The Rice Seed Supply and Demand System in the Ayeyarwady Delta, Myanmar

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Context

Rice is a priority crop for local and national food security in Myanmar; it is not only the most important crop for home consumption, but also a crop with large export potential. Twenty five per cent of the rice acreage is located in the Ayeyarwady delta. In many studies, access to and the use of quality seed of well adapted and farmer-preferred varieties is indicated as a key bottleneck to further professionalise the rice sector. The purpose of this study was to analyse the rice seed sector in the Ayeyarwady delta and document seed use, demand and supply. The study aims to provide the Livelihood and Food Security Trust Fund (LIFT) with recommendations for its future investments for improving the rice seed sector's performance in an integrated and sustainable way, in order to enhance farmers' access to quality seed of superior varieties and contribute to food security and economic development.

This study

The study consisted of three components: (i) a seed use survey; (ii) a seed supply survey; and (ii) a seed sector assessment. Based on these study components the study team was able to link variety, seed use and supply to develop a scenario for forecasting seed demand. The study has been implemented in four selected townships in the lower and upper Ayeyarwady delta. The lower and upper delta have different agroecologies and therefore farmers also show differences in rice growing techniques and use of varieties. The townships surveyed in the lower delta are Bogale and Labutta; the townships surveyed in the upper delta are Danuphyu and Hinthada. For the seed supply survey and the seed sector assessment, stakeholders outside of the Ayeyarwady region have also been visited, i.e. in Nay Pyi Taw, Yangon and Yezin.

Variety use

Our studies showed that 82 per cent of rice growers in the lower delta, and 95 per cent in the upper delta use one or two varieties per rice growing season. A generally observed trend is that with the commercialisation of a crop, the number of varieties grown by individual farmers reduces. The main selection criteria for varieties are yield potential, adaptability to soil conditions, market price and maturity period. Varieties used vary between the lower and upper delta, but also between the four townships. The Pawsan group of varieties and Thee Htet Yin are highly preferred in the lower delta, whereas Sin Thukha is highly preferred in the upper delta. Hmawbi-2 and Sin Thwe Latt are used in high frequencies in Danuphyu but not Hintada, whereas Shwe Wah Htun is very popular in Hinthada and rarely grown in Danuphyu. The Meedome group of local varieties is only grown in Labutta. Farmers are generally satisfied with their varieties, and 84 per cent in the lower delta and 68 per cent in the upper delta indicated that they will use the main variety of the last production season again. An average of 42 per cent of the farmers indicated that they renew their variety every 3 seasons; most probably they alternate varieties as part of a larger variety portfolio, and select a variety from this portfolio when they renew their seed stock. The main source of information on new varieties is from farmers' own observations and informal networks (85 per cent).

Seed use

The majority of the farmers – 96 per cent in the lower delta and 70 per cent in the upper delta – source their seed either from their own fields, or from other informal seed sources. Ninety per cent of farmers consciously select their seed based on the appearance in the field or at harvest. Formal and intermediary seed sources include specialised farmer seed producers, government projects and rice specialisation companies (RSCs). Seventy two per cent of the farmers interviewed in the lower delta and 82 per cent in the upper delta, indicated renewing their seed stock every 2 or 3 seasons. Grain yields appeared to be highest when farmers used first generation certified/quality seed. Yields are highly dependent on variety, for example the varieties of the local Pawsan group showed lower yields (47 baskets/acre, lower delta) than the variety Thee Htet Yin

(85 baskets/acre, lower delta). In specific cases, yields are also dependant on delta location. This was the case for the Sin Thukha variety which yielded much lower in the lower delta (42 baskets/acre) than in the upper delta (75 baskets/acre). Poverty level and gender of the head of the household hardly influenced grain yields. Using optimal urea applications influenced yields positively; and farmers producing grain for the RSC Gold Delta achieved higher yields. The latter is probably due to rice growing support received from the company. The higher sales prices for local varieties do not compensate for the lower yields obtained with local varieties, and gross profit is higher for farmers producing rice of improved varieties.

Early generation seed (EGS) production

The Department of Agricultural Research (DAR) is the sole producer of breeder seed for the Ayeyarwady region. Foundation seed is produced by four government run seed farms of DAR and the Department of Agriculture (DOA): (i) Myaungmya Research Farm in Myaungmya; (ii) Myanmar Rice Research Centre in Hmawbi; (iii) Tagontaing Seed Farm in Hinthada; and (iv) Thayaung Chaung Seed Farm in Pathein. A total of 1,208 baskets of foundation seed of 11 rice varieties was produced in the 2015/16 cropping season in the Ayeyarwady region. The same DOA and DAR seed farms produce registered seed, and also the Aukywingyi Seed Farm in Pyapon is involved in registered seed production. Development organisations such as Radanar Ayar and Metta Development Foundation are also supporting registered seed production. In the 2015/16 cropping season, a total of 23,657 baskets of registered seed of nine different varieties was produced and sold to township offices, development organisation projects, private companies and farmers directly. Registered seed produced in the Ayeyarwady region was also sold to customers in other regions such as Bago, Mandalay and Sagaing.

Varieties used for certified seed production

A total of 15 improved varieties are being used for certified seed production. The highest volume of certified seed produced is from six main varieties – Sin Thukha, Sin Thwe Latt, Paw San Yin, Thee Htet Yin, Ayar Min and Hnan Kar, which represent over 70 per cent of the total volume of certified seed produced each year.

Certified seed producers

Three distinct types of seed producer are involved in certified seed production in the Ayeyarwady delta. These include contact farmers, contract farmers and independent seed growers. Contact farmers are directly supported by the DOA extension office at township level; contract farmers are seed producers who multiply seed on contract for private companies or development organisation projects linked with rice millers; and independent seed growers are seed producers often supported by seed projects of development organisations. In Bogale Township contact farmers supported by the DOA extension office are the major source of certified seed providing almost 90 per cent of the total volume of certified seed produced over the past four years, whilst development organisations, mainly Radanar Ayar, GRET and WHH, supported the remaining 10 per cent. In Labutta Township, DOA extension supported contact farmers produced over 80% of the total amount of certified seed produced over the past four years; projects implemented by Mercy Corps and the Japan International Cooperation Agency (JICA) have supported contract farmers to produce the remaining 20 per cent of certified seed. In Hinthada Township, only DOA extension supported contact farmers produced certified seed. However, in Danphyu Township, certified seed produced by the contract farmers of the RSC Gold Delta was approximately 40 per cent of the total amount of certified seed disseminated in the township over the past four years.

Trends of certified seed production

The volumes of certified seed production and sales show an increasing trend from 2012 to 2015 of at least 6.5 per cent each year, while there was a decrease of 4 per cent in the 2015/16 season. Seed producers sell on average 62 per cent of the total amount of certified seed they produce. By measuring the amount of certified seed disseminated, it is estimated that less than 6 per cent of the total rice production area in the Ayeyarwady region is currently cultivating certified seed. Overall, there is an increasing trend of certified seed production in all four study townships. The seed distribution data from the four townships show that the upper Ayeyarwady delta has a higher

percentage of rice production area cultivating certified seed than the lower delta. The lower delta has 0.4 to 5 per cent of the area covered by certified seed, while this is 8 to 29 per cent in the upper delta.

Rice seed systems in the Ayeyarwady region

The seed sector analysis showed that seed systems in the Ayeyarwady delta can be generalised into three clusters: informal seed systems; formal seed systems; and intermediary seed systems with facilitated loose or temporary linkages to the formal systems. The informal system includes farmer-saved seed, and seed exchanged with family, friends and neighbours. In the informal system, both local and recycled improved varieties (second or higher generation recycled seed) are important. The formal system can be divided into two sub-systems, i.e. the public-private system and the private system. In the public-private system, through the DOA extension, DOA seed farms provide contact farmers with registered seed which is multiplied into certified seed. The formal private system is run by private companies which often work with seed contract growers. Private RSCs like Gold Delta produce certified seed with selected contract growers; this seed is sold to their contract grain growers as a service. In the intermediary seed system, several development organisations including LIFT partners, support seed growers organised in different ways in the production of quality seed.

Rice seed value chain

Seed value chain operations include plant genetic resource management, variety development, EGS production, seed multiplication, seed dissemination and finally, seed use. Farmers using the seed as input for grain production are driving the seed value chain. The operators in the value chain are supported by service providers. Seed value chain services include seed quality assurance, credit for seed producers and seed extension. Seed operators and service providers work in a specific context or enabling environment. The main challenges for rice seed chain operators are promoting variety turn-over, creating variety awareness/popularising new varieties, inadequate seed production and processing equipment, access to sufficient quantities of quality registered seed, access to seed inspection services, sustainability of community-based production schemes, and unstable demand for certified/quality seed. The main challenges for rice seed chain service providers are insufficient capacity for seed inspection, lack of internal quality control procedures by some seed producers, limited capacity and infrastructure of the Yangon seed laboratory, lack of responsibility of variety promotion/market development for new varieties, lack of credit for seed production and a fragmented seed value chain with limited communication and collaboration between different stakeholders.

Seed intervention landscape

Through its various implementing partners, LIFT is a key development partner involved in seed sector development in the Ayeyarwady delta. LIFT's implementing partners include the International Rice Research Institute (IRRI), Radanar Ayar Rural Development Association, Metta Development Foundation, Mercy Crops and a consortium of WHH and GRET. Besides these, JICA, the Australian Centre for International Agricultural Research, and the Food and Agriculture Organization have been involved in supporting seed production and dissemination projects. Most interventions focussed on the intermediary seed system, while few targeted the formal public-private seed system. Further, various seed interventions supported seed value chain operators and service providers, whilst the seed policy and enabling environment was least supported.

Seed policy environment

Myanmar has made significant progress over the last three years in the development and establishment of the national seed policy and regulatory frameworks. A new national seed policy was approved in 2016; the existing Seed law enacted in 2011, was amended in 2015; the national seed regulations were approved in 2016; and the Plant Variety Protection law was approved by the end of 2015. Also, the protection of farmers' rights and enhancement of their benefits was enacted in 2013. In addition, Myanmar has enacted a number of policies that are supportive to the seed sector, which include the Plant Pest Quarantine law of 1993; the Fertiliser law of 2002; the Pesticide law of 1990; and the Farmland law of 2012. Moreover, based on the above mentioned

policy framework and other strategic documents, in 2016 a seed road map has been developed and approved by the Ministry of Agriculture, Livestock and Irrigation.

Policies and private seed sector development

The national seed policy provides an integrated perspective on the development of the seed sector and its various seed systems. Both the Seed law and seed regulations promote a pathway of liberalisation for the seed sector, decreasing the role of the public sector and increasing the role of the private sector. This provides opportunities for the private sector in variety registration, EGS production, internal seed quality control through on-site seed laboratories, and reduction of fake seed in the seed market by enforcing mandatory information on seed labels. Further, the variety registration process has become more efficient by shortening it to one season and limiting it to three location trials.

Policies and challenges for the intermediary seed system

However, the seed law and seed regulations have also created constraints to certain seed systems. In relation to seed certification, the Seed law and regulations require a mandatory and full certification system. Considering the current capacity and status of the intermediary seed system in Myanmar, it would be beneficial to allow alternative quality assurance systems like a system of Quality Declared Seed (developed by FAO), or a system of truthfully labelled seed (like in Bangladesh, India and Nepal). Also, the participatory guarantee system, a quality control system applied for community-based seed production by a number of LIFT implementing partners, may be considered as an alternative system to support small-scale, farmer-based and decentralised seed production schemes. The Seed law and seed regulations allow a stronger private sector role in the production of EGS. However, there is a need to define the division of roles between the public and private sector for this task.

Business and investment climate in Myanmar

The recently launched World Bank Group report *Enabling the Business of Agriculture* (EBA) measures and monitors regulations that affect the functioning of agriculture and agribusiness in 40 countries. The World Bank EBA project used 18 indicators covering six topics namely seed, fertilisers, machinery, finance, transport and markets. Among the six key areas analysed in the report, Myanmar is ranking lowest as compared to its neighbouring/Association of Southeast Asian Nations countries, in finance, transportation and markets. It is second lowest in machinery and seed. Coversely, Myanmar ranked second highest in fertilisers after Vietnam.

Regional seed demand and scaling up

At the level of the Ayeyarwady region, 522,835 baskets of certified seed were disseminated in 2016/17, sufficient to cover 4.2 per cent of the total rice area. With minor annual increases (1 per cent) in rice area and seed production, and without interventions in seed sector development, the quantity of certified seed is estimated to increase to 550,000 baskets over 5 years. However, with investment in seed sector development, and with a 4 per cent annual rate of increase in certified seed purchase, the seed market would grow to 667,500 baskets, and cover nearly 5 per cent of total rice area by 2021/22. This is still a modest seed purchase frequency, but represents an additional 118,000 baskets of certified seed which would cover 48,000 acres. The area for certified seed production would need to increase from 9,142 to 11,218 acres, requiring significant organisational infrastructure with seed growers and market development. Similarly, the EGS system would need to increase modestly to facilitate the growth in certified seed production. This forecast growth in the seed market would need to be strategically planned, and hence, a more focussed approach at the township level is required.

Seed demand in the study townships

In the current report we provide separate seed demand projections for Danuphyu and Hintada townships in the upper Ayeyarwady delta because of differences, and joint seed demand projections for Bogale and Labutta townships in the lower Ayeyarwady delta because of similarities shown in rice production and certified seed-use characteristics. Different demand projections were based on the current proportions of land area sown with certified seed.

Associated requirements of registered seed, foundation seed and breeder seed were also calculated for the four townships.

Supporting seed sector transformation

Based on our studies of seed demand, seed use and seed supply, and on the seed sector and seed value chain analysis, which includes an analysis of the enabling environment, we have formulated recommendations for strengthening the Ayayarwady delta rice seed sector. We organised the recommendations using five building blocks of rice seed sector transformation: (i) strengthening of the demand; (ii) organisation of the production base; (iii) organisation of the service sectors; (iv) public sector governance; and (v) sector alignment and accountability.

Key recommendations

1. Promote the uptake of new varieties through providing farmers with adequate information on these varieties
2. Promote the uptake of new varieties through market creation
3. Strengthen the demand for quality seed by showing its value to farmers
4. Strengthen the demand for quality seed by differentiating for quality in the grain market
5. Strengthen the informal seed system for increased access to farmer preferred varieties and quality seed
6. Strengthen the business orientation of seed producers in intermediary seed systems
7. Upgrade the seed production infrastructure of the public seed farms
8. Upgrade capacity and infrastructure of the Yangon seed quality control laboratory
9. Develop a township level seed quality assurance unit
10. Strengthening seed processing and storage facilities
11. Support an enabling seed regulatory framework for emerging private seed producers
12. Establish a seed sector platform for dialogue, alignment and coordination for the Ayeyarwady region

For each recommendation we describe in the report the current situation and the change envisaged. We shortly describe actions contributing to the strategy, who should be involved in its implementation, and how LIFT may potentially contribute. In specific cases we also give examples related to the strategy, either encountered in Myanmar or in other countries.

List of abbreviations and acronyms

ACIAR	Australian Centre for International Agricultural Research
ADSP	Agricultural Development Support Program
CDI	Centre for Development Innovation
DAR	Department of Agricultural Research
DOA	Department of Agriculture
DUS	Distinctness, uniformity and stability
EGS	Early generation seed
FAO	Food and Agricultural Organization
FGD	Focus group discussion
HH	Head of household
IRRI	International Rice Research Institute
ISSD	Integrated seed sector development
ISTA	International Seed Testing Association
JICA	Japan International Cooperation Agency
LIFT	Livelihoods and Food Security Trust Fund
MADB	Myanmar Agricultural Development Bank
MMK	Myanmar Kyat
MOALI	Ministry of Agriculture, Livestock and Irrigation
ODK	Open Data Kit
OPV	Open pollinated variety
QDS	Quality Declared Seed
PBR	Plant breeders' rights
PGR	Plant genetic resources
PGS	Participatory guarantee system
PPP	Purchasing power parity
PVP	Plant Variety Protection
PVS	Participatory variety selection
RSC	Rice specialisation company
SPA	Seed producer association
SPC	Seed producer cooperative
UNOPS	United Nations Office for Project Services
UPOV	International Union for Protection of new Varieties of Plants
USAID	United States Agency for International Development
USD	United States dollar
VCU	Value for cultivation and use
WUR	Wageningen University & Research

1. INTRODUCTION

Display of different rice types at the Department of Agriculture (Thijssen, Wageningen Centre for Development Innovation, 2016)

Rice sector in Myanmar

Rice is the priority crop for local and national food security in Myanmar; it is not only the most important crop for home consumption, but also a crop with large export potential (Ministry of Agriculture and Irrigation and IRRI, 2015; Ministry of Commerce, 2015). Myanmar has 8 million ha of rice, of which 2 million are located in the Ayeyarwady region (Department of Agricultural Research interview). The Government of Myanmar aims to boost rice production and thus better ensure food self-sufficiency, as well as gain a larger share of Myanmar in international rice trade. In 2015, the Ministry of Agriculture, Livestock and Irrigation (MOALI, formerly Ministry of Agriculture and Irrigation) published the *Myanmar Rice Sector Development Strategy* (Ministry of Agriculture and Irrigation and IRRI, 2015), which aims to guide the Government in prioritising its rice sector investments and improving structural weaknesses in the rice value chain. The Department of Trade Promotion of the Ministry of Commerce, published the *Rice Sector Strategy 2015-2019*, as part of the *National Export Strategy* (Ministry of Commerce, 2015), providing directions for increasing rice marketability, rice production volumes and rice quality.

Access to quality seed of superior varieties is a key bottleneck

Both strategies mentioned above indicate the under use of quality seed of superior varieties as one of the weaknesses in the rice value chain, with poor understanding of seed quality and the low availability of quality seed mentioned as key bottlenecks in the rice value chain. Less than 10 per cent of the cultivated rice acreage is sown with high quality seed of improved varieties.

Challenges mentioned in relation to seed include:

- New high-yielding and stress-tolerant rice varieties do not reach farmers, and farmers continue to grow local varieties facing low productivity
- Farmers use their own farm-saved seed for the next season, which perpetuates problems of low seed quality, mixed varieties and low yields
- Government seed farms neither produce breeder and foundation seed of farmer-demanded varieties; nor do they produce sufficient quantities
- The rice value chain is very fragmented, due to limited communication and collaboration between different government institutes
- There are limited private investments and public-private partnerships due to unfavourable government regulations, with few private companies supplying certified and good quality seed

Purpose of the study

The Wageningen Centre for Development Innovation (CDI) at Wageningen University & Research (WUR) has been contracted by the United Nations Office for Project Services (UNOPS) to carry out a study on the rice seed supply and demand systems in the Ayeyarwady delta, Myanmar, for the Livelihood and Food Security Trust Fund (LIFT). The purpose of the study is to provide an analysis of the rice seed sector in the Ayeyarwady region that documents the demand and supply of quality seed. Moreover, the study shall characterise the different rice seed systems; analyse bottlenecks in rice seed value chains; evaluate the effect and influence of seed organisations and development projects on the sector; and examine the influence of the policy, legislative and regulatory environment on the sector. The study has to provide recommendations to LIFT for its future investments for improving the rice seed sector's performance in an integrated and sustainable way, in order to enhance famers' access to quality seed of superior varieties and contribute to food security and economic development.

Steps in the study and this report

The current report presents the findings of the field study, as implemented by a team of Dutch and Myanmar experts in the period 24 October to 2 November 2016. The study results were presented to rice seed sector experts at the Department of Agriculture (DOA) in Nay Pyi Taw on 17 January 2017 and reviewed by a number of invited experts and LIFT. Based on their comments, the report was further improved. It will be presented and discussed in a final workshop with a wide range of seed sector stakeholders working in the Ayeyarwady delta in Pathein on 24 March 2017.

The field study has been prepared through the development of a desk review and a research plan which have been published as separate documents (see below). LIFT reviewed and approved these documents before the start of the field study.

Desk review

The desk review (Thijssen *et al.*, 2016) has examined existing documentation on seed sector development in Myanmar and the Ayeyarwady region, including projects supported by LIFT. Based on recently published studies and strategic documents on the rice sector and the seed sector in Myanmar, as well as on policy documents, it gives background information on the seed sector in Myanmar and the Ayeyarwady delta. The desk review provides a first insight into the study questions as provided by the UNOPS request for proposals. Additional questions have been added, related to interventions as suggested in the recently published *Myanmar Rice Sector Development Strategy* (Ministry of Agriculture and Irrigation, 2015), as well as the road map for Myanmar's seed sector 2017-2020 (DOA, 2016). The information in the desk review was assessed through the field study and further detailed and revised where necessary.

Research plan

The review informed the design of the field research. The research plan (Subedi *et al.*, 2016) provides the study research questions, the research design, methods and tools, as well as the sampling strategy for both the quantitative and qualitative surveys, methods for data analysis and the work plan for the field work as well as the whole study. Key information necessary to understand the design of the study is summarised in the current study report.

