capacity (baskets)	Drying facility	Power source
23	SM-4	Pain Hne Taung	Yes	small scale miller	66	60-69	M	200	Yes	diesel
24	SM-5	Pain Hne Taung	No	small scale miller	34	30-39	M	100	Yes	diesel
25	MM-1	Laputta	Yes	medium scale miller	54	50-59	M	1500	Yes	EPC grid
26	MM-2	Laputta	Yes	medium scale miller	30	30-39	M	1500	No	EPC grid
27	MM-3	Laputta	Yes	medium scale miller	25	20-29	M	1500	Yes	EPC grid
28	MM-4	Laputta	Yes	medium scale miller	61	60-69	M	1200	No	EPC grid

G. Age and gender of farmer and miller participants

Age (years)	No. of participants
19 and below	1
20-29	2
30-39	7
40-49	8
50-59	7
60-69	3



Gender	No. of participants
Male	24
Female	4