Setup of the current report

The current report provides the results of the study. We introduce the study methodology in Chapter 2. In Chapter 3 we share the results of each of the study components, i.e. the seed use survey, the seed supply survey and the seed sector assessment. In Chapter 4 we discuss the linkages between variety and seed use and supply and demand; compare main results in the lower and upper delta of Ayayarwaddy; and compare different seed production and marketing business models. Chapter 5 concludes with strategic recommendations to improve the functioning of the rice seed sector, including possible interventions that may be supported by LIFT.

2. STUDY METHODOLOGY

The study team visits Metta seed farm (Subedi, Wageningen Centre for Development Innovation, 2016)

2.1 General study approach

2.1.1 Study team

The study team consisted of three international consultants – Abishkar Subedi (team leader) and Marja Thijssen, both of CDI in the Netherlands and Genevieve Audet-Bélanger of the Royal Tropical Institute (KIT), also based in the Netherlands. The team also included Tin Maung Shwe and Naing Lin Oo from the Myanmar organisation Agribusiness and Rural Development Consultants. Moreover, the team worked with 10 enumerators and two enumerator supervisors. The study team was divided into two groups which worked in parallel (the task division among the teams and the study schedule can be found in Annex 1).

2.1.2 Definitions

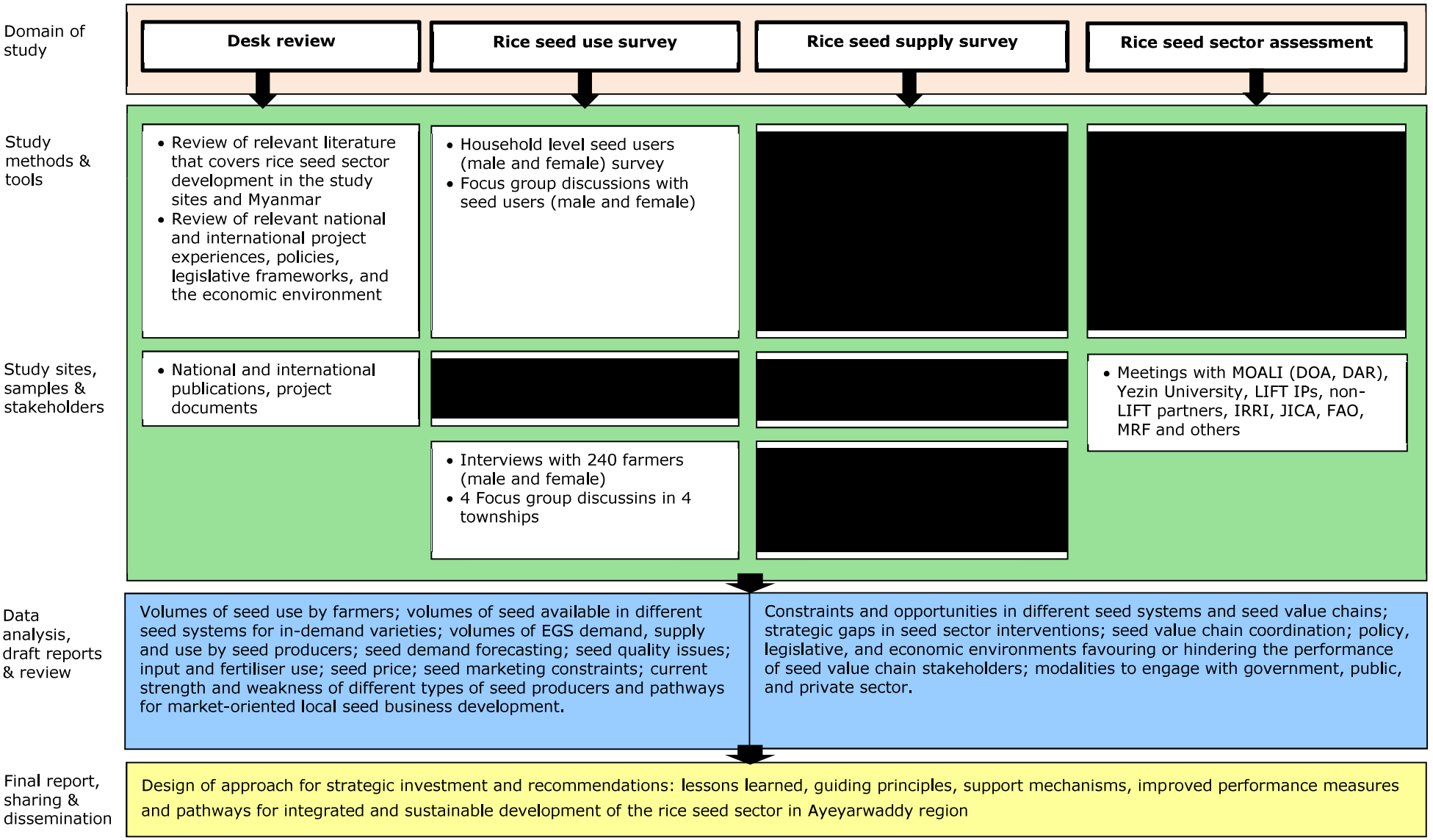
To ensure common understanding, the study team agreed to use a number of simple definitions for technical terms related to seed systems, varieties and seed:

- Formal seed systems: systems involving specialised activities of the seed value chain governed by an official regulatory environment. Seed in formal systems predominantly carries the label of full certification, and activities along the seed value chain are to a large extent commercialised
- Informal seed systems: systems including activities of farmers, rural communities and other stakeholders saving, exchanging, bartering, gifting, and selling seed without formal regulatory involvement and varying degrees of commercial orientation
- Intermediary seed systems: systems involving individual seed entrepreneurs and varying degrees of organised groups of seed producers and entrepreneurs and/or their associations that are engaged in commercial seed production and marketing with facilitated loose or temporary linkages to formal organisations including research, extension, markets, financial services, and regulation
- Local varieties including traditional varieties and landraces; varieties which have not been improved by formal research, and have been grown by farmers for generations
- Improved varieties including high yielding varieties (HYV); varieties which have been developed by formal research
- Superior varieties: varieties which fit with specific farmer demands, including improved varieties that have been formally released and possibly recycled through intermediary and informal seed systems, as well as local varieties
- Seed recycling: the practice of keeping a part of the grain harvest as seed to be sown the following season. Recycled seed can be sourced from the farmer's own field, but also exchanged within the community with other farmers, neighbours and family
- Quality seed: seed that germinates well and is free from seed-borne pests and diseases, and that has been produced with the intention of producing seed, following certain protocols; quality seed can be certified or not
- Certified seed: seed that has been produced with the intention of producing seed, following certain protocols; its quality is assured through field inspections and seed laboratory tests

2.1.3 Study outline

Find a summary of the study outline in Figure 1.

Figure 1 Framework for research design and study methodology



2.1.4 Study sites

Differences between upper and lower Ayeyarwady delta
Due to the clear differences between the rice production systems in the southern (lower) and northern (upper) part of the Ayeyarwady delta, we proposed to implement the study in two townships in each area. In the lower delta resource-poor farmers largely depend on their own farm-saved seed; in the upper delta, there is more formal sector engagement, with farmers increasingly becoming engaged in commercial farming and improved variety uptake. The difference in rice agroecology between the lower Ayeyarwady delta and the upper delta results in different rice growing techniques and different rice varieties. During the monsoon season, the lower delta exhibits deeper levels of water in the fields and the soil is not saline. In the summer season, the lower delta does not exhibit higher levels of water and the soils vary in salinity. The upper delta is located beyond salt water intrusion (Van Driel and Nauta, 2014). A common pest in the lower Ayeyarwady delta are small crabs which cut the rice plants. In the fields of the upper delta, brown hopper and cut worms are more common. The transplanting technique in the lower delta uses the fork because of deeper water levels at the time of transplantation.

Four selected townships in upper and lower Ayeyarwady delta
The selected townships of the upper Ayeyarwady delta are Danuphyu and Hinthada; the townships of the lower Ayeyarwady delta are Labutta and Bogale (see Figure 2). Of the three townships suggested by LIFT for the lower Ayeyarwady delta, Labutta was selected because it was most affected by the Nargis cyclone and has a greater presence of development partner projects. Bogale and Mawlamynegyun are rather similar in terms of agroecology and support projects but Bogale was chosen as the second township for the lower delta. The choice of four very different townships will make the survey more representative of the entire Ayeyarwady region as compared to the three townships originally proposed in the request for proposals. However, the selection of the four townships remains purposive based on geography and the different characteristics the areas exhibit in terms of agroecology and climatic conditions affecting rice production – but are 'typical' of the Ayeyarwady delta.

Visits to seed users, seed producers and other seed sector stakeholders
The seed use study consisted of household seed user surveys and focus group discussions (FGDs) in four townships of the Ayeyarwady region. For the seed supply survey we interviewed farmer seed growers and agro-dealers in the same four townships, but also visited a specialised farmer seed grower close to Nay Pyi Taw, the Gold Delta Rice Specialization Company (RSC) in Danuphyu, and LIFT implementing partners engaged in seed production in the lower Ayeyarwady delta. To assess early generation seed (EGS) production, we visited the Tagontaing Seed Farm in Hinthada and the Thayaung Chaung Seed Farm in Pathein, both operating under DOA; and we visited the Myaungmya Research Centre in Myaungmya, operating under the DAR. In Yangon we visited the seed quality control laboratory. For the rice seed sector assessment we interviewed an additional number of stakeholders in Yangon and Nay Pyi Taw, including DOA and DAR. Find the details of the visits in the day-to-day field study programme in Annex 1.

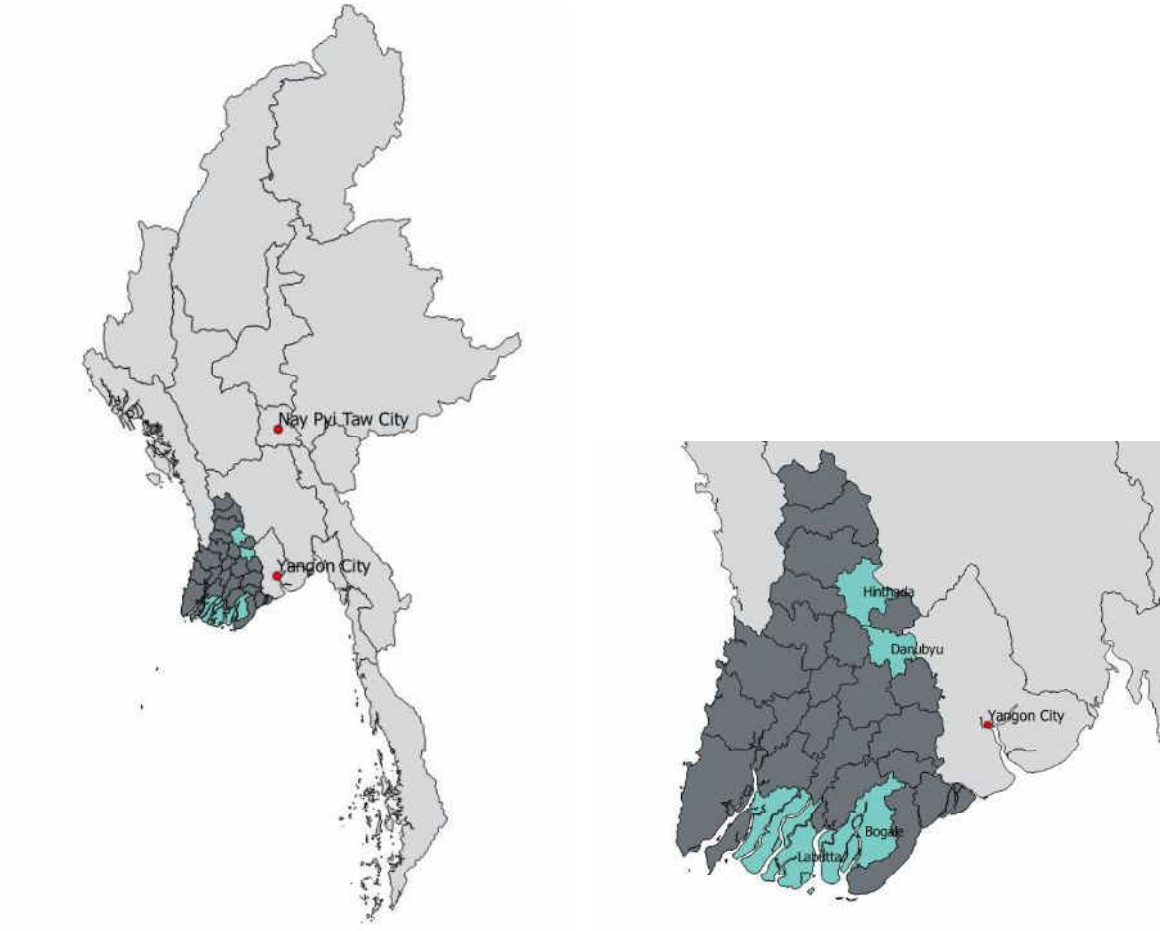


Figure 2 Locations of data collection in selected townships in the Ayeyarwady delta

2.2 Seed use survey

2.2.1 Data collection tools

Household survey with Open Data Kit (ODK) and tablets

The questions of the quantitative household survey can be found in the research plan (Subedi *et al.*, 2016). For data collection of the household survey we used ODK and tablets. The use of tablets avoids the resource consuming process of typing and re-coding paper surveys. Moreover, it is faster and less error prone and allows for the introduction of real-time quality checks, allowing enumerators to identify and amend errors during the interview. For example, based on production, land use and sales values, the tablet can immediately compute average yield and price. With this real-time feedback, enumerators can verify if numbers are within reasonable ranges and rephrase the questions when appropriate. The tablets also function as GPS devices recording the location of each and every survey; all interviews were plotted on a map.

FGDs

Two types of FGDs were organised to supplement the household data collected in the townships and serve as a triangulation method. Cards and ranking exercises were used to facilitate the discussions. In the FGDs with seed users, between five to 10 farmers discussed issues related to rice production and variety preferences. In the FGDs with the townships' seed sector stakeholders, extension officers, seed producers and development organisation, representatives discussed issues related to the roles and functions of stakeholders in the seed value chain, opportunities and challenges for the different seed sector actors, and the biggest challenges of the rice seed sector. Participants of the FGDs were invited with the help of the local consultants, local authorities, LIFT

field officers and local partners as well as the extension officers. Find the participants in the FDGs in Annex 4.

2.2.2 Sampling

Minimum sample size calculation

The calculations of the minimum sample size for the household interviews given below assume a power of 80 per cent at significance level of 5 per cent. The yield differences between local and improved open pollinated varieties (OPVs) were used to calculate the sample size because yields are a key determinant and outcome of the use of different variety types. Because of the very low prevalence of hybrid varieties and the lack of incentives for producers to sow hybrid varieties, the team has decided not to pursue the seed-user survey on hybrids and will focus on typical seed users instead.

The following yield data were used:

- 65 per cent rice farmers are using improved varieties
- Yield of local varieties is 2-3 t/ha
- Yield of improved varieties is 4-5 t/ha
- Yield of hybrid rice is 10-15 t/ha
- 2 per cent of the total rice area is cultivating hybrid rice in Myanmar (out of a total of 6,529,370 ha)

(Source: Myanmar Ministry of Commerce, 2015)

Assuming local varieties have a yield of 3 t/ha, the minimum sample size needed to detect a yield difference of 2 t/ha (i.e., under the expectation improved varieties would have a yield of 5 t/ha) are two groups of 67 observations, so a total of 134 observations. Assuming that 65 per cent of a randomly selected sample will be producing an improved variety, the sample size correction would imply a total sample of 146 observations, therefore 51 observations of a local variety and 95 of an improved variety. Find in Figure 3 minimal sample size versus effect size.

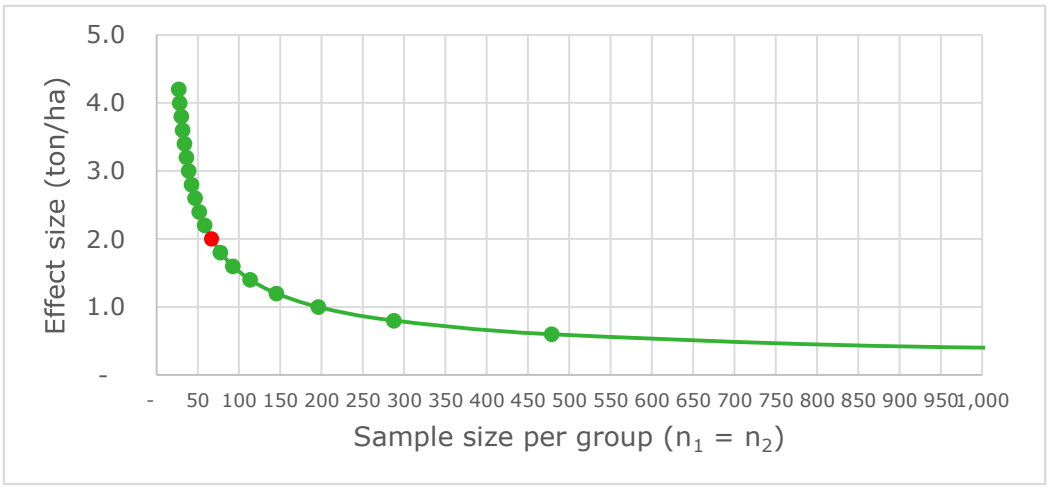


Figure 3 Minimal sample size versus effect size for local compared to improved varieties

Note: power = 80%, alpha = 5%

Assuming that 65 per cent of a random sample is using improved varieties, the team recommended a minimal random sample of 150 observations to allow the comparison of local varieties with improved varieties. To make up for drop-outs and to reduce the odds of having a very small number of observations for certain indicators because the survey was planned in two locations, the sample size was increased to 240 producers to allow a comparison between local varieties and improved varieties.

Sampling method

Purposive sampling is a non-probability sampling method. The team preconized a selection of 'typical case' approach based on the knowledge of the research area by local experts and the LIFT team to make a selection of tracts and villages. Village and village tracts were selected based on a set of predetermined criteria. The following criteria were developed in order to avoid important selection bias or convenient selection of villages, while remaining logistically feasible to conduct the survey in the time available:

- Availability of farmers growing different rice varieties (local varieties and improved varieties) for interview
- Availability of farmers producing certified rice seed for interview
- Farmers willingness to answer for interview
- Road accessibility to visit the village for interview /boat accessibility
- Agroecology for the lower Ayeyarwady delta

Within the proposed sample of 240 farmers, calculations of the minimum sample assuming a power of 80 per cent at significance level of 5 per cent should enable the team to collect sufficient information to differentiate between the yield differences between local and improved varieties. Within the upper and lower Ayeyarwady delta locations, it is not expected to find great variation between villages and therefore the team limited itself to five villages per township. The selected townships and villages covered the range of varieties used by the producers in the upper and lower Ayeyarwady delta regions. Table 1 presents the villages selected for the survey.

Table 1 Townships and villages of the household survey

Region	Townships	Village tracts	Villages	Type of soil
Lower Ayeyarwady delta	Labutta	Kyar Kan 2	Min Kone	Fresh
		Kyein Kwin	Ohn pin su	Brakish
		Ohn Ta Pin	Aung Hla	Saline
		La Put Ta Lote (North)	La Put Ta Lote (North)	Fresh
		Nyaung Lein	Nyaung Lein	Fresh
	Bogale	Sa Bai Kone	Ngapi Tone Ka Lay	Fresh
		Tha Zin Kone	Ah Kei Chaung	Brakish
		Tha Zin Kone	Koe Eain Tan	Saline
		Aye	Pay Chaung	Fresh
		Tha Kan Wa	Kyon Hpar	Fresh
Upper Ayeyarwady delta	Danuphyu	Ah La Myo	Ah La Myo	Fresh
		Ta Myar	Nan Daw Kone	Fresh
		Kyon Ta Nee	Kyon Ta Nee	Fresh
		Yae Le	Wai Lar Wai Chaung Hpyar	Fresh
		Tha Byu	War Yon Chaung Ywar Ma	Fresh
	Hinthada	Ta Loke Htaw	Ta Loke Htaw	Fresh
		Htan Ta Pin (Du Yar)	Oke Hpo Chaung (Myauk Su)	Fresh
		Neik Ban	Neik Ban	Fresh
		Kya Khat Kwin	Kya Khat Kwin	Fresh
		Kaw Zan	Kaw Zan	Fresh

As suggested by the LIFT team and agreed upon during the kick off meeting in Yangon (24 October 2016), household lists available at village level were used for sampling households in the village. The total number of households on the list was divided by 12 and every x household was selected

to get 12 households selected per village and to reach 240 surveys in total. Figure 4 and Figure 5 show the household survey spread in the lower and the upper Ayeyarwady delta, respectively.

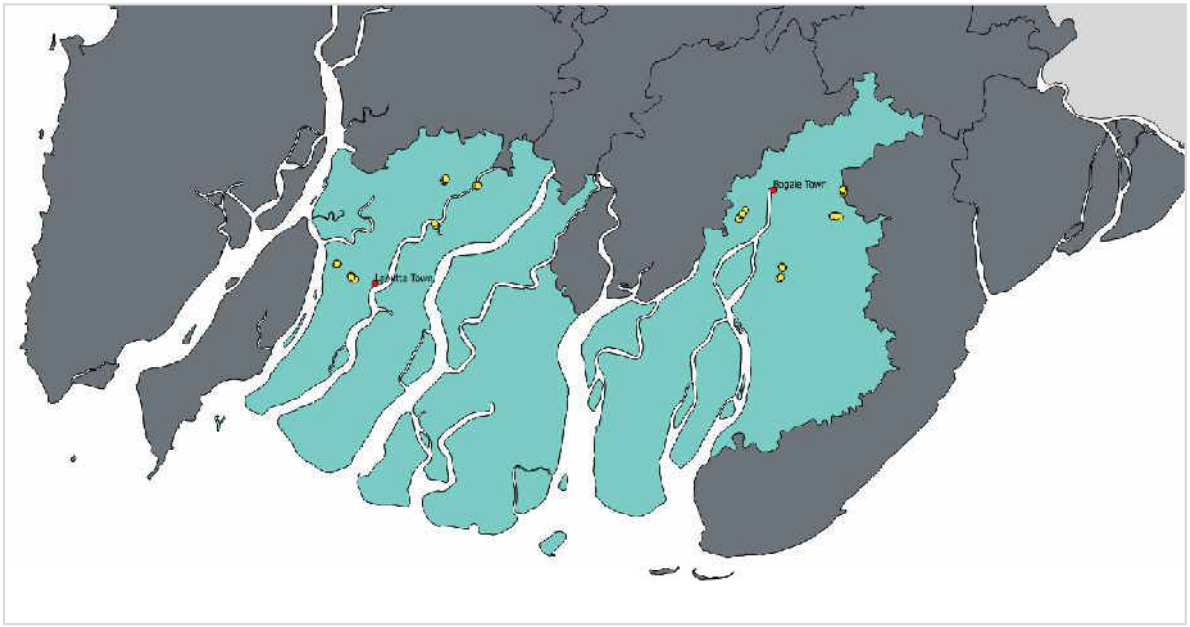


Figure 4 Household survey spread in the lower Ayeyarwady delta

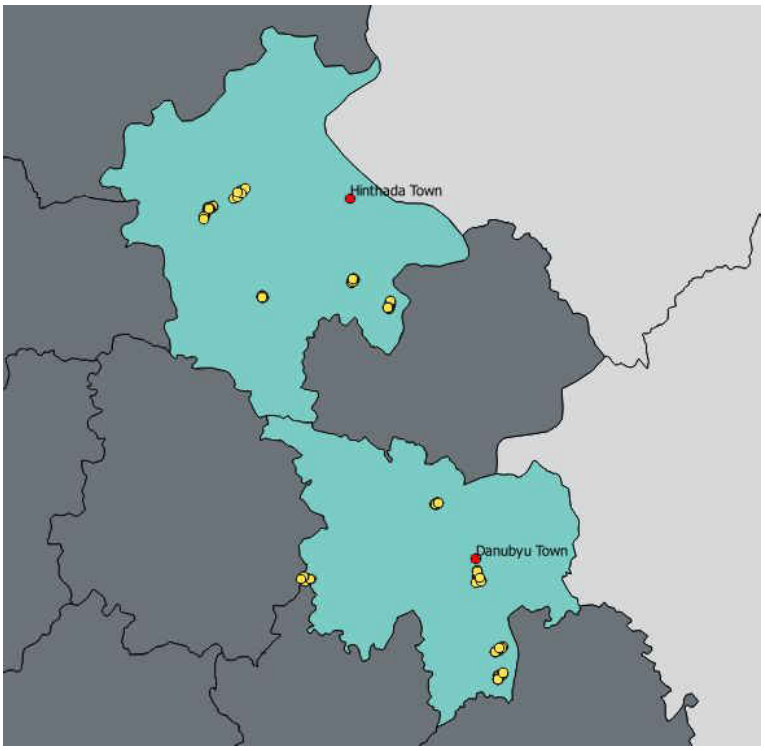


Figure 5 Household survey spread in the upper Ayeyarwady delta

2.2.3 Training of enumerators and survey pre-testing

Training

Before the implementation of the survey, enumerators and supervisors were trained in Yangon on 24 October 2016. The training had four objectives: (i) learn appropriate behaviour during farmer interviews; (ii) create understanding on the content and technical terms of the survey; (iii) create understanding on the terms used and translated into Burmese; and (iv) learn how to use the tablets and the data collection application (ODK collect).

Behaviour for and during data collection
Enumerators were selected because of their knowledge of agriculture. However, while making use of their knowledge to distinguish between answers which do and do not make sense, it is important to refrain from imposing views or influencing the answers of the respondents. For 'why' questions, enumerators were asked to probe and not read the list of potential answers. Enumerators were asked to introduce the purpose of the interview to the household head and any household members present, based on the consent text (see Annex 2). At the start of the survey, formal consent needed to be recorded and a signature needed to be given. Without an explicit consent, it was not possible to continue with the survey. All households participating in the survey had the right not to answer a question and were allowed to withdraw at any time. Points explicitly spelled-out and consented upon were the purpose of the study; the no-compensation rule; and expectation management with regard to project participation. Only respondents of 18 years or older were interviewed for the study.

Content and technical terms
During the enumerator training all survey questions were introduced and terminology was defined. Special attention was given to variety types and seed sources. Simple definitions were used to ensure common understanding (see section 2.1.2 on definitions). Moreover, additional contextualisation of the survey was performed based on the enumerators' knowledge of the rice seed sector.

The following modifications were made to the household survey as a result of the training:

- Definition of a household: people living under the same roof who share revenues and expenses
- Additional crops potentially grown by the household: pulses, vegetables, *dhani*, betel vine, mustard, mung beans, *jute*, maize
- Reasons for low or high yields in the season surveyed: pests and diseases, sowing period, harvest timing, variety of rice seed used
- It was agreed upon that intercropping is not a common practice in the dDelta for rice and should not be included in the survey
- Change of kilometres to miles
- Removal of Diammonium phosphate and insecticide (which is covered with pesticide) and added gypsum as a type of fertiliser; NPK and compounds to be listed together
- Addition of viss as a unit for compost and manure (1 viss = 0.6124 kg)
- Creation of feedback values on data collected in baskets rather than kg
- Check of the automatic calculations in the survey (yields and conversions in local/international units)
- When the respondent does not know the answer, 99 can be used as code to indicate 'don't know'
- Creation of a maximum value entered for yields
    - Local variety: 70 baskets
    - Improved variety: 100 baskets

Common understanding
All the survey questions were translated to Burmese. Furthermore, during the training, the enumerators were asked to translate and describe important terms (see the definitions and the terms given above) to make sure that everyone used the same terminology when administering the questionnaire. Enumerators also practiced the full questionnaire in pairs and helped each other with translation and interpretation.

Functioning of the tablets
A practical demonstration on tablets' functionalities was done with enumerators practising simultaneously. Familiarisation with the tablet and ODK application continued while enumerators practiced the survey, but they quickly mastered both. The simple interface of the tablet and familiarity of enumerators with smartphones was helpful in the process. A short manual and

explanations on the data collection application were provided to all enumerators. The supervisors benefited from an additional training session on data handling and transfer.

Sampling in practice

The sampling method was explained in detail to the team supervisors who were charged to make the in-village selection of households to be interviewed. The supervisors requested the household list from the village authority. Since 12 farmers were to be interviewed per village, the number of households on the list was divided by 15. The result of the division was used to select every x household on the list for interview. Three additional households on the list were also selected in the case of unavailability or inadequacy of candidate households (e.g. do not produce rice for their own benefit). Household lists were prepared in 2014 for the elections. Criteria to engage in an interview were:

- Consent given
- Rice was produced in 2015 or 2014
- Households produce rice for their own benefit on their own or rented land, and are not exclusively hired labourers in others fields (i.e. household has its own rice production figures)
- Are not 'seed growers' (even if operating informally); the focus is on seed users

Pretesting

Pretesting of the household survey was done in the Pantanaw Township, Kyontonekalay village tract, Taline Su village. The village authorities and villagers had been informed that the team would come for the pretest. A short meeting with the enumerators was conducted to recapitulate the day of training prior to the pretest. After introducing the research and the purpose of the visit to the local authorities, enumerators started to interview selected farmers. The coordination team visited the different households where enumerators were conducting the pretest survey to monitor the questioning and enumerator performance. After the survey, everyone reconvened to discuss the outcomes, the questions, the functionality of the skip logic and the automatic calculations used in the questionnaire. The following adjustments were made to the survey based on the pretest:

- Addition of a question on rented land (yes/no)
- Addition of an option for herbicides mixed with urea or NPK/compound
- Modification of the question order
- Addition of rice millers as a seed source
- Agreement on the definition of room for PPI[1] question three: a two-storey house has two rooms, but levels with only a slight difference in height and which are not separated are considered one room
- The question on loan specifically referred to the Myanmar Agricultural Development Bank (MADB) loan (instead of multiple answers possible)

The following last minute changes were made after the first day of data collection:

- Tsuper and 'other' option were added to fertilisers
- A skip pattern on variety was modified
- Telephone was changed from integer data to decimal for data display purposes

[1] The Progress out of Poverty Index® (PPI®) is a poverty measurement tool for organisations and businesses with a mission to serve the poor. The PPI is statistically-sound, yet simple to use: the answers to 10 questions about a household's characteristics and asset ownership are scored to compute the likelihood that the household is living below the poverty line – or above by only a narrow margin. Find the questions in Annex 3.

2.2.4 Data cleaning and data output

The final quantitative household survey consisted of 243 completed interviews. Data cleaning was performed in Stata. Automatic functions were used to convert unknown data to missing data (e.g. unknown production figures) as well as to remove outliers. We removed extreme values from calculated variables (e.g. yields per acre which are derived from land size and production figures). We used an iterative trimming procedure, with four standard deviations. The procedure works as follows: the average and standard deviation of a variable is computed and all values which are outside the range of the average plus or minus four standard deviations are replaced by a missing value. The new average and standard deviation is computed and the trimming is repeated. The procedure is applied until no values need to be trimmed any further. Very few data were computed to missing with these functions. More often than not, the full sample size of N243 was used to perform the data analysis. However the N varies depending on how many producers were targeted for specific questions. For example, if farmers had not paid for the seed they used, they were not asked for the price of the seed, which means that the N for the seed price is lower than the full sample size.

The team decided to reclassify the seed type question to include two different variables: one on variety type, i.e. local or improved; and one on seed generation, i.e. first generation seed (quality or certified seed) or recycled seed (recycled at least once). No distinction was made between first generation quality seed and certified seed of improved varieties because field work showed that farmers do not know the difference between the two seed types. Moreover, certification was found not to be an important factor when it comes to seed purchase and the number of observations for each was small, limiting statistical analysis.

Variety names and types were checked against the list provided in the desk review (Thijssen *et al.*, 2016). Find the main varieties as reported by the farmers interviewed in Table 2.

Table 2 Main varieties according to type reported in the household survey

Variety name	Variety type
Hmawbi-2	Improved variety
Manaw Thukha	Improved variety
Meedome	Group of local varieties
Pawsan	Group of local varieties
Shwe War Htun	Improved variety
Sin Thwe Latt	Improved variety
Sin Thukha	Improved variety
Thee Htet Yin	Improved variety
Yarkyaw-2	Improved variety

Note: Only those varieties are indicated which have been mentioned more than five times.

For the analysis, most data are presented separately for the lower and upper Ayeyarwady delta. When this is not the case the reason is because the data is limited and there is a non-statistical difference between the two locations.

Definitions for the regressions are:

- R2: indicates the goodness of fit of the model. The R2 (R squared) represents how much of the variability in the dependent variable is predicted/captured by the model
- The Adjusted R2 corrects for the number of variables so you can compare different models
- Constant: is the base level. It is the expected value of the dependent variable when all independent variables have value 0
- The area and area squared allows for a combined nonlinear effect of area

2.2.5 Limitations

The team was able to complete all the planned household interviews within the timeframe dedicated to the study. However, because of the harvest season, it was sometimes difficult to meet farmers for the household survey. This was also the case for the FGDs. In Bogale and Labutta, it was possible to meet all farmers; however, in Danuphyu and Hinthada, it only possible to meet with a limited number of farmers. The women were especially difficult to reach.

As planned, lists were used to select the households to be interviewed for the study. However, we found that these lists were not always complete but had to use what was available.

The townships were selected by LIFT and the study team. Since the four townships were selected purposively for the study, it means that the data gathered in the townships cannot be generalised to the whole of the Ayeyarwady delta. At township level, the team is confident that the methodology used provides good insights into farmers' practices.

The sample size was calculated on the basis of yield differences between local and improved varieties. However, for detailed analysis combining additional variables, the sample size is sometimes too small to find statistically significant differences and draw robust conclusions.

Data were collected on rice farmers' last rice grain production season in the past 2 years. No data was collected for the present season (2016 monsoon) because it was not complete at the time of the survey, making it impossible to collect yield or sales figures. The data collected provide insights into general production practices and do not account for different practices for different rice plots.

2.3 Seed supply survey

2.3.1 Data collection tools

For the seed supply survey we used checklists with data tables and matrices. These were used during interviews with DOA seed farms, a DAR research farm and a seed farm managed by a development organisation. A combination of FGDs and key informant interviews were used with seed farm managers and their staff. For those seed farms which we could not visit, we have collected the seed production datasets through e-mail contact. We did individual interviews with seed producers (contact farmers, seed growers, and private company) and agro-dealers. For the seed grower and agro-dealer interviews we used questionnaires which were translated into Burmese.

We also did visual observations of seed production facilities and seed production plots, and have used secondary data to complement the interviews and observations, such as the seed farms' annual reports with the latest seed production data tables. We used secondary data from the DOA seed division on seed production and distribution of certified seed from 2012 to the 2016 monsoon season for the whole of the Ayeyarwady region as well as for the specific study townships. In addition, we have organised an expert review with DAR breeders to get clarity on and validate variety names. Find detailed information on the formats used for the interviews and discussions in the research plan (Subedi *et al.*, 2016).

2.3.2 Stakeholders interviewed

Interviews at seed farms

In total we have collected data from four DOA seed farms (Tagontaing Seed Farm, Hinthada; Thayaung Chaung Seed Farm, Pathein; Myanmar Rice Research Centre, Hmawbi; and Aukywingyi Seed Farm, Pyapon), one DAR research farm (Myaungmya Research Farm, Myaungmya) and one seed farm managed by a development organisation (Metta seed farm, Pathein). Details of the participants are shown in Table 4. The discussions at seed farms focussed on the varieties in the

seed production chain, the class of EGS produced, EGS seed production volumes, demand and supply in different production seasons, the seed farm infrastructure, quality assurance system, human resources, and the key issues and challenges.

Interviews with producers of certified/quality seed
In each study township we interviewed four seed producers, totaling 16 seed producers altogether (the list of seed producers interviewed can be found in Annex 4). These seed producers are contact farmers supported by DOA or seed growers supported by development organisations. We have also interviewed the Gold Delta RSC field production team in Danuphyu and the management team in Yangon. The interviews with seed producers focussed on key performance areas of the seed producers, including skills of seed production and organisational management, as well as their strategic linkages in the seed value chain. Other points that were discussed include the seed production area, the seed production and sales volumes, source of EGS, pre and post-harvest management skills, seed infrastructure, business planning, marketing and promotion, and customer relations.

Survey of agro-dealers
We interviewed two agro-dealers per township, totalling eight altogether (Annex 5). The interviews focussed on crop and variety portfolio, seed demand and sales figures, customers preferred varieties and key feedback from customers.

2.3.3 Limitations
The team was able to complete the interviews as per the research plan, with some exceptions. The meeting with Dagon International RSC as listed in the programme schedule could not be organised as the representatives from the seed company were not available. Similar to Gold Delta RSC, Dagon International is producing seed for its own contract rice grain producers. However, the study team collected data from two additional seed farms managed by DOA, which were not listed in the original research plan and field study programme schedule, because of their importance for EGS production in the Ayeyarwady region.

2.4 Seed sector analysis

2.4.1 Data collection tools
During the interviews with key informants we used different frameworks to collect information on the rice seed sector. These included matrices for analysing operators and service providers in the seed value chain, and matrices for analysing project interventions in the seed value chain – Including interventions in the enabling environment. We developed interview guidelines and checklists for discussions with different key informants to get insight into the study questions. Find detailed information on the formats in the research plan (Subedi *et al.*, 2016).

2.4.2 Stakeholders interviewed
Find the key informants that we interviewed to discuss the status of the rice seed sector in Table 3.

Table 3 Key informants interviewed during the field study

Domain/ type of organisation	Name organisation	Location of discussion	Persons interviewed, position
Public sector	Department of Agriculture	Nay Pyi Taw	- U Thet Zin Maung, Director Seed Division - Mint Oo, Director Agriculture Extension Division - U Htin Aung Shein, Deputy Director Agriculture Extension Division - Daw Thu Zar Myint, Director Rice Division - Aye Min, Advisor to DG DOA
	Department of Agricultural Research	Yezin	- U Naing Kyi Win, Director General - Dr Hmwe Hmwe, Deputy Director - Dr Maung Maung Tar, Director - Daw Win Thida Oo, Assistant research officer - Daw Myinth Myinth San, Senior research assistant
	Tagontaing Seed Farm, DOA	Hinthada	- Daw Ni Ni Hlaning, Farm manager - Daw Yin Tint, Seed processing manager - Sandar Strein, Staff officer
	Thayaung Chaun Seed Farm, DOA	Pathein	- Daw Khin Htay Oo, Farm manager - U Than Lwin, Staff officer - Daw Sande Htun, Staff officer - Daw Lai Lai Aye, Deputy manager - Daw Kyi Kyi Oo, Deputy assistant staff officer - Daw Naing Naing Maw, Deputy assistant staff Officer
	Myaung Mya Research Farm, DAR	Myaung Mya	- U Htain Lin Tun
	Lower Myanmar Seed Quality Control Lab	Yangon	- Daw San San Aye, Head of the Seed Quality Control Lab
	Yezin University, Department of Plant Breeding, Physiology and Ecology	Yezin	- Dr Than Myint Htun, Lecturer - Dr Han Phyo Aung, Lecturer
Private sector	Gold Delta Rice Specialization Company	Danuphyu and Yangon	- Aye Lwin, Deputy Managing Director - Dr Min Aung, Senior Advisor - Than Tun, General Manager - U Htay Aung, General Manager - U Than Aye, Manager - U Tin Maung Win, Senior General Manager - U Kyi Tijn, Manager - Nyein Nyein, Assistant Chief Accountant
	Seed grower Aye Tan	Nay Pyi Taw	- U Aye Than
	Myanmar Rice Federation	Yangon	- U Aung San, CEO - Khin Soe, Advisor - Lwin Oo, Advisor - Min Min Aung, R&D Department

Domain/ type of organisation	Name organisation	Location of discussion	Persons interviewed, position
LIFT IPs	GRET	Bogale	- U Kyaw Saing, Agri coordinator - U Ko Ko Maung, Agronomist - U Han Wunna Aug, Agronomist - Yadanar Win, Agronomist - Justine Scholle, Technical advisor - Yin Yin Aye, Operational coordination
	Mercy Corps	Yangon	- Mark Munoz, Program manager Delta program - Thet Oo, Agriculture technical advisor - Kyi Khaing Win, Market development advisor - Thinzar Soe, Senior M&E Officer
	Metta	Pathein	- U Khin mg Latt, Programme coordinator - Chin Cho Myint, Seed farm supervisor - Nay Bcute Htrs, Project coordinator - Nwe Ni Soe, Seed production, M&E coordinator - Khun Aung Than Htay, Branch Office coordinator - H Aung Mynit Soe, Field worker
	Radanar Ayar	Bogale	- Zaw Htet Aung, Partnership coordinator - Ngu Wah Hlaing, M&E coordinator - Thet Naung Soe, Senior agro-tech officer
	WHH	Yangon	- Peter Hinn, Country Director - Jana Korner, Head of project Bogale
International organisations	FAO	Yangon	- Yo Khaung, Programme officer (Forestry) - E Thin Ya Soe, Programme officer (Nutrition & gender)
	IRRI	Yangon	- Dr. Jongsoo Shin, IRRI Myanmar Representative - Dr. Romeo Villamin Labios, Scientist II – Agronomist

Note: contact details are available upon request

2.4.3 Limitations

The persons met at the Food and Agriculture Organization (FAO) were not aware of the FAO seed related projects implemented over recent years, and unfortunately the responsible country coordinator for the Japan International Cooperation Agency (JICA) was out of the country during our field study. Nevertheless, through interviews with the other stakeholders, we did get some insight into the seed interventions supported by FAO and JICA. The company Dagon International was not available for an interview, but we got a lot of information from two visits to Gold Delta, and another highly professional and commercial rice seed grower in Nay Pyi Taw, i.e. U Aye Than.

3. RESULTS

Farmers in Ayeyarwady delta drying rice grain (Audet-Bélanger, Royal Tropical Institute, 2016)

3.1 Seed use survey

3.1.1 Rice and livelihood strategies

Poverty level

The Simple Poverty Scorecard with 10 low-cost indicators from Myanmar's 2009/10 Integrated Household Living Conditions Assessment was used to assess the poverty level of the households interviewed for the survey (PPI; Schreiner, 2012). The scorecard uses 10 country specific questions enabling the user to estimate the likelihood that the consumption pattern of a household is below a certain poverty line (see Annex 3). Results show that the households interviewed have on average an 83 per cent chance of being under the USD 2.50/day purchasing power parity (PPP) line (International 2005 PPP), but only a 14 per cent chance of being under the USD 1.25/day PPP line (International 2005 PPP). Put more simply, the probability that households interviewed will be considered poor is high (83 per cent probability) while they are unlikely to be considered extremely poor (14 per cent probability). No statistically significant difference in poverty levels was found between the two survey locations.

Importance of rice

Households interviewed largely produce rice with the purpose of selling their harvest. In the majority of cases, most of the harvest is sold (92 per cent) and some is kept for consumption (Table 4). This results in rice production being an important or very important source of income for interviewed households (90 per cent). However, that is not to say that rice is not also an important staple when it comes to food security. Virtually all households interviewed reported rice as important for food security (Table 5). And although producers may sell large quantities of their rice directly after the harvest, they are likely to buy back quantities from the market at different periods in time. This enables farmers to avoid storing freshly harvested rice in poor storage conditions which would lead to postharvest losses. In some cases, farmers also need the cash at harvest and simply cannot afford to wait to sell their rice grain. At harvest time, farmers typically report lower prices for their rice than if they are able to hold onto their rice until after the harvest (FGD).

Table 4 Intended use of rice produced

Intended use of rice produced	Freq.	%
HH consumption and gifts only	2	0.8
Sales only	7	2.9
HH consumption and sales equally	4	1.7
Mostly HH consumption and some sales	6	2.5
Mostly sales and some HH consumption	224	92.2

Note: N243

Table 5 Importance of rice production for household income and food security

Importance of rice	Freq.	%	Cumul.
Importance of rice production for HH income			
Little importance	5	2.1	100.0
Somewhat important	19	7.8	97.9
Important	42	17.3	90.1
Very important	177	72.8	72.8

Importance of rice	Freq.	%	Cumul.
Importance of rice for food security			
Somewhat important	1	0.4	100.0
Important	28	11.5	99.6
Very important	214	88.1	88.1

Note: N243

Loans for rice production

Loans for rice production are made available to farmers by the state-run MADB. Farmers can get Burmese Kyats (MMK) 150,000 per acre under rice production for up to 10 acres (Thant, 2016; FGD). Interviewed rice farmers largely reported that at least half of their contracted MADB loans was spent on rice production, and by the time of the interview, the loan had been repaid for the past production season. The contracted MADB loan averages MMK 796,000, with higher amounts contracted in the lower than in the upper Ayeyarwady delta (Table 6). The higher average value for the contracted MADB loan in the lower delta region is explained by the larger average rice area per producer in this area (Table 8). The main expenditures covered by the loan were fertilisers (39 per cent) and hired labour (36 per cent; Table 7), which are important expenses and constraints for rice producers (FGD). The MADB is not the only source of credit available to farmers who wish to access loans, but it is widely used and was specifically asked for in the survey.

Table 6 MADB loans for rice production among households interviewed

	Lower Ayeyarwady delta	Upper Ayeyarwady delta
Loan received from MADB for rice production	94%	93%
s.e.	2%	2%
N	122	121
Half of loan was spent on rice production	97%	99%
s.e.	2%	1%
N	115	113
Full amount of loan is repaid	97%	100%
s.e.	2%	0%
N	115	113
Average amount of loan (MMK)	881,491	709,821
s.e	59,902	32,521
N	114	112

Note: N243

Table 7 Main expenditure covered with the MADB loan

	Freq.	%
Fertiliser	89	39.0
Hire labourers	82	36.0
General rice production	33	14.5
Purchase machinery or tools for rice production	11	4.8
Rent machinery for rice production	7	3.1
Other	6	2.6
Total	228	100.0

Note: N228

Acreage of rice

The average area of land available for agricultural production of the households interviewed is 12.4 acres (Table 8). However, large variation exists among households, with some households having up to 75 acres of land. The average acreage under rice production was 11.6 acres during the last cropping season, occupying most of the available land of the households interviewed. Large variations were recorded among household areas under rice cultivation (1.5 acres to 58 acres). Only 9 per cent of the households interviewed rented land for rice production.

Table 8 Area under rice production

Area	N	Mean	Min	Max
Total land	243	12.4	1.5	75.0
Rice area	243	11.6	1.5	58.0
Rice area lower Ayeyarwady delta	122	13.3	2.0	58.0
Rice area upper Ayeyarwady delta	121	9.8	1.5	35.0

Note: N243; area in acres

Figure 6 presents the area of land being used by the interviewed farmers to cultivate rice in the lower and the upper Ayeyarwady delta. In general, farmers in the upper delta tend to have smaller areas of rice (less than 10 acres) in greater proportion than in the lower delta, but in both locations the majority of interviewed farmers cultivated between five and 20 acres of rice.

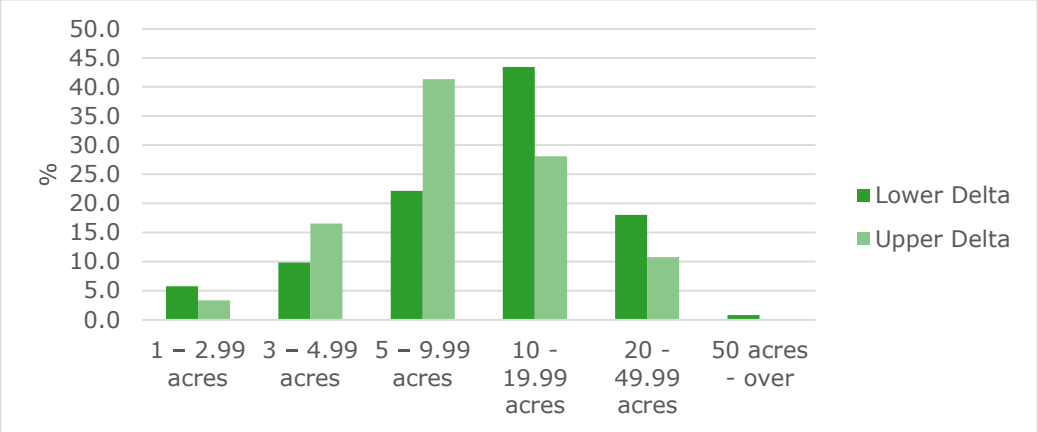


Figure 6 Rice production area last season per survey location

Crops in addition to rice

Figure 7 shows the percentage of farmers who grow specific crops alongside rice. Pulses are by far the most common in addition to rice, grown by 52 per cent of the farmers, followed by betel vines and vegetables. The pulses grown include mung bean, black gram, green gram and pigeon pea.

Production season

The interviewed farmers were asked to provide detailed information on the last season during which they had produced rice. As the last season in which rice was produced, the monsoon season of 2015 was predominantly discussed (by 77 per cent of farmers). Virtually all farmers interviewed produced rice in the monsoon season (they were asked about additional seasons in which they had grown rice if they had selected an alternative season to monsoon in a separate question). FGDs also confirmed that the monsoon season is the main paddy production season. The residual water of the monsoon rains in the lower Ayeyarwady delta allows for households to produce rice across 2 seasons in the year, while in the higher delta, farmers generally stick to the monsoon season to grow rice (Table 9).

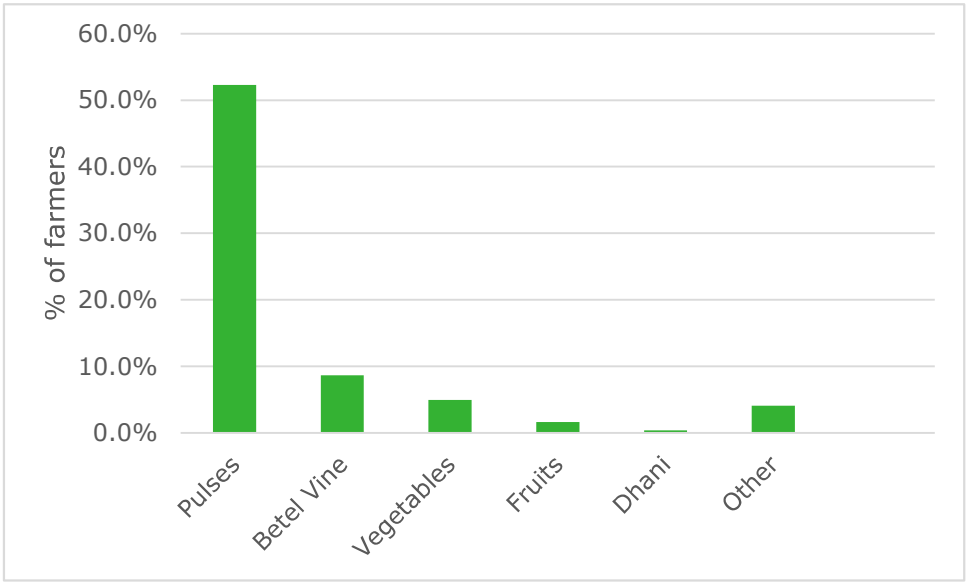


Figure 7 Additional crops and percentage of farmers per crop

Table 9 Last rice production season

Last season of production for rice	Lower Ayeyarwady delta freq.	Higher Ayayarwady delta freq.	Total freq.	Total %
Summer (dry) season – February to May 2016	46	1	47	19.4
Monsoon (main) season – June to November 2015	67	119	186	76.5
Summer (dry) season – February to May 2015	9	1	10	4.1

Note: N243

3.1.2 Rice varieties

Number of varieties

Interviewed households predominantly use one (45 per cent) or two (44 per cent) varieties simultaneously in their fields. Half of the rice producers in the lower Ayeyarwady delta only used one variety predominantly, while 40 per cent in the upper delta used one variety only. Fifty five per cent of producers used two varieties simultaneously in their most recent paddy production season (Table 10). While it may be surprising that producers reported using only one variety during the past season, it is important to bear in mind that this does not mean that farmers are relying on a single variety for paddy production. Rice growers rely on a portfolio of varieties which they use alternatively in response to various factors including popularity of the variety on the market and grain price.

Table 10 Number of varieties used per household per production season

Number of varieties	Lower Ayeyarwady delta		Upper Ayeyarwady delta		Total	
	Freq.	%	Freq.	%	Freq.	%
1	61	50.0	48	39.7	109	45
2	39	32.0	67	55.3	106	44
3	20	16.4	6	5.0	26	11
4	2	1.6	0	0	2	1

Note: N243

Improved and local varieties

The main variety sown by interviewed farmers in the most recent rice production season was most commonly an improved variety (78 per cent), which is often referred to by farmers as a high yielding variety. However, the two survey locations exhibit clear differences in the type of variety used (Table 11). In the lower Ayeyarwady delta, the main variety sown was an improved variety in 59 per cent of cases and a local variety in 41 per cent. The local varieties are mainly grown in the monsoon season. In the upper Ayeyarwady delta, improved varieties are more predominant with 98 per cent of fields sown with such varieties.

Table 11 Type of varieties used

Type of variety used	Lower Ayeyarwady delta %	Upper Ayeyarwady delta %	Total %	N
Local variety	41.3	2.5	21.9	53
Improved variety	58.7	97.5	78.1	189

Note: N242

Specific varieties used

Farmers rely on a range of varieties for rice production. Interviewed farmers were asked to identify the variety they had sown in the greatest quantity for the most recent season (Table 12). Variety use is location specific with Sin Thukha most commonly found in the upper Ayeyarwady delta (32 per cent) and sown in much higher quantities than in the lower Ayeyarwady delta (7 per cent), while Pawsan (23 per cent) is only used in the lower delta. Sin Thukha, Thee Htet Yin (summer variety), Manaw Thukha and Sin Thwe Latt are used in both survey locations. The Meedome group of varieties are the only local varieties apart from the Pawsan group which were reported by more than five interviewed farmers.

There are a number of different Pawsan varieties which are all sub-selections from the original variety Pawsan Hmwe, which is strongly photosensitive and can only be grown in the monsoon season. For example, Paw Sann Bay Kyar and Paw Sann Yin are farmers' selections from Pawsan Hmwe which are only slightly photosensitive. Other sub-selections refer to regions in which the Pawsan rice is produced, like Shwebo Pawsan, i.e. Pawsan grown in Shwebo. In the seed demand study we collated all Pawsan varieties into one group.

The percentage of 'other varieties' in the lower Ayeyarwady delta is quite low. These are varieties for which farmers did not give a name or which have less than five (generally only one or two) observations. Thirteen of the 29 observations for 'other varieties' concern a local variety; the observations include seven local varieties and two improved varieties.

Figure 8 presents the main variety used per township. While careful interpretation is necessary due to the low number of observations per variety and township, it appears that some varieties are specifically used in certain townships. For example, Shwe War Htun is more commonly found in Hinthada Township, Pawsan and Thee Htet Yin in Labutta and Bogale, and Hmawbi-2 in Danuphyu. Sin Thuka and Thee Htet Yin are found in all four townships surveyed but the latter is a variety predominantly used in the summer season. Pawsan and Meedome are not single varieties, but are variety groups composed of various types of the same name, but with slightly different characteristics. It was not possible to investigate further which specific variety within the group was sown by the farmer.

Table 12 Main varieties used during the last production season

Lower Ayeyarwady delta			Upper Ayeyarwady delta		
Variety	Freq.	%	Variety	Freq.	%
Thee Htet Yin	36	29.5	Sin Thukha	39	32.2
Pawsan group	28	23.0	Shwe War Htun	25	20.7
Sin Thukha	9	7.4	Sin Thwe Latt	17	14.0
Meedome group	9	7.4	Hmawbi-2	14	11.6
Manaw Thukha	8	6.6	Manaw Thukha	8	6.6
Sin Thwe Latt	3	2.5	Thee Htet Yin	5	4.1
Yarkyaw-2			Yarkyaw-2	5	4.1
Hmawbi-2			Pawsan group		
Shwe War Htun			Meedome group		
Other	29	23.7	Other	8	6.8

Note: Other: unknown names and less than 5 observations

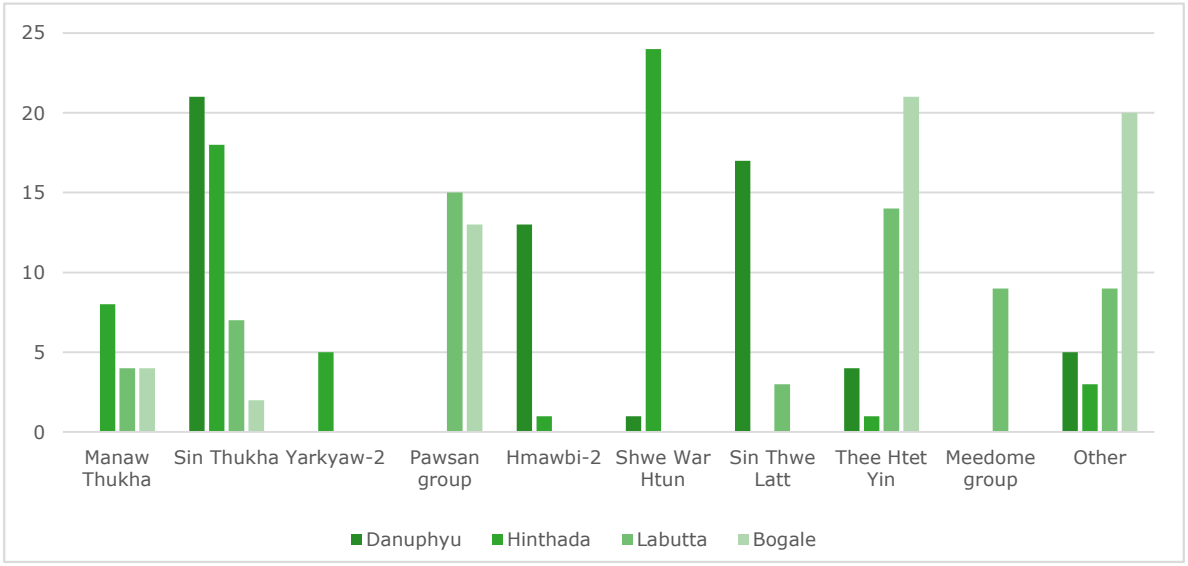


Figure 8 Frequencies of main variety per township

Note: Other: unknown names and less than 5 observations; N243

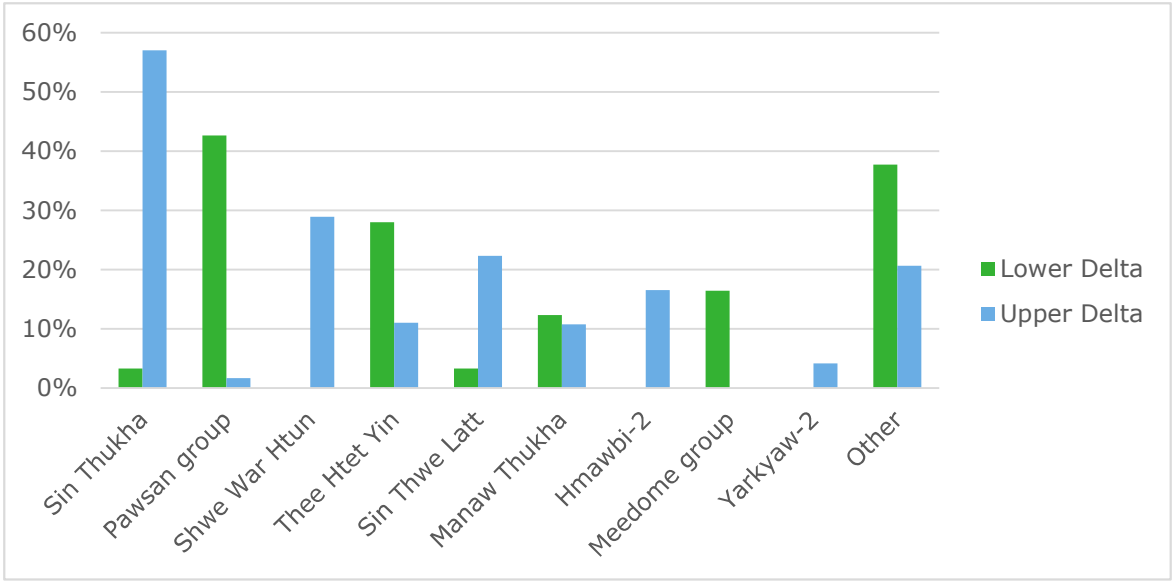


Figure 9 Percentage of producers having sown one of the specific varieties in the past season

More than half of the interviewed farmers reported using more than one variety in their fields in the same production season (Table 10). Table 12 shows which varieties were sown in the greatest quantities, whilst Figure 9 represents the percentage of farmers having sown a specific variety, irrespective of whether it was the main or additional variety. Only Manaw Thuka was equally used in the lower and upper Ayeyarwady delta (Table 12). Other varieties show a clear distinction between the lower and upper regions. Sin Thuka was predominantly used in the upper Ayeyarwady delta where it is appreciated for its milling properties, while Pawsan was sown in the lower delta where market prices for this variety are high (FGD) and it is well adapted to soil conditions. The number of 'other varieties' is quite high in Bogale – again these are either the nameless varieties or those observed less than five times, but generally only once or twice.

Variety selection criteria

Farmers indicated yield potential as the most important criteria for selecting a specific variety (26 per cent) followed by suitability to soil conditions (22 per cent) and market price (18 per cent) (Table 13). In reality, rice producers do not select a variety based on one criteria, but select varieties based on a combination of different characteristics. Hence, a variety may generate high yields, but fetch a low market price because of poor milling and cooking qualities. Therefore despite the higher yields, farmers may disregard such a variety. Another important criteria is climate tolerance because high yielding varieties are no use to farmers if they can't tolerate water logging in the lower delta are, for example.

Table 13 Principal reason for selecting the main variety

Main reason for selecting a variety	Freq.	%
High yields	63	25.9
Best adapted to soil conditions	54	22.2
High market price	44	18.1
Maturing cycle	36	14.8
Tolerance to waterlogging	15	6.2
Taste	11	4.5
Only variety available	4	1.6
Tolerance to drought	4	1.6
Adapted to climatic conditions	4	1.6
Other	8	3.2

Note: N243

The interviewed farmers indicated in general that they were content with the variety they had sown in the greatest quantity in the last rice production season (Table 14). Farmers largely reported being satisfied of their main variety sown in the past production season on all issues we checked for (Table 14) This was echoed during FGDs with farmers in the four townships where the survey was rolled out. Farmers in the lower Ayeyarwady delta scored their variety positively over 83 per cent or more for the different issues checked for. The same trend was observed in the upper Ayeyarwady delta, however, fewer farmers mentioned that they would use the same variety again (68 per cent). This does not mean that the variety is completely ruled out of the individual farmer's variety portfolio. In reality, farmers rely on a portfolio of varieties and alternate varieties they sow. Farmers closely follow market trends which in turn impacts on variety selection. Appreciated varieties by consumers and those fetching high market prices are most commonly used by farmers (FGD).

Table 14 Main variety used and expectations of producers

Main variety used and expectations of producers	Lower Ayeyarwady delta %	Upper Ayeyarwady delta %
Variety meets expectations on maturing cycle	100	100
Variety is adapted to soil conditions	98	99
Variety is available when seeds are sought	96	95
Variety meets expectations on rice market price	95	95
Variety is adapted to climatic conditions adaptability	94	98
Variety meets expectations on labour requirements	88	93
Will use this variety again	84	68
Variety meets expectations on yields	84	94
Variety meets expectations on flavour/cooking requirements	83	81

Note: Percentage of positive answers; N243

Variety renewal

Over 50 per cent of the interviewed farmers produced more than one variety of rice in their last production season (Table 10). Farmers tend to work from a portfolio of varieties which meets their expectations in terms of yields, adaption to climatic and soil conditions and market price (Table 13). Every few seasons, farmers are inclined to change one or more varieties in their portfolio in order to maximise the effects of the aforementioned criteria. During FGDs and interviews, farmers made clear that they constantly readjust their varietal portfolio in function of these criteria. Most commonly, the farmers interviewed reported to seek a different variety every 3 seasons (42 per cent; Table 15). In this instance, 'different' does not necessarily mean to get an entirely new variety, but that producers add or replace a variety to their portfolio. While it can be an entirely new variety that they have never used, it is more likely to be a variety which is known to them, but of which they did not have a seed stock (FGD). Variety renewal seems to be coordinated with the seed stock renewal (Table 22). Hence, it can be hypothesised that when farmers renew their seed stock, they are likely to acquire a so-called 'different' variety.

Table 15 Variety change

Seeking a different variety[2]	Lower Ayeyarwady delta %	Upper Ayeyarwady delta %	Total %	N
Every season	4.1	8.3	6.2	15
Every 2 seasons	22.1	24.8	23.5	57
Every 3 seasons	37.7	46.3	42.0	102
Every 4 seasons	8.2	8.3	8.2	20
Every 5 seasons or more	11.5	9.1	10.3	25
Never	16.4	3.3	9.9	24

Note: N243

[2] Survey question: How often do you seek a different rice variety?

The majority of farmers interviewed rely on informal networks (family, friends and neighbours) to gain information about new rice varieties. This means that this informal network, as well as a farmer's own observations, play a substantial role in terms of variety selection (Table 16). Formal networks such as specialised seed producers, companies or projects play a much more limited role (15 per cent) in contributing to variety selection.

Table 16 Source of information for decision making on variety to use

	Lower Ayeyarwady delta		Upper Ayeyarwady delta	
	Freq.	%	Freq.	%
Own observation	64	52.5	87	71.9
Informal network	39	32.0	16	12.22
Formal network	19	15.6	18	15.2
Total	122	100.0	121	100

Note: N243

3.1.3 Rice seed

Seed generation

No distinction was made for the seed generation of local varieties because in most cases, seed is recycled from a farmer's own rice production (see also Table 20). For improved varieties, first generation seed (certified/quality seed) was not encountered in the lower Ayeyarwady delta among surveyed farmers, but was reported by 27 per cent of the farmers in the upper delta. Yet, most of the seed of improved varieties was second generation seed or seed that had been recycled for more than two generations (71 per cent; Table 17).

Table 17 Seed generation used

Seed generation used	Lower Ayeyarwady delta %	Upper Ayeyarwady delta %	Total %	N
Local variety – all (generally recycled seed of second generation and more	41.3	2.5	21.9	53
Improved variety – recycled seed (second generation and more)	58.7	71.1	64.9	157
Improved variety – certified/quality seed (first generation)	0.0	26.5	13.2	32

Note: N242

Source of the seed

For the main varieties grown in the lower Ayeyarwady delta, farmers used recycled seed from their own fields (87 per cent of cases). Few farmers reported to having obtained their seed of their main variety from informal sources like family, friends and neighbours, or from formal sources such as specialised seed producers, private companies or projects (government or development organisations). While farmers have reported to not accessing first generation seed of improved varieties in the lower delta, they have cited receiving second generation seed of improved varieties through projects and a company (which are considered formal seed sources). It is possible to hypothesise that in some cases formal sources facilitate the acquisition of good quality recycled seed, but this is not a regular or encouraged practice. We cannot conclude from the data that no first generation quality/certified seed is available in the lower delta. The data only show that for the interviewed farmers, recycled seed of improved varieties was the main seed sourced.

In the upper Ayeyarwady delta, the source of the main variety used was also the farmers' own fields (53 per cent). However, the formal sources such as specialized seed producers, farmer groups and private companies like Gold Delta represented a non-negligible seed source for the main variety sown by interviewed farmers (31 per cent). Farmers interviewed in the lower delta relied more heavily on informal sources (own field and others) than in the upper Ayeyarwady delta (Table 18).

Table 18 Sources of seed of the main variety sown

Source of seed	Lower Ayeyarwady delta %	Upper Ayeyarwady delta %	%	N
Informal source – own field	86.9	52.9	70.0	170
Informal source – other	9.0	16.5	12.8	31
Formal source	4.1	30.6	17.3	42

Note: N243

Table 19 lists the various formal seed sources and the frequency of their use by farmers in the lower and upper Ayeyarwady delta. Specialised seed producers are the predominant source with a total of 17 observations out of 42, followed by the RSC Gold Delta Rice with 12 observations, and government projects at 7 observations.

Table 19 Frequencies of formal sources per Ayeyarwady delta location

Formal seed source	Lower Ayeyarwady delta	Upper Ayeyarwady delta	Total
Specialised farmer seed producer	1	16	17
Gold Delta Rice Specialization Company	0	12	12
Project Government	1	6	7
Development organisation project	2	0	2
Research institute	0	1	1
Rice miller	1	0	1
Other	0	2	2
Total	5	37	42

Note: N42

Table 20 presents the breakdown of seed sources per variety type. It clearly shows that seed of local varieties tends to be recycled from farmers' own harvest in both survey locations. Seed of improved varieties is also frequently recycled from farmers' own fields. In the lower Ayeyarwady delta, 86 per cent of the seed of improved varieties was recycled from own fields, while 10 per cent came from an informal source and 4 per cent from a formal source. In the upper Ayeyarwady delta, 52 per cent of the seed of improved varieties was recycled from own fields, while 31 per cent was acquired from a formal source and 17 per cent from an informal source.

Table 20 Source of the seed per variety type

Number of varieties	Local variety		Improved variety		Total	
	Freq.	%	Freq.	%	Freq.	%
Lower Ayeyarwady delta						
Informal source – own field	45	90.0	61	85.9	106	87.6
Informal source – other	4	8.0	7	9.9	11	9.1
Formal source	1	2.0	4	4.2	4	3.3
Total	50	100.0	72	100.0	121	100.0
Upper Ayeyarwady delta						
Informal source – own field	3	100	61	51.7	64	52.9
Informal source – other	0	0	20	17.0	20	16.5
Formal source	0	0	37	31.4	37	30.6
Total	**3**	**100.0**	**98**	**100.0**	**121**	**100**

Note: N242

Distance to seed

Few farmers reported having to travel to the source of their seed (N45). Most of these farmers (N39) are located in the upper Ayeyarwady delta, where a greater proportion of farmers reported procuring seed from a formal source (Table 18). Farmers in the upper delta travelled on average 7.5 miles (N39), and 80 per cent of farmers encountered the seed source within 10 miles of their household (Table 21). With limited confidence due to the low number of observations, it can be assumed that the seed source (in the cases where seed was acquired) was closer to farmer households in the lower Ayeyarwady delta at an average a distance of 3.9 miles (N6). In 90 per cent of the cases, motorised transport (motorcycle, car, taxi, bus) was used to reach the seed source.

Table 21 Average distance producers travelled to seed source

	Lower Ayeyarwady delta		Upper Ayeyarwady delta	
Distance	**Freq.**	**%**	**Freq.**	**%**
0 to 1 miles	3.0	50.0	3.0	7.7
1.1 to 5 miles	2.0	33.3	15.0	38.5
5.1 to 10 miles	0.0	0.0	13.0	33.3
10.1 miles and more	1.0	16.7	8.0	20.5
Total	6.0	100.0	39.0	100.0

Note: N45

Seed stock renewal

Rice seed can be recycled for 2 to 3 seasons without being dramatically affected by degeneration. In other words, germination of the seed and purity of the variety remains acceptable, even if the rice seed is recycled more than once and for up to 3 seasons. However, this largely depends on the practices of seed selection, seed cleaning and seed storage. Interviewed farmers who had saved a part of their harvest as seed (N181) more commonly reported having recycled their seed for 3 seasons (52 per cent) and 2 seasons (24 per cent; Table 22). The practice that farmers reported makes agronomic and economic sense (FGD), and explains the very low number of observations for seasonal renewal (2.2 per cent on average). Of the interviewed farmers, very few never renew their seed stock (4 per cent).

Table 22 Seed stock renewal

Seed stock renewal	Lower Ayeyarwady delta %	Upper Ayeyarwady delta %	Total %	N
Never	6.6	1.3	4.4	8
Every season	2.8	1.3	2.2	4
Every 2 seasons	23.6	25.3	24.3	44
Every 3 seasons	48.1	57.3	51.9	94
Every 4 seasons	13.2	12.0	12.7	34
Every 5 seasons or more	5.7	2.7	4.4	8

Note: N181

Seed recycling practices

In both the lower and upper Ayeyarwady delta regions, the interviewed farmers made sure to select and store their rice seed according to variety (Table 23). The selection of what will be considered and treated as rice seed is done by most farmers in the field (69 per cent; Table 24). A fifth (21 per cent) of the farmers interviewed reported making the selection at harvest time based on the appearance of the panicle (size, colour), making it a critical selection criteria.

Table 23 Seed selection and storage practice

Seed selection and storage practice (% positive answers)	Freq.	%
Rice seed selection according to variety	168	93
Storage of rice seed according to variety	101	97

Note: N181, 104

Table 24 Main selection criteria of rice seed when recycled from own field

Selection criteria (% positive answers)	Freq.	%
Appearance in field	124	68.5
Appearance at harvest	38	21.0
Variety	11	6.1
None	6	3.3
Other	2	1.1

Note: N241

Of the farmers interviewed, 75 per cent recycled seed from their last rice harvest. Recycling is more common place in the lower Ayeyarwady delta, with 87 per cent of interview farmers having done so, than in the upper Ayeyarwady delta where 53 per cent recycled there seed (Table 18). Second or older generation seed of improved varieties are the most common types of seed used (Table 25); farmers recycled on average 2.6 baskets per acre of second season or older generation seed. The very low number of observations and rather large standard error for the nonrecycled (first generation) seed (N5) makes it difficult to draw robust conclusions. However, a plausible explanation for the higher quantity of recycled certified/quality seed (first generation; 3.5 baskets per acre) is its higher quality and therefore better performance than second (or older) generation seed. First generation seed is used as starting material for multiplication whilst second generation is used to cover a greater area the following season.

Table 25 Number of baskets of rice kept as seed according to seed generation sown

Baskets per acre	Mean	Std E	Min	Max	N
Local variety	2.3	0.2	0.5	6.0	50
Improved variety – recycled (second generation and more)	2.6	0.1	0.2	5.9	124
Improved variety – certified/quality seed (first generation)	3.5	0.7	2.5	6.0	5

Note: Amounts in baskets per acre; N179

Seed rate

The seed rate used for local varieties the rate used for improved varieties was significantly different (mean of respectively 2.1 and 2.8 baskets per acre) (Table 26). The difference in seed rate may be explained by the sowing style. Local varieties are more common in the lower delta; broadcasting cannot always be used in the lower delta and manual sowing by hand and fork is required. Broadcasting is the typical sowing technique in the upper delta; in the upper delta hardly any local varieties are used. Commonly, broadcasting requires more seed than manual planting.

Table 26 Number of baskets of rice seed sown according to variety type

Baskets per acre	Mean	Std E	Min	Max	N
Local variety	2.1	0.12	1	5	51
Improved variety	2.8	0.07	1	5	188

Note: N239

Seed price

A higher number of farmers interviewed paid for their seed in the upper Ayeyarwady delta as opposed to lower Ayeyarwady delta. This relates most likely to the fact that more farmers sourced the seed they used from formal sources in upper Ayeyarwady delta. The difference between farmers who purchased seed in the two survey locations is significant with a p-value smaller than 1 per cent (Table 27).

Table 27 Payment for the seed of the main variety

% of producers	Lower Ayeyarwady delta	Upper Ayeyarwady delta	Diff.	p-value
Producers who purchased seed last season	14%	40%	-27%	0.0000
s.e.	3.1%	4.5%		
N	122	121		

Note: N243

It is difficult to draw robust conclusions for the seed price data due to the low number of observations. Seed of local varieties seems to have the highest price (MMK 8,800 per basket; Table 28). The higher seed price for local varieties was confirmed by farmers during FGDs in the lower Ayeyarwady delta; the seed price is linked to the higher market price of local varieties. In the upper Ayeyarwady delta certified/quality seed of improved varieties has a higher price than recycled seed of improved varieties (MMK 7,496 versus MMK 6,789 respectively). Seed price is higher in the lower delta than in the upper delta; the difference in average seed price between the lower and the upper Ayeyarwady delta for recycled seed of improved varieties is significant with a p-value smaller than 1 per cent (MMK 8,771 and MMK 6,789 respectively; Table 28).

Table 28 Average market price of seed per variety type

	Mean	Std E	Min	Max	N
Lower Ayeyarwady delta					
Seed of local variety	8,800.0	374.2	8,000	10,000	5
Recycled seed of improved variety	8,770.8	441.1	6,000	10,000	12
Upper Ayeyarwady delta					
Recycled seed of improved variety	6,788.9	293.2	5,000	10,000	21
Certified/quality seed of improved variety	7,496.0	317.6	5,000	10,000	25

Note: N63

There are too few observations of local varieties to justify a separated regression between the two variety types (Table 29). Yet, when a regression is performed on the seed prices of improved varieties it is found that the seed sourced from neighbours, family or friends had a statistically significant lower price as compared to the seed from other sources. In the full model, seed of local varieties was purchased at a significantly higher price than seed of improved varieties (p-value <1%). Seed purchase from neighbours, family or friends is significantly lower, but this is due to the domination of the improved variety type for this seed source.

Table 29 Regression: effects on rice seed price per basket

Selection criteria (% positive answers)	Improved varieties	Full Model
Seed type: certified/quality seed (1st generation seed)	-1,104.000 (694.171)	-1,104.000 (673.458)
Seed source: neighbour, family or friend	-1,620.695 (588.135)***	-1,552.082 (525.708)***
Seed source: formal	552.382 (745.086)	585.418 (714.921)
Variety type: local variety		1,716.667 (723.932)**
Constant	8,047.618 (408.100)***	8,014.582 (381.248)***
Adjusted R2	0.1276	0.1646
N	58.0000	63.0000

Note: * p<0.1; ** p<0.05; *** p<0.01; s.e. in parenthesis

Gender roles and seed practices

Farmers interviewed were asked about gender roles in the household with regard to seed management practices around rice seed. The number of observations varies depending on household practices on seed purchase and seed recycling. Yet, activities are predominantly left to the head of the household, which in most cases is a man (12 per cent of households interviewed were female headed). When women are the head of the household, they also make the decisions. During FGDs it was difficult to meet with women, nevertheless, a classification of gender roles for the different steps of rice production was done with FGD participants. The outcomes of the discussions were similar to the survey findings. Generally, women were said to participate in the broadcasting of seed and transplanting as well as the harvest and the cleaning (Table 30).

Table 30 Gender roles and seed practices

	Variety selection		Goes to seed source		Pays for the seed		Recycles the seed	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
Man head of	204	84.0	36	78.3	57	86.4	136	82.9

	Variety selection		Goes to seed source		Pays for the seed		Recycles the seed	
	Freq.	%	Freq.	%	Freq.	%	Freq.	%
household								
Woman head of household	29	11.9	5	10.9	6	9.1	14	8.5
Man	8	3.3	3	6.5	2	3.0	12	7.3
Woman	2	0.82	2	4.5	1	1.5	2	1.2
Total	243	100.0	46	100.0	66	100.0	164	100.0

3.1.4 Inputs

Urea is the most commonly used fertiliser in both the lower and upper Ayeyarwady delta (Table 31). Eighty six per cent of interviewed farmers in the lower delta and 93 per cent in the upper delta used urea. The difference of 6 per cent between the two survey locations is low but significant. Few other fertilisers and agrochemicals are widely used across the two survey locations. Potash, although not widely used (13 per cent) is common to both the lower and upper delta, while gypsum, compost and fungicides are also used in low frequencies.

The two survey locations exhibit clear differences with regard to the number of producers using NPK (or potassium), T-Super, manure, herbicide and pesticide. In the lower Ayeyarwady delta, the use of T-Super and pesticides is common (77 and 43 per cent of surveyed farmers, respectively), whereas both are less common in the upper delta. Manure (61 per cent), NPK (60 per cent) and herbicide (59 per cent) were reported to be used more frequently in the upper delta as compared to the lower delta. The different soil conditions in the two delta locations are likely to be the cause for the difference in practices.

Table 31 Inputs used per survey location

	Lower Ayeyarwady delta %	s.e. %	Upper Ayeyarwady delta %	s.e. %	Diff. %	p-value %
Urea	86	3	93	2	-6	10*
NPK	26	4	60	4	-34	0***
T-Super	77	4	27	4	49	0***
Gypsum	7	2	12	3	-5	17
Potash	13	3	13	3	0	99
Manure	7	2	61	4	-54	0***
Compost	6	2	13	3	-7	5**
Herbicide	15	3	59	4	-44	0***
Pesticide	43	4	12	3	30	0***
Fungicide	9	3	7	2	2	66

Note: Per cent of producers surveyed; N243; * p<0.1; ** p<0.05; *** p<0.01

The DOA recommends different fertiliser application rates to achieve regular and optimal yields for improved varieties i.e., if producers use the recommended rate of 50 kg of urea and 12.5 kg of T-Super, they can achieve regular yields. However, if they apply the recommended rate of 100 kg of urea, 25 kg of T-Super and 12.5 kg of potash, they can achieve the higher, optimal yields. Table 32 shows the frequency of producers who applied urea, T-Super and potash at the different recommendation rates. Starred quantities are recommended for optimal yields of improved varieties. There is quite some variation between fertilisation levels, but the majority of interviewed producers used different amounts of fertiliser to the recommended rates for optimal yields, even when using a 20 per cent margin below and above optimal quantities.

Table 32 Recommended and optimal fertilisation levels for all variety types

	Lower Ayeyarwady delta		Upper Ayeyarwady delta	
	Freq.	%	Freq.	%
Urea				
Other quantities	63	60.0	54	48.2
40-60 kg per acre	13	12.4	44	39.3
80-120 kg per acre	29	27.6	14	12.5
Total	105	100.0	112	100.0
Tsuper				
Other quantities	53	70.7	16	48.5
10-15 kg per acre	8	10.7	3	9.1
20-30 kg per acre	14	18.7	14	42.4
Total	75	100.0	33	100.0
Potash				
Other quantities	7	53.9	12	65.5
10-15 kg per acre	6	46.2	4	34.5
Total	13	100.0	16	100.0

The fertiliser source is between 0-5 miles from farming households for nearly 50 per cent of cases in both lower and upper Ayeyarwady delta (Table 33). The most important difference lies in the proximity to fertiliser and other agrochemicals. Only a very low percentage of farmers interviewed in the lower delta (between 3 per cent and 5 per cent) sourced their products within 0-1 miles from their households, compared to about a fifth in the upper delta (21 per cent producers on average). The different geography of the two survey locations means that travel in the lower delta is exacerbated by difficult transport. For example in the lower delta, farmers had to travel by boat in 63 per cent of cases to source their fertiliser, whereas motorised transport was used in 95 per cent of cases in the upper delta.

Table 33 Distance to fertiliser and agrochemicals

	Lower Ayeyarwady delta			Upper Ayeyarwady delta		
Distance	**Freq.**	**%**	**Cumul. %**	**Freq.**	**%**	**Cumul. %**
Fertiliser source						
0 to 1 miles	3	2.7	2.7	25	20.8	20.8
1.1 to 5 miles	54	48.2	50.9	28	23.3	44.1
5.1 to 10 miles	32	28.6	79.5	45	37.5	81.6
10.1 miles and more	23	20.5	100.0	22	18.3	100.0
Total	112	100.0		120	100.0	
Other agrochemicals (herbicides, pesticides)						
0 to 1 miles	3	5.0	5.0	17	22.4	22.4
1.1 to 5 miles	19	31.7	36.7	17	22.4	44.8
5.1 to 10 miles	24	40.0	76.7	36	47.4	92.2
10.1 miles and more	14	23.3	100.0	6	7.9	100.0
Total	60	100.0		76	100.0	

3.1.5 Yields

Average yields reported by interviewed farmers are lower in the lower Ayeyarwady delta than in the upper delta (Table 34). On average, producers harvested 63 baskets of rice per acre in the

lower delta as opposed to 73 baskets in the upper delta, with a statistically significant difference between the reported means (p-value <1 per cent). The standard error of the mean is small (below 5 per cent) indicating limited variation of the sampled distribution and accuracy of the data. While cautious analysis is required because of the low number of observations, varieties across the two locations show important variations in yields. In the lower delta, Thee Htet Yin, which is predominantly grown in the summer season, gives the highest yields – close to 85 baskets per acre. Other varieties (with below 5 observations per variety) in general have average yields of 67.4 baskets per acre. Pawsan and Sin Thukha varieties, although appreciated for their marketing potential, have relatively low yields at 44.5 and 41.5 baskets per acre, respectively. In the upper delta, all frequently cited varieties except Shwe War Htun, yielded above 70 baskets per acre. The highest yields were derived from the Hmawbi-2 variety at 78.4 baskets per acre. The Sin Thukha variety yielded statistically significant higher yields in the upper delta than in the lower delta (p-value <1 per cent), with 74.7 baskets per acre as compared to 41.5 baskets per acre, suggesting it performs better in the upper delta.

Table 34 Average yields per survey location and per variety

Yields per location	Mean	s.e.	Min	Max	N
Lower Ayeyarwady delta	62.8	2.1	20.0	110	122
Upper Ayeyarwady delta	72.9	1.3	33.3	114	121
Varieties lower Ayeyarwady delta					
Thee Htet Yin	84.7	2.6	36.3	110	36
Pawsan	44.5	2.0	22.0	66	27
Sin Thukha	41.5	4.3	20.0	60	9
Other varieties	67.4	4.7	27.8	100	27
Varieties upper Ayeyarwady delta					
Hmawbi-2	78.4	3.7	55.0	112	14
Sin Thukha	74.7	2.1	51.4	114	39
Sin Thwe Lat	73.1	2.7	50.0	98	17
Shwe War Htun	66.0	2.5	33.3	90	25

Note: Yield in baskets per acre

Calculated means of each seed type show that first generation (certified/quality) seed of improved varieties result in higher yields (80 baskets per acre) than recycled seed (second generation or more) of improved varieties, which in the lower and upper Ayeyarwaddy delta result in similar yields of 71 baskets per acre. The lowest recorded yields were derived from the seed of local varieties in the lower delta, at 50 baskets per acre (Table 35). Minimum and maximum yields per acre vary widely for each seed type, suggesting factors other than just seed type have an influence on yields.

Table 35 Average yields per variety type

Yields	Mean	s.e.	Min	Max	N
Lower Ayeyarwady delta					
Local variety	50.4	2.6	22.0	100.0	5
Improved variety – recycled seed (second generation or more)	71.2	2.7	20.0	110.0	71
Upper Ayeyarwady delta					
Improved variety – recycled seed (second generation or more)	70.5	1.4	33.3	114.0	86
Improved variety – certified/quality seed (first generation)	79.9	2.2	50.0	112.0	32

Note: Yield in baskets per acre; N194

Table 36 is the result of a regression on yields which accounts for land size, source of seed, variety type, fertiliser usage and number of varieties sown. Looking at local varieties only (first column), the upper Ayeyarwady delta has statistically significant higher yields. However, the larger the area under cultivation, the statistically significantly lower the expected yields. The use of fertiliser on local varieties does not statistically impact the yields obtained.

When looking at improved varieties only (second column), statistically significant higher yields are produced using urea fertiliser. Statistically significant lower yields are observed in rice grain production when a higher number of varieties are used simultaneously. Use of first generation seed of improved varieties (certified/quality seed) gives statistically significant higher yields.

In the full model (column three) there are more observations with improved varieties and they therefore have a dominating effect. Local varieties have statistically significant lower yields and once controlled for variety type, the lower/upper Ayeyarwady delta effects disappear. This is expected since variety type is strongly related to delta location (Table 11). First generation seed of improved varieties has a statistically significant higher yield, as Table 36 suggests.

Generally, statistically significant higher yields are observed in production using urea fertiliser. Statistically significant lower yields are observed in production when using a higher number of varieties. The same phenomenon is observed for larger areas (statistically significantly lower yields). The latter is likely due to the difficulty of hiring labourers to perform work in the fields and at harvest (FGD) resulting in a negative impact on yields. The source of seed has no effect once other factors are discounted. The full regression model has an adjusted R2 of 33.8 per cent, which indicates that a large amount of variability in the sample is captured by this model.

Table 36 Regression: effects on rice yield

	Local varieties	Improved varieties	Full Model
Upper Ayeyarwady delta	21.830 (10.564)**	-0.712 (3.541)	2.823 (3.314)
Seed Source: Informal – neighbour, family or friend	-13.849 (10.203)	-2.048 (3.761)	-4.377 (3.549)
Seed Source: Formal	-10.998 (15.812)	-6.153 (6.429)	-8.397 (6.027)
Fertiliser use (y/n): NPK	-1.815 (6.147)	5.749 (2.919)*	3.276 (2.596)
Fertiliser use (y/n): T-Super	7.469 (6.334)	0.740 (3.190)	3.679 (2.766)
Fertiliser use (y/n): Urea	7.957 (6.015)	16.311 (4.760)***	12.828 (3.713)***
Fertiliser use (y/n): Other	-1.467 (9.843)	3.346 (3.790)	0.396 (3.392)
Number of varieties	-0.823 (3.720)	-7.120 (2.418)***	-4.301 (1.958)**
Rice area cultivated (acres)	-1.876 (0.893)**	0.221 (0.575)	-1.003 (0.383)***
Rice area cultivated (acres), squared	0.035 (0.016)**	-0.018 (0.016)	0.018 (0.009)**
First generation seed (certified/quality)		11.878 (7.003)*	14.308 (6.666)**
Variety type: Local variety			-14.094 (3.589)***
Constant	58.828	65.768	69.407

	Local varieties	Improved varieties	Full Model
	(10.325)***	(6.585)***	(5.367)***
Adjusted R2	0.1170	0.1680	0.3382
N	49.0000	169.0000	218.0000

Note: Yield in baskets per acre; * p<0.1; ** p<0.05; *** p<0.01; s.e. in parenthesis

Gender of the household head does not have a statistically significant influence on the average yield produced per household, with a difference of only 1.5 baskets per acre (Table 37).

Table 37 Yield according to gender of head of household

Yields	Mean	s.e.	Min	Max	N
Men HH	67.7	1.3	20.0	114.0	214
Women HH	69.3	3.6	31.3	110.0	29

Note: Yield in baskets per acre; N243

When yields are compared for households which are below or equal to the average probability to be living under USD 2.50 or USD 1.25, to households which have scored above the average probability to be living under the USD 2.50 or USD 1.25 poverty line (see section 3.1.1), no significant statistical difference was found between the producers in the lower and upper delta (Table 38). The difference in yields between the two groups varies from 1 to 5 baskets per acre, with slightly higher yields achieved by households who scored below the average probability of living under the poverty lines.

Table 38 Yield related to poverty level

	Lower Ayeyarwady delta				Upper Ayeyarwady Delta			
PPI and yields	Below av. prob.	Above av. prob.	diff	p-value	Below av. prob.	Above av. prob.	diff	p-value
PPI USD 1.25								
Yields (baskets/acre)	63.2	62.3	0.90	0.83	73.8	70.8	2.98	0.27
s.e.	2.8	3.2			1.4	2.5		
N	71	51			83	38		
PPI USD 2.50								
Yields (baskets/acre)	66.5	61.6	4.83	0.33	75.5	71.4	4.09	0.12
s.e.	4.4	2.4			2.2	1.5		
N	29	93			43	78		

Note: av. prob. = average probability. PPI = Progress out of Poverty Index. PPI USD 1.25: 13.9%; PPI USD 2.50: 83.5%

Table 39 shows the statistically significant difference (p-value <1%) between the average yields per season (monsoon or summer season). Higher yields of 84 baskets per acre were achieved in the summer seasons of February to May 2016 and 2015, as compared to 62.9 baskets per acre achieved in the monsoon season of 2015. This is likely due to the higher percentage of improved varieties used in the summer season (85 per cent of seed used in the summer season).

Table 39 Yield according to season

Yield	Mean	s.e.	Min	Max	N
Monsoon season 2015	62.9	1.4	20.0	114.0	186
Summer season	84.2	2.3	36.7	110.0	57

Note: Yield in baskets per acre; N231

Because of the very low number of producers using optimal levels of fertiliser it is not possible to compute the effect of such practices on yields (Table 32). The only possible analysis is looking at yields of improved varieties according to normal and optimal quantities of urea (because it has the highest number of observations). Table 40 shows a statistically significant difference (p-value < 10 per cent) in yields between normal and optimal urea fertilisation practices, with optimal practices resulting in higher yields among the farmers interviewed.

Table 40 Yield of improved varieties related to urea fertilisation

Yield	Mean	s.e.	Min	Max	N
40-60 kg urea per acre	73.3	1.8	38.6	100.0	54
80-120 kg urea per acre*	78.8	2.6	40.0	110.0	40

Note: Yield in baskets per acre; N94

When yields are compared according to buyer type (Table 41), data suggests that producers who sell to companies (Gold Delta for example) have significantly higher yields (p-value <5%) than other producers when using improved varieties. Although careful interpretation is required because of the low number of observations, the difference in mean yields could potentially be explained by the tighter control and support farmers receive when they sell their rice grain to private companies as buyers.

Table 41 Yield of improved varieties according to buyers

Yield	Mean	s.e.	Min	Max	N
Other buyers	71.6	1.4	20.0	114.0	174
Gold Delta RSC	81.3	2.9	66.7	112.0	17

Note: Yield in baskets per acre; N190

3.1.6 Sales

Farmers interviewed in the lower Ayeyarwady delta reported rice millers as the main buyer of their rice harvest (38 per cent of producers), closely followed by village traders (36 per cent of producers) and market traders (26 per cent of producers; Table 42). Over half of interviewed farmers in the upper Ayeyarwady delta reported village traders to be the main buyers of their rice (57 per cent). Other buyers such as rice millers, traders at the market and private companies like Gold Delta buy in relatively equal proportions.

Table 42 Main buyer of rice per survey location

	Lower Ayeyarwady delta		Upper Ayeyarwady delta	
Main buyer	Freq.	%	Freq.	%
Rice miller	46	38.3%	18	15.3%
Trader at the village	43	35.8%	67	56.8%
Trade at the market	31	25.8%	17	14.4%
Company	0	0.0%	16	13.6%
Total	120	100.0%	118	100.0%

Note: % of producers; N238

The minimum selling price for rice is virtually the same between the lower and upper Ayeyarwady delta (MMK 3,000), but the maximum price in the lower delta is MMK 1,500 higher than in the upper delta (Table 43). This variation results in a higher average selling price for rice in the lower delta (MMK 5,900) as compared to the upper delta (MMK 4,988). The difference of about MMK

1,000 per basket between the two survey locations is statistically significant (p-value <1%) and is likely due to the different variety types.

Farmers interviewed in the lower Ayeyarwady delta fetched a higher price for their Pawsan rice (MMK 6,962 per basket) as compared to the other most commonly used varieties. However, the price difference with Sin Thukha rice is not statistically significant; Sin Thukha is the variety with the second highest selling price for rice in the lower delta (MMK 6,653 per basket). Pawson and Sin Thukha varieties were also sold for higher minimum prices of around MMK 4,000 and MMK 5,000, while other varieties fetched lower minimum prices of around MMK 3,000 per basket.

In the upper Ayeyarwady delta, the Hmawbi-2 and Sin Thukha varieties are fetching similar prices for a basket of rice (MMK 5,163 and MKK 5,123 respectively). The difference in average selling price for Sin Thukha rice between the lower and upper delta is statistically significant (p-value <1%), which suggests that producers are able to sell this rice at a higher price in the lower delta than in the upper delta. The reason may be that the variety is more widespread in the upper delta when compared to the lower delta.

No significant statistical difference was found between average selling prices for households who scored below or above the USD1.25 and USD2.50 poverty probability lines (see section 3.1.1), which suggests that households which are more likely to be poor are still able to market their rice at a similar price to households which are less likely to be poor.

Table 43 Average selling price of rice per survey location

Average selling price	Mean	s.e.	Min	Max	N
Lower Ayeyarwady delta	5,904	122	2,999	8,000	120
Upper Ayeyarwady delta	4,988	54	3,000	6,497	117
Varieties lower Ayeyarwady delta					
Pawsan	6,962	187	4,098	8,000	28
Sin Thukha	6,653	310	5,297	8,000	9
Thee Htet Yin	4,742	154	2,999	7,996	36
Other varieties	5,544	230	2,999	7,996	26
Varieties upper Ayeyarwady delta					
Hmawbi-2	5,163	133	3,998	5,997	14
Sin Thukha	5,123	92	3,898	6,497	38
Shwe War Htun	5,012	132	3,000	5,997	24
Sin Thwe Lat	4,557	128	3,998	5,800	17

Note: Price in MMK per basket of rice; N237

Table 44 is the result of a regression looking at the buyer effect as well as parameters such as variety type, seed type and survey location and their effects on rice selling prices. When looking at different buyers only (not considering survey location), village traders offer a statistically significant lower price, which is often the case for farm gate sales. Companies too, offer a statistically significant lower price, but are likely to offer additional services to rice producers.

Variety type has been used as a parameter in the regression. There is no statistically significant effect when analysing local varieties only against the different parameters (second column). Looking at improved varieties only, statistically significant lower prices are observed in the upper Ayeyarwady delta as compared to prices in the lower delta for the same variety type. As for the buyer effect, companies offer a weakly statistically significant lower price as compared to other buyers for improved varieties.

In the full sample, local varieties have statistically significant higher prices. This can be explained by the fact that amongst others, Pawsan is a highly appreciated variety which fetches higher prices on the local markets (FGD). Once controlled for the variety type, there is no statistically significant buyer effect, which means that the variety type has more importance than the buyer when it comes to selling prices. This holds true with the exception of companies, who offer a weakly statistically significant lower price but usually offer a secure market to producers buying bulk quantities of rice at once (FGD). Yet, after controlling for buyers and variety type, statistically significant lower prices are still reported in the upper Ayeyarwady delta.

Table 44 Regression: effects on rice price per basket

	Buyer effect	Local varieties	Improved varieties	Full model
Buyer: Trader at the village	-501.547 (170.205)***	-59.590 (413.913)	-205.346 (162.700)	-205.120 (155.492)
Buyer: Trader at the market	147.267 (206.372)	-93.547 (422.276)	320.323 (195.265)	201.285 (179.831)
Buyer: Company	-1,107.100 (302.098)***		-560.388 (290.383)*	-574.283 (314.899)*
Upper Ayeyarwady delta		-1,369.989 (912.220)	-298.721 (142.026)**	-347.937 (152.451)**
Seed Type: First generation improved			86.075 (209.919)	100.070 (230.697)
Variety Type: Local variety				1,149.933 (168.848)***
Constant	5,727.073 (135.102)***	6,677.068 (270.970)***	5,403.767 (140.877)***	5,454.630 (142.759)***
Adjusted R2	0.0879	-0.0089	0.0918	0.3136
N	237.0000	51.0000	186.0000	237.0000

Note: * p<0.1; ** p<0.05; *** p<0.01; s.e. in parenthesis

3.1.7 Profit model

A simple profit model was created based on the reported expenses by farmers on seed, fertiliser and agro-chemicals, and the sales of rice baskets (Table 45). On average, revenues per acre are MMK 281,220. Gross profits per acre are higher for farmers having used improved varieties (MMK 294,444) than they are for local varieties (MMK 233,350). Once expenses on seed, fertiliser and agrochemicals are accounted for, net profits remain higher for improved varieties, despite their lower selling price (MMK 5,152 compared to MMK 6,602) and greater investments. Higher productivity compared to local varieties makes up for the higher investments.

Farmers reported using the Pawsan local variety because of the higher prices fetched on the market. However, when other factors are considered, this decision seems to be less profitable than opting for an improved variety which offers high(er) yields. The data also suggests that farmers who invested more heavily in seed (usually improved varieties) tend to also invest more heavily in fertiliser and agrochemicals. The regression performed on yields (Table 36) also suggests that fertiliser application has a positive influence on yields for improved varieties but not on local varieties. This would explain the higher investments when using improved varieties when compared to local varieties (Figure 10).

Table 45 Profit model for local and improved varieties

Revenues against costs	Mean	s.e.	Min
N	50	181	231
	Local	**Improved**	**All**

Revenues against costs	Mean	s.e.	Min
VALUE OF PRODUCTION			
Sales (basket per acre)	37	58	54
Price/basket	6,602	5,152	5,459
Revenues (per acre)	**233,350**	**294,444**	**281,220**
COSTS			
Seed costs (per acre)	2,095	6,339	5,420
Urea costs (per acre)	10,020	24,797	21,598
NPK costs (per acre)	2,935	7,881	6,810
T-Super costs (per acre)	6,462	7,298	7,117
Gypsum costs (per acre)	51	449	363
Other fertilisers costs (per acre)	380	1,313	1,111
Manure costs (per acre)	79	72	74
Compost costs (per acre)	-	17	13
Herbicides costs (per acre)	242	2,179	1,760
Pesticides costs (per acre)	471	659	619
Fungicides costs (per acre)	28	394	314
Total costs	**22,763**	**51,398**	**45,200**
Revenues minus costs (per acre)	**210,587**	**243,046**	**236,020**

Note: all costs and revenues are in MMK

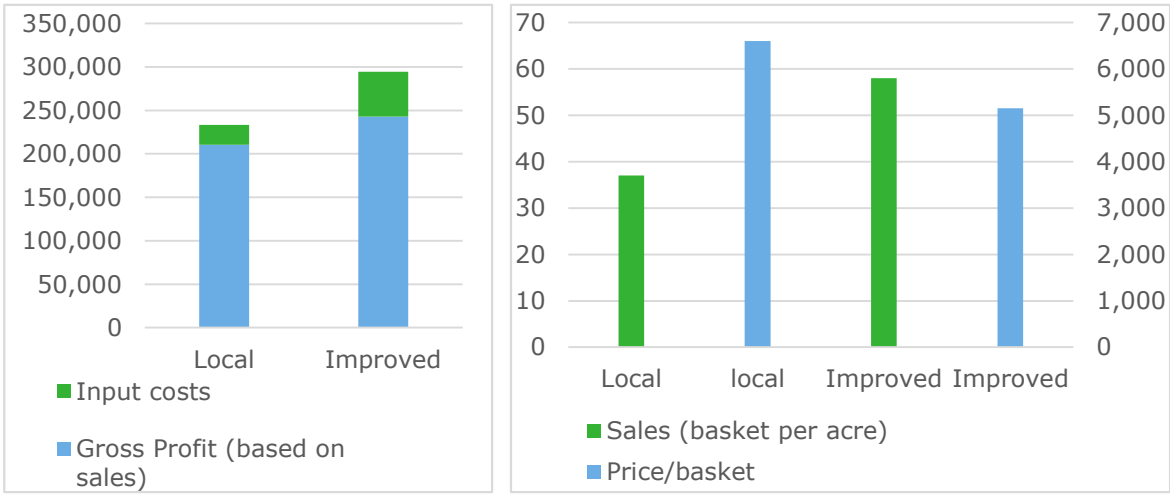


Figure 10 Graph profit model

Note: results per acre; profit in MMK

3.2 Seed supply survey

In this section, we document and analyse the seed production and seed supply data of the Ayeyarwady region for different categories of seed, i.e. breeder seed, foundation seed, registered seed and certified seed. For the EGS classes of foundation seed and registered seed, we provide data from the 2015/16 production seasons as well as from the 2016 monsoon season. We provide the certified seed production data from the 26 townships in the Ayeyarwady delta for four consecutive production seasons (2012/13, 2013/14, 2014/15, 2015/16). We analyse the major trends of the regional level data, but also give detailed data on certified seed production for the four study townships.

3.2.1 EGS production and supply in the Ayeyarwady region

Nucleus and breeder seed

DAR in Yezin is the sole producer and maintainer of nucleus seed and breeder seed of rice varieties. Breeder seed is produced from nucleus seed. All DOA seed farms and DAR research farms operating in the Ayeyarwady delta source breeder seed from DAR Yezin.

Foundation seed

Foundation seed is produced from breeder seed. In the Ayeyarwady region, foundation seed is produced in four government run farms: (i) Myaungmya Research Farm, Myaungmya; (ii) Myanmar Rice Research Centre, Hmawbi; (iii) Tagontaing Seed Farm, Hinthada; and (iv) Thayaung Chaung Seed Farm, Pathein. Whereas Myaungmya Research Farm is under the management of DAR, the Myanmar Rice Research Centre, Tagontaing Seed Farm and Thayaung Chaung Seed Farm are DOA seed farms. A total of 1,208 baskets of foundation seed of 11 rice varieties was produced in the 2015/16 cropping season in the Ayeyarwady region by the four farms (more detailed information in Table 46). Most of the seed farms produce foundation seed for their own use, i.e. they multiply it for one more generation so it becomes registered seed. However, some quantity of foundation seed was also sold to other seed farms in the Ayeyarwady region and beyond.

In the 2015/16 production season, the price of foundation seed was between MMK 10,000 and MMK 12,000 per basket, depending upon the variety. Varieties such as Thee Htet Yin, Paw San Yin, Ayar Min, Sin Thukha and Sin Thwe Latt are highly demanded, and foundation seed for such types was produced in large quantities. The demand for foundation seed was not fully met for varieties such as Ayar Min, Sin Thukha and Thee Htet Yin since many seed farms retain quantities of foundation seed for their own registered seed production for the next season, and only supply surplus foundation seed to other seed farms.

Table 46 Foundation seed production in Ayeyarwady region in the 2015/16 season

	Variety	Seed farm	Foundation seed production area (acres)	Volume of foundation seed produced (baskets)	Foundation seed sales price (MMK/ basket)	Foundation seed customers
1	Ayar Min	Myanmar Rice Research Centre, Tagontaing Seed Farm, Thayaung Chaung Seed Farm	6.5	311.5	10,000	Own use, Seed farms (Myay Mon, Pwint Phyu, Mayungmya)
2	Hmawbi-2	Myanmar Rice Research Centre	3	158	10,000	Seed farms (Pauktapin, Warshaung, Mayungmya)
3	Myaungmya May	Myaungmya Research Farm	0.38	15	12,000	Shwelong wakhema
4	Paw San Yin	Myaungmya Research Farm, Thayaung Chaung Seed Farm	4	49	12,000	Own use, Seed farm (Aukywingyi)
5	Paw San Bay Kyar	Thayaung Chaung Seed Farm	1	30	12,000	Mon state
6	Sar Ngan Khan	Myaungmya Research Farm	0.38	13	12,000	Own use, Seed farms

	Variety	Seed farm	Foundation seed production area (acres)	Volume of foundation seed produced (baskets)	Foundation seed sales price (MMK/ basket)	Foundation seed customers
7	Sin Thukha	Myanmar Rice Research Centre, Myaungmya Research Farm, Tagontaing Seed Farm, Thayaung Chaung Seed Farm	4.39	213.45	10,000	Own use, Seed farms (Thonekhwa, Mayungmya)
8	Sin Thwe Latt (salt tolerant)	Thayaung Chaung Seed Farm, Tagontaing Seed Farm	3	137.5	10,000	Own use, Seed farm (Aukywingyi), Townships (Pyapon, Hmaw Bi)
9	Swarna Sub-1	Thayaung Chaung Seed Farm, Myaungmya Research Farm	1.39	57.5	10,000	Own use, Seed farms (Yekyi Ingebou, Shwelong)
10	Thee Htet Yin	Myanmar Rice Research Centre, Myaungmya Research Farm	16	142.5	10,000	Own use, Seed farms (Tagontaing, Warshaung, Aukwingyi, Myaungmya)
11	Yadanar Toe	Myanmar Rice Research Centre	1.5	81	10,000	Own use, Seed farms (Aung Myay Yar, Pwitphyu)
	Total		**42**	**1208**		

Note: Data collected from Thayaung Chaung Seed Farm, Aukywingyi Seed Farm, Tagontaing Seed Farm, Myanmar Rice Research Centre, Myaungmya Research Farm and DOA seed division, 2016.

In the 2016 monsoon season, foundation seed of 17 varieties was produced on 50 acres of land, with a seed harvest of 2,292 baskets (Table 47). The Myanmar Rice Research Centre produced foundation seed of the varieties Shwe Myanmar, Yaymyopkhan-1, Yaymyopkhan-2, Shwe War Htun, Shwe Pyitan and Kyaw Zeya, i.e. varieties which are not used by other seed farms in the Ayeyarwady delta. For these new varieties, registered and certified seed production was not reported.

The Myaungmya Research Farm reported that due to excessive rainfall during harvesting time, the seed harvest was severely reduced or completely lost for at least 3 acres of foundation seed production (Table 48). Varieties affected included Myaungmya May, Paw San Yin, Sar Ngan Khan, Sin Thukha and Swarna Sub-1.

Table 47 Foundation seed production in Ayeyarwady region in the 2016 monsoon season

	Variety	Seed farm	Seed production area (acres)	Volume of foundation seed produced (baskets)
1	Ayar Min	Myanmar Rice Research Centre, Tagontaing Seed Farm, Thayaung Chaung Seed Farm	6	247

	Variety	Seed farm	Seed production area (acres)	Volume of foundation seed produced (baskets)
2	Hmawbi-2	Myanmar Rice Research Centre	1.5	93
3	Myaungmya May	Myaungmya Research Farm	0.38	4.5
4	Paw San Yin	Myanmar Rice Research Centre, Myaungmya Research Farm, Chaung Seed Farm	3.13	135
5	Paw San Bay Kyar	Thayaung Chaung Seed Farm, Myanmar Rice Research Centre	2	90
6	Sar Ngan Khan	Myaungmya Research Farm	0.38	0
7	Sin Thukha	Myanmar Rice Research Centre, Myaungmya Research Farm, Thayaung Chaung Seed Farm, Tagontaing Seed Farm	8.39	381
8	Sin Thwe Latt (salt tolerant)	Thayaung Chaung Seed Farm, Myanmar Rice Research Centre, Tagontaing Seed Farm	8.5	400
9	Swarna Sub-1	Thayaung Chaung Seed Farm, Myaungmya Research Farm	1.39	40
10	Thee Htet Yin	Myaungmya Research Farm, Tagontaing Seed Farm	1.66	5
11	Yadanar Toe	Myanmar Rice Research Centre, Tagontaing Seed Farm	8.5	434
12	Shwe Myanmar	Myanmar Rice Research Centre	0.6	36
13	Yaymyopkhan-1	Myanmar Rice Research Centre	1.5	90
14	Yaymyopkhan-2	Myanmar Rice Research Centre	1.6	96
15	Shwe War Htun	Myanmar Rice Research Centre	1	60
16	Shwe Pyitan	Myanmar Rice Research Centre	1.5	90
17	Kyaw Zeya	Myanmar Rice Research Centre	1.5	90
	Total		**50**	**2,292**

Note: Data collected from Thayaung Chaung Seed Farm, Tagontaing Seed Farm, Myanmar Rice Research Centre, Myaungmya Research Farm and DOA seed division, 2016.

Table 48 Foundation seed losses at Myaungmya Research Farm in the 2016 monsoon season

	Variety	Production area (acres)	Foundation seed loss
1	Myaungmya May	0.38	18.5 baskets
2	Paw San Yin	1.5	Complete harvest
3	Sar Ngan Khan	0.38	Complete harvest
4	Sin Thukha	0.39	15 baskets
5	Swarna Sub-1	0.39	Complete harvest

Note: Data collected from Myaungmya Research Farm, 2016

Registered seed

Registered seed is produced from foundation seed. Both DAR research farms and DOA seed farms are involved in the production of registered seed. Foundation seed was either produced on site, or purchased from other farms. In addition to the public sector, several development organisations such as Radanar Ayar and Metta are also involved in registered seed production. However, their registered seed production is small. In the 2015/16 cropping season, a total of 23,657 baskets of registered seed of nine different varieties was produced and sold to different customers (Table

49). Customers included township offices, development organisation projects, private companies, and farmers (direct sales). Registered seed was not only sold to customers in the Ayeyarwady region, but also to customers from other regions such as Bago, Mandalay and Sagaing regions. Altogether, five seed farms were involved in registered seed production: Myaungmya Research Farm (Myaungmya), Myanmar Rice Research Centre (Hmawbi), Tagontaing Seed Farm (Hinthada), Thayaung Chaung Seed Farm (Pathein), and Aukywingyi Seed Farm (Pyapon). The Aukywingyi Seed Farm of DOA mainly focusses on registered seed production and sources foundation seed from other seed farms.

Interviewed seed farm managers indicated that they were only able to meet 50 per cent of the demand for registered seed. They also indicated that only 20 per cent of demand for registered seed of Ayar Min and Sin Thukha varieties is met by seed farms. The reasons for this as mentioned by seed farm managers include: insufficient volumes of foundation seed, lack of supplementary irrigation facilities during the dry season; lack of seed farm equipment such as seed processing machinery; lack of seed storage facilities; lack of human resources; and shortage of skilled labour in the market.

Table 49 Registered seed production in Ayeyarwady region in the 2015/16 season

	Variety	Seed farm	Registered seed production area (acres)	Volume of registered seed produced (baskets)	Registered seed sales price (MMK/ basket)	Registered seed customers
1	Ayar Min	Myanmar Rice Research Centre, Tagontaing Seed Farm, Thayaung Chaung Seed Farm	154.5	7,008	8,000	Yangon, Bago, Ayeyarwady, Mandalay, Sagaing regions, Contact farmers in Hinthada
2	Hmawbi-2	Myanmar Rice Research Centre	50	2,813	8,000	Yangon, Bago, Ayeyarwady, Mandalay, Sagaing regions
3	Myaungmya May	Myaungmya Research Farm	1.69	120	8,000	Myaungmya, Einmae, Bogale
4	Paw San Yin	Myaungmya Research Farm, Thayaung Chaung Seed Farm Myanmar Rice Research Centre, Aukywingyi seed farm, Radanar Ayar - Bogale	86	3,095	8,000 10,000	Yangon, Ayeyarwady, Sagaing regions
5	Paw San Bay Kyar	Thayaung Chaung seed farm	17	453	8,000	NA
6	Sar Ngan Khan	Myaungmya Research Farm	5.78	289	10,000	Kyaung kone, Myaungmya, Einme, Labutta, Maw Kyun
7	Sin Thukha	Myanmar Rice Research Centre, Myaungmya Research Farm, Tagontaing Seed Farm, Thayaung Chaung Seed Farm	76.92	6,166	8,000	Yangon, Bago, Ayeyarwady, Pathein. Kyaung kon, Kan Gyi Daunt, Kyone Pyaw, Myaungmya, Einme, Labutta, Maw Kyun
8	Sin Thwe Latt (salt tolerant)	Tagontaing Seed Farm, Aukywingyi Seed Farm	18.5	1,113	8,000	NA

	Variety	Seed farm	Registered seed production area (acres)	Volume of registered seed produced (baskets)	Registered seed sales price (MMK/ basket)	Registered seed customers
9	Thee Htet Yin	Myanmar Rice Research Centre, Myaungmya Research Farm, Tagontaing Seed Farm, Aukywingyi seed farm	43.44	2,485	8,000	Yangon, Bago, Ayeyarwady regions ; Pathein, Kyaung kone, Kan Gyi Daunt, Kyone Pyaw, Myaungmya, Einme, Labutta, Maw Kyun, , Maubin, Pantanaw, Hinthada, Phyarpon
	Total		**448**	**23,657**		

Note: Data collected from Thayaung Chaung Seed Farm, Tagontaing Seed Farm, Myanmar Rice Research Centre, Myaungmya Research Farm, Aukywingyi Seed Farm, Radanar Ayar in Bogale and DOA seed division, 2016. NA = data not available

In the 2016 monsoon season, a total of 19,472 baskets of registered seed were produced from nine varieties (Table 50). In addition to DOA and DAR farms, the development organisation Metta was also involved in registered seed production through its own farm located in Pathein Township.

Table 50 Registered seed production in Ayeyarwady region in the 2016 monsoon season

	Variety	Seed farm	Seed production area (acres)	Volume of registered seed produced (baskets)
1	Ayar Min	Myanmar Rice Research Centre, Tagontaing Seed Farm, Thayaung Chaung Seed Farm, Metta Seed Farm	126	6,833
2	Hmawbi-2	Myanmar Rice Research Centre	42	2,604
3	Myaungmya May	Myaungmya Research Farm	2	104
4	Paw San Yin	Thayaung Chaung Seed Farm, Metta Seed Farm	18	630
5	Paw San Bay Kyar	Thayaung Chaung Seed Farm	12	345
6	Sar Ngan Khan	Myaungmya Research Farm	4	163
7	Sin Thukha	Myanmar Rice Research Centre, Tagontaing Seed Farm, Thayaung Chaung Seed Farm, Myaungmya Research Farm	126	6,986
8	Thee Htet Yin	Tagontaing Seed Farm, Myanmar Rice Research Centre, Myaungmya Research Farm, Metta Seed Farm	32	1,729
9	Sin Thwe Latt	Metta Seed Farm	1	78
	Total		**363**	**19,472**

Note: Data collected from Thayaung Chaung Seed Farm, Tagontaing Seed Farm, Myanmar Rice Research Centre, Myaungmya Research Farm, Aukywingyi Seed Farm, Metta Seed Farm and DOA seed division, 2016.

3.2.2 Overview of certified seed production in the Ayeyarwady region

Type of seed producers

We have observed three distinct types of seed producers involved in certified seed production in the Ayeyarwady delta. These include contact farmers, contract farmers and independent seed growers. Contact farmers are directly supported by DOA extension office at township level. This category of seed producers is the most dominant and produces the largest quantity of certified seed available in the Ayeyarwdaddy region. Contract farmers are seed producers who multiply seed as part of a contract with private companies or development organisation projects linked with rice millers. Independent seed growers are often supported by seed projects of development organisations.

Improved varieties used for seed production

A total of 14 improved varieties are being used for certified seed production. The highest volume of certified seed produced is mainly from six varieties; Sin Thukha, Sin Thwe Latt, Paw San Yin, Thee Htet Yin, Ayar Min and Hnan Kar, which represent over 70 per cent of the total volume of certified seed produced each year (Table 51). The major sources of registered seed for seed producers are the Tagontaing Seed Farm (Hinthada), Myaungmya Research Farm (Myaungmya), Myanmar Rice Research Centre (Hmawbi), Thayaung Chaung Seed farm (Pathein), and Aukywingyi Seed Farm (Pyapon).

Table 51 Varieties and volumes of certified seed production and distribution in Ayeryarwaddy region from 2012 to 2016

Production year	Varieties	Number of townships	Total number of seed producers	Seed production area (acres)	Volume of seed produced (baskets)	Volume of seed disse-minated (baskets)
2012/13	Sin Thukha, Sin Thwe Latt, Paw San Yin, Manaw Thukha, Thee Htet Yin, Shwe War Htun, Ayar Min, Hnan Kar, Yadanar Toe, Hmawbi-2, Paw San Bay Kyar (11)	26	1,354	6,677	543,066	339,240
2013/14	Sin Thukha, Sin Thwe Latt, Paw San Yin, Paw San Bay Kyar, Manaw Thukha, Thee Htet Yin, Ayar Min, Hnan Kar, Yadanar Toe, Hmawbi-2 (10)	26	1,779	9,833	746,998	462,808
2014/15	Sin Thukha, Sin Thwe Latt, Paw San Yin, Paw San Bay Kyar, Ayar Min, Thee Htet Yin, Manaw Thukha, Shwe Pyi Htay, Swarna Sub-1, Shwe War Htun, Sar Ngan Khan Sin Thwe Latt, Hmawbi-2, Hnan Kar (13)	26	2,165	12,749	976,516	605,345
2015/16	Sin Thukha, Sin Thwe Latt, Paw San Yin, Paw San Bay Kyar, Thee Htet Yin, Swarna Sub-1, Shwe War Htun, Ayar Min, Hnan Kar, Yadanar Toe, Hmawbi-2 (11)	26	1,721	11,257	843,038	522,835

Source: DOA seed division, 2016 and seed data from Radanar Ayar, GRET, WHH, Mercy Corps, Metta and Gold Delta Company, 2016

Certified seed production and seed distribution

The volumes of certified seed production and sales show an increasing trend from 2012 to 2015 of at least 6.5 per cent each year, while there was a decrease of 4 per cent in the 2015/16 season (Table 52). Seed producers sold on average 62 per cent of their certified seed to farmers or rice millers each year. Sales to farmers were independently managed, or facilitated through linkages supported by the DOA extension office. At least 38 per cent of their remaining certified seed was saved for the next season to produce the next generation of certified seed (CS-2).

Area covered with certified seed

We used seed disseminated data to measure how much of the total rice production area is covered by certified seed in four subsequent production years in the Ayeyarwady region (2013/14, 2014/15, 2015/16 and 2016/17 (Table 52). The figures show an increasing trend from 3 per cent to 5 per cent in the 2015/16 production season. There is a slight decrease in the 2016/17 production season due to both contact farmers and seed growers supported by development organisations, disseminating lower volumes of seed in the 2015/16 season. While the current data capture most seed production initiatives in the Ayeyarwady region, some data are still likely to have been missed. Considering this missing data, we estimate that less than 6 per cent of the total rice production area in the Ayeyarwady region is currently cultivating certified seed.

Table 52 Rice production area covered with certified seed in Ayeyarwady region from 2013 to 2017

Production area	Total rice production area (acre)	Seed disseminated by contact farmers supported by DOA (baskets)	Seed disseminated by seed growers supported by projects of development organisations (baskets)	Seed disseminated by private seed company (baskets)	Total seed disseminated (baskets)	% of rice production area covered by certified seed
2013/14	4,400,872	300,809	10,063	28,368	339,240	3.1
2014/15	4,980,146	421,941	12,809	28,058	462,808	3.8
2015/16	5,026,831	559,343	15,859	30,143	605,345	4.9
2016/17	5,026,831	483,002	9,833	30,000	522,835	4.2

Note: Contact farmers seed data was received from the DOA seed division, 2016; seed data of development organisation projects are from Radanar Ayar, GRET, WHH, Metta, Mercy Corps and JICA; private company data are from RSC Gold Delta, 2016. Since the production area figures are not available for the 2016/17 season at the time of the study we assumed it is similar to the 2015/16 production season. The average seed rate used by farmers in the study sites is 2.45 baskets per acre (see Table 26).

3.2.3 Overview of certified seed production and distribution in the four study townships

The seed production and distribution data from the lower Ayeyarwady delta (Bogale and Labutta townships) and the upper delta (Danuphyu and Hinthada townships) were analysed for four consecutive production years (2012/13, 2013/14, 2014/15, 2015/16), and for the 2016 monsoon season. Overall, there is an increasing trend of certified seed production in all four study townships (Figure 11). However, certified seed production in the lower delta is found to be lower than in the upper delta. In Danuphyu Township, the highest amount of certified seed was produced due to the efforts of the RSC Gold Delta. In the 2014/15 production season, the volume of seed produced in Bogalay Township was almost three times the amount produced in the previous season. This appears to be the result of high volumes produced for one single variety of certified seed viz. Paw San Yin.

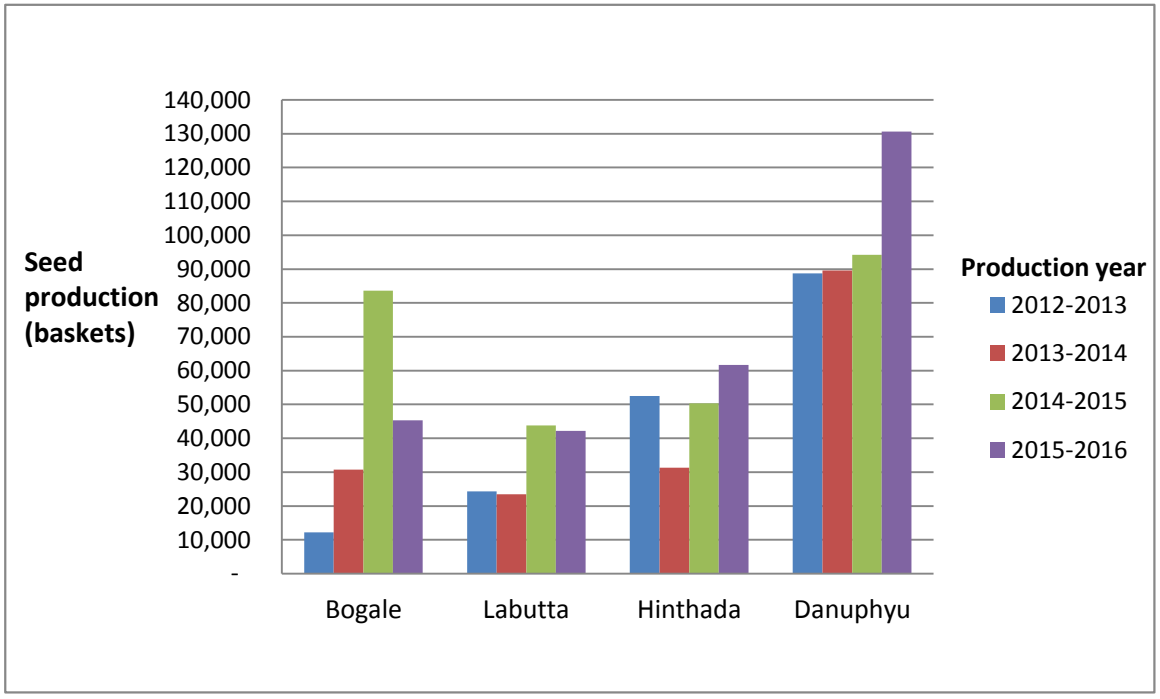


Figure 11 Seed production in the four study townships representing the lower (Bogale and Labutta) and the upper upper (Hinthada and Danuphyu) Ayeyarwady delta

A total of 15 varieties were used for certified seed production in the four study townships (Table 53). The varieties 90 days, Sin Shweli, Hnan Kar and Paw San Bay Kyar are only produced in the lower Ayeyarwady delta while the varieties Ayar Min, Yadanar Toe and Shwe War Htun are only produced in the upper delta.

Table 53 Varieties used for certified seed production in the study townships

	Name of variety	Lower Ayeyarwady delta		Upper Ayeyarwady delta	
		Bogale	Labutta	Hinthada	Danuphyu
1	Ayar Min			X	X
2	Hmawbi-2	X			X
3	Manaw Thukha		X	X	X
4	Paw San Yin	X	X	X	
5	Shwe War Htun			X	X
6	Sin Thukha	X	X	X	X
7	Sin Thwe Latt	X	X	X	X
8	Swarna Sub-1	X	X	X	
9	Thee Htet Yin	X	X	X	X
10	90 Days	X			
11	Hnan Kar	X	X		
12	Sin Shweli	X			
13	Yadanar Toe				X
14	Paw San Bay Kyar	X			
15	Paw San Hmwe	X			

The seed distribution data from the four townships shows that the upper Ayeyarwady delta has a higher percentage of rice production area cultivating certified seed than the lower delta. The lower delta has 0.4 to 5 per cent of the total area covered by certified seed, while 6 to 29 per cent is covered in the upper delta (Figure 12).

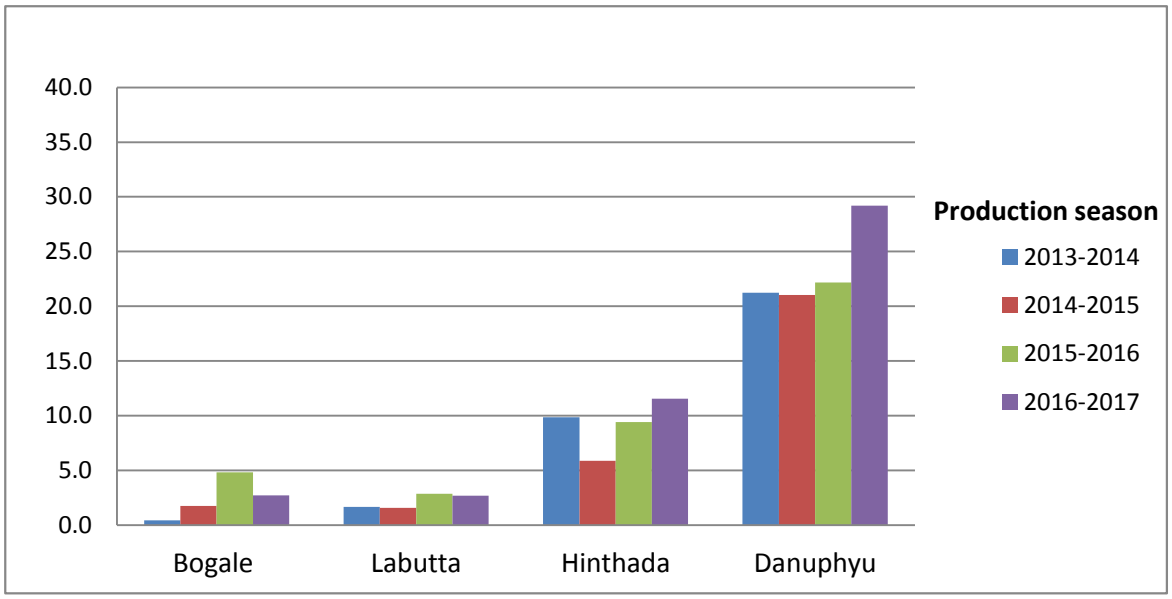


Figure 12 Percentage of the rice production area under certified seed in the four study townships

3.2.4 Certified seed production and distribution in Bogale Township

In Bogale Township, certified seed was produced for 11 different varieties from the 2012/13 to the 2015/16 production season (Table 54 and Table 55). Certified seed of the varieties Paw San Yin, Thee Htet Yin and Sin Thwe Latt represent the highest volumes of certified seed produced and distributed. Contact farmers supported by DOA extension are the major source of certified seed, producing over 80 per cent of the total volume in Bogale Township. Development organisations, mainly Radanar Ayar, GRET and WHH have been supporting seed growers to produce certified seed of seven varieties (Table 55). Hmawbi-2, 90 days, Yadanar Toe and Sin Shweli (possibly recycled hybrid seed) are produced by seed growers supported by these organisations, but not by DOA supported contact farmers.

Table 54 DOA supported certified rice seed production in Bogale Township from 2012 to 2016

Production year	Variety name	Total contact farmers	Seed production area (acres)	Seed produced (baskets)	Seed dissemi-nated (baskets)	Seed saved for next season (baskets)
2012/13	Sin Thwe Latt	2	14	994	596	398
	Thee Htet Yin	5	40	2,120	1,272	848
	Paw San Bay Kyar	3	28	1,393	836	557
	Paw San Yin	5	39	1,717	1,030	687
	Hnan Kar	2	17	988	593	395
	Total	**17**	**138**	**7,212**	**4,327**	**2,885**
2013/14	Sin Thwe Latt	1	7	510	306	204
	Thee Htet Yin	4	35	2,465	1,479	986
	Paw San Yin	53	425	21,906	13,144	8,762
	Total	**58**	**467**	**24,881**	**14,929**	**9,952**
2014/15	Sin Thwe Latt	23	185	13,257	7,954	5,303
	Thee Htet Yin	8	60	4,136	2,482	1,654
	Paw San Yin	134	1070	59,731	35,839	23,892
	Swarna Sub-1	4	30	NA	NA	NA
	Total	**169**	**1,345**	**77,124**	**46,275**	**30,849**

Production year	Variety name	Total contact farmers	Seed production area (acres)	Seed produced (baskets)	Seed dissemi-nated (baskets)	Seed saved for next season (baskets)
2015/16	Sin Thukha	1	10	787	472	315
	Sin Thwe Latt	33	260	21,061	12,637	8,424
	Paw San Yin	12	100	5625	3,375	2,250
	Thee Htet Yin	24	200	14,470	8,682	5,788
	Swarna Sub-1	1	10	664	398	266
	Total	**71**	**580**	**42,607**	**25,564**	**17,043**

Source: DOA seed division, 2016; NA = data not available

Table 55 Certified rice seed production supported by development organisations in Bogale Township from 2012 to 2016

Production year	Variety name	Seed produced (baskets)	Seed disseminated (baskets)
2012/13	Hnan Kar, Paw San Hmwe, Sin Thwe Latt, Thee Htet Yin, Yadanar Toe	5,000	2,000
2013/14	Hnan Kar, Paw San Hmwe, Sin Thwe Latt, Thee Htet Yin, Yadanar Toe, Paw San Yin	5,882	2,703
2014/15	Hnan Kar, Paw San Hmwe, Sin Thwe Latt, Thee Htet Yin, Yadanar Toe	6,476	2,750
2015/16	Thee Htet Yin, Yadanar Toe, 90 days, Paw San Yin (Bay Gyar Lay)	2,734	2,137

Source: Seed data collected from Radanar Ayar, GRET and WHH, 2016

From the 2013/14 to the 2015/16 season, seed production data showed an increasing trend in the percentage of rice production area cultivating certified seed, mainly due to the large amount of seed produced by contact farmers of DOA in the 2015/16 season (Table 56). In the 2013/14 production season, only 0.4 per cent of the rice production area was covered with certified seed; by 2015/16, this increased to 4.8 per cent. The increase was mainly due to the widely sown variety Paw San Yin, which covered a seed production area of 134 acres.

Table 56 Rice production area covered with certified seed in Bogale Township from 2013 to 2017

Year	Total rice production area (acres)	Seed disseminated by contact farmers supported by DOA (baskets)	Seed disseminated by seed growers supported by projects of development organisations (baskets)	Total seed disseminated (baskets)	% of rice production area covered by certified seed
2013/14	410,705	4,327	4,000	8,327	0.4
2014/15	411,654	14,929	2,703	17,632	1.7
2015/16	413,566	46,275	2,750	49,025	4.8
2016/17	413,566	25,564	2,137	27,701	2.7

Note: Contact farmer seed data received from the DOA seed division, 2016; seed data of development organisation projects are from Radanar Ayar, GRET and WHH. Since the production area in 2016/17 was not available at the time of study, we assumed that it is similar to the 2015/16 production season. The average seed rate used by farmers in the study sites is 2.45 baskets per acre (see Table 26).

3.2.5 Certified seed production and distribution in Labutta Township

In Labutta Township, certified seed of seven different varieties was produced from the 2012/13 to the 2015-2016 production season (Table 57 and Table 58). Certified seed of the varieties Paw San Yin, Sin Thwe Latt, and Manaw Thukha represented the highest volumes produced and distributed. Contact farmers supported by DOA extension were the major source of certified seed, producing over 98 per cent of the total amount in Labutta Township. The development organisations Mercy Corps and JICA supported contract farmers to produce certified seed of the varieties Sin Thukha, Paw San Yin, Thee Htet Yin and Sin Thwe Latt (Table 58).

Table 57 DOA supported certified rice seed production in Labuta Township from 2012 to 2016

Production year	Variety name	Total contact farmers	Seed production area (acres)	Seed produced (baskets)	Seed dissemi-nated (baskets)	Seed saved for next season (baskets)
2012/13	Sin Thukha	5	40	2,977	1,786	1,191
	Manaw Thukha	9	69	5,262	3,157	2,105
	Paw San Yin	10	83	4,554	2,732	1,822
	Sin Thwe Latt	4	33	2,624	1,574	1,050
	Hnan Kar	12	100	5,584	3,352	2,232
	Total	**40**	**325**	**21,001**	**12,601**	**8,400**
2013/14	Sin Thukha	1	10	920	552	368
	Sin Thwe Latt	18	144	9,845	5,907	3,938
	Paw San Yin	10	76	4,256	2,554	1,702
	Thee Htet Yin	1	10	842	505	337
	Manaw Thukha	1	10	752	451	301
	Hnan Kar	2	16	1,112	667	445
	Total	**33**	**266**	**17,727**	**10,636**	**7,091**
2014/15	Sin Thukha	1	10	858	510	348
	Sin Thwe Latt	21	171	12,633	7,580	5,053
	Paw San Yin	24	190	10,486	6,292	4,194
	Mamaw Thukha	14	113	8,574	5,149	3,425
	Swarna Sub-1	11	89	900	540	360
	Thee Htet Yin	12	100	7,099	4,259	2,840
	Total	**83**	**673**	**40,550**	**24,330**	**16,220**
2015/16	Sin Thukha	6	51	4,325	2,595	1,730
	Paw San Yin	26	210	11,754	7,052	4,702
	Thee Htet Yin	6	51	3,699	2,219	1,480
	Manaw Thukha	2	15	1,172	703	469
	Swarna Sub-1	12	100	6,254	3,752	2,502
	Sin Thwe Latt	20	156	10,432	6,259	4,173
	Total	**72**	**583**	**37,636**	**22,580**	**15,056**

Source: DOA seed division, 2016

Table 58 Certified rice seed production supported by development organisations in Labutta Township from 2012 to 2016

Production year	Variety name	Seed produced (baskets)	Seed disseminated (baskets)
2012/13	Sin Thukha, Paw San Yin, Thee Htet Yin	3349	3349

2013/14	Sin Thukha, Paw San Yin, Thee Htet Yin	5,745	4,554
2014/15	Sin Thukha, Paw San Yin, Thee Htet Yin	3,272	3,272
2015/16	Sin Thukha, Paw San Yin, Thee Htet Yin	4,578	1,449

Source: Seed data collected from Mercy Corps and JICA, 2016

Seed production data from both contact farmers and contract farmers showed an increase in the area covered with certified seed from 2013/14 to the 2015/16 production season, with a slight decrease in the 2016/17 season (Table 59). In comparing the data from Labutta with the data from the other three study townships, Labutta produced the lowest volume of certified seed and had the lowest percentage of rice production area covered with certified seed.

Table 59 Rice production area covered with certified seed in Labutta Township from 2013 to 2017

Year	Total rice production area (acres)	Seed disseminated by contact farmers supported by DOA (baskets)	Seed disseminated by seed growers supported by projects of development organisations (baskets)	Total seed disseminated (baskets)	% of rice production area covered by certified seed
2013/14	392,464	12,601	3,349	15,950	1.7
2014/15	392,682	10,636	4,554	15,190	1.6
2015/16	392,686	24,330	3,272	27,602	2.9
2016/17	392,686	22,580	3,459	26,039	2.7

Note: Contact farmer seed data received from DOA seed division, 2016; seed data of development organisation projects are from JICA and Mercy Corps. Since the rice production area in 2016/17 was not available at the time of study we assumed that it is similar to the 2015/16 production season. The average seed rate used by farmers in the study sites is 2.45 baskets per acre (see Table 26).

3.2.6 Certified seed production and distribution in Hinthada Township

In Hinthada Township certified seed of eight different varieties was produced from the 2012/13 to the 2015/16 production season (Table 60). The highest volumes of certified seed were produced and distributed for the Sin Thukha, Shwe War Htun and Manaw Thukha varieties. Contact farmers supported by DOA extension were the only source of certified seed produced in Hinthada Township.

Table 60 DOA supported certified rice seed production in Hinthada Township from 2012 to 2016

Production year	Variety name	Total contact farmers	Seed production area (acres)	Seed produced (baskets)	Seed dissemi-nated (baskets)	Seed saved for next season (baskets)
2012/13	Sin Thukha	24	194	14,996	8,998	5,998
	Shwe War Htun	50	398	30,049	18,029	12,020
	Sin Thwe Latt	6	49	3,691	2,215	1,476
	Manaw Thukha	6	44	3,263	1,958	1,305
	Thee Htet Yin	1	5	321	193	128
	Paw San Yin	1	2	131	79	52

Production year	Variety name	Total contact farmers	Seed production area (acres)	Seed produced (baskets)	Seed dissemi-nated (baskets)	Seed saved for next season (baskets)
	Ayar Min	1	1	65	39	26
	Total	**89**	**693**	**52,516**	**31,511**	**21,005**
2013/14	Sin Thukha	48	382	29,302	17,581	11,721
	Sin Thwe Latt	3	27	2,057	1,234	823
	Total	**51**	**409**	**31,359**	**18,815**	**12,544**
2014/15	Sin Thukha	34	271	25,959	15,575	10,384
	Manaw Thukha	4	49	3,892	2,335	1,557
	Shwe War Htun	27	222	18,026	10,816	7,210
	Swarna Sub-1	1	2	171	103	68
	Ayar Min	4	31	2,235	1,341	894
	Total	**70**	**575**	**50,283**	**30,170**	**20,113**
2015/16	Sin Thukha	63	503	44,436	26,662	17,774
	Sin Thwe Latt	1	1	85	51	34
	Thee Htet Yin	10	81	6,190	3,714	2,476
	Mamaw Thukha	1	11	891	535	356
	Swarna Sub-1	4	23	1,890	1,134	756
	Shwe War Htun	12	100	8,182	4,909	3,273
	Total	**91**	**719**	**61,674**	**37,005**	**24,669**

Source: DOA seed division, 2016

Seed production data from contact farmers showed an uneven seed distribution trend from 2012 to 2016 however on average, 6 to 12 per cent of the rice production area was covered by certified seed (Table 61). In the 2014/15 production season the area sown with certified seed decreased to 5.9 per cent. This was due to the production of only two varieties (Sin Thukha, Sin Thwe Latt) in the 2013/14 production season (Table 60).

Table 61 Rice production area covered with certified seed in Hinthada Township from 2013 to 2017

Year	Total rice production area (acre)	Seed disseminated by contact farmers supported by DOA (baskets)	Total seed requirement to cover 100% rice area with certified seed	% of rice production area covered by certified seed
2013/14	130,346	31,511	228,106	13.8
2014/15	130,433	18,815	228,258	8.2
2015/16	130,542	30,170	228,449	13.2
2016/17	130,542	37,005	228,449	16.2

Note: Seed data received from DOA seed division, 2016. Since the production area in 2016/17 was not available at the time of study we assumed that it is similar to 2015/16 production season. The average seed rate used by farmers in the study sites is 2.45 baskets per acre (see Table 26).

3.2.7 Certified seed production and distribution in Danuphyu Township

In Danphyu Township, certified seed of eight different varieties was produced from the 2012/13 to the 2015/16 production season (Table 62). The highest volumes of certified seed produced and distributed were for the Sin Thukha, Sin Thwe Latt and Hmawbi-2 varieties. Certified seed was produced by the contact farmers supported by the DOA extension office and the contract farmers supported by the RSC Golden Delta (Table 63).

Table 62 DOA supported certified rice seed production in Danuphyu Township from 2012 to 2016

Production year	Variety name	Total contact farmers	Seed production area (acres)	Seed produced (baskets)	Seed dissimi-nated (baskets)	Seed saved for next season (baskets)
2012/13	Sin Thukha	11	90	7,977	4,786	3,191
	Sin Thwe Latt	48	385	34,800	20,880	13,920
	Manaw Thukha	1	7	525	315	210
	Thee Htet Yin	1	8	604	362	242
	Ayar Min	3	29	2,209	1,325	884
	Yadanar Toe	4	33	2,788	1,673	1,115
	Hmawbi-2	16	129	11,459	6,875	4,584
	Total	**84**	**681**	**60,362**	**36,216**	**24,146**
2013/14	Sin Thukha	25	200	15,478	9,287	6,191
	Sin Thwe Latt	45	361	26,548	15,929	10,619
	Thee Htet Yin	7	57	3,981	2,389	1,592
	Manaw Thukha	1	6	427	256	171
	Ayar Min	2	13	870	522	348
	Hmawbi-2	25	200	14,180	8,508	5,672
	Total	**105**	**837**	**61,484**	**36,891**	**24,593**
2014/15	Sin Thukha	29	229	19,450	11,670	7,780
	Sin Thwe Latt	33	267	22,450	13,470	8,980
	Manaw Thukha	9	75	6,037	3,622	2,415
	Shwe War Htun	1	7	547	328	219
	Thee Htet Yin	3	25	1,318	791	527
	Hmawbi-2	23	183	14,288	8,573	5,715
	Total	**98**	**786**	**64,090**	**38,454**	**25,636**
2015/16	Sin Thukha	89	712	58,477	35,086	23,391
	Sin Thwe Latt	28	223	18,455	11,073	7,382
	Ayar Min	4	30	2,106	1,264	842
	Hmawbi-2	34	269	21,581	12,949	8,632
	Total	**155**	**1234**	**100,619**	**60,372**	**40,247**

Source: DOA seed division, 2016

Table 63 Certified rice seed production by RSC Gold Delta in Danuphyu Township from 2012 to 2016

Production year	Variety name	Seed produced (baskets)	Seed disseminated (baskets)
2012/13	Sin Thwe Latt, Hmawbi-2	28,368	28,368
2013/14	Sin Thwe Latt, Hmawbi-2	28,058	28,058
2014/15	Sin Thwe Latt, Hmawbi-2	30,143	30,143
2015/16	Sin Thwe Latt, Hmawbi-2	30,000	30,000

Source: Seed data collected from the RSC Gold Delta, 2016

Seed production and dissemination of certified seed produced by contact farmers showed a remarkable increase in the 2016/17 production season (additional 57 per cent). Gold Delta contributes one third of the disseminated seed in the township (Table 64). The area covered with certified seed from 2012 to 2016 was 21-22 per cent; this area increased to 29 per cent in the

2016/17 season. In the last production season, large volumes of the variety Sin Thukha have been produced and disseminated.

Table 64 Rice production area covered with certified seed in Danuphyu Township from 2013 to 2017

Year	Total rice production area (acres)	Seed disseminated by contact farmers supported by DOA (baskets)	Seed disseminated through private company (baskets)	Total seed disseminated (baskets)	% of rice production area covered by certified seed
2013/14	124,097	36,216	28,368	64,584	21.2
2014/15	126,034	36,891	28,058	64,949	21.0
2015/16	126,310	38,454	30,143	68,597	22.2
2016/17	126,310	60,372	30,000	90,372	29.2

Note: Seed data received from DOA seed division, 2016; Private company seed data from the company Gold Delta; Since the production area in 2016/17 was not available at the study time we assumed that it is similar to the last production season. The average seed rate used by farmers in the study sites is 2.45 baskets per acre (see Table 26).

3.3 Seed sector analysis

3.3.1 Rice seed systems

Rice seed systems in Myanmar

For farmers to realise the full potential of rice seed, it needs to be available at the right time and place, in the required quantity, of an acceptable quality, at an affordable price, and of a variety well suited to the local agroecological conditions and farmer/market demands. Farmers gain access to seed from different seed sources or systems; each seed system has its own value chain, with a specific configuration of operators, service providers and an enabling environment affecting its operation. Seed system analysis helps to understand the reality farmers face in accessing seed.

The various rice seed systems operating in the Ayeyarwady region are demonstrated in Table 65. Based on the insights from key informant interviews, we have adapted the seed system analysis from the desk review (Thijssen *et al.*, 2016). Seed systems are characterised based on the key operators in the system, the type of varieties used, the seed quality assurance mechanism, and the distribution and marketing system of the seed (Subedi *et al.*, 2013).

Table 65 Rice seed systems in the Ayeyarwady delta

Characteristics	Informal seed system	Intermediary seed system	Formal seed system	
	Farmer saved seed	Community-based	Public-private	Private
Key actors	Farmers	development organisations, rice millers and specialised seed producer farmers	Government, rice millers and contact farmers	Private companies, farmer contract growers
Types of varieties	Local varieties, recycled improved varieties	Improved varieties, local varieties	Improved varieties, local varieties	Improved varieties
Types of seed quality	Informal seed	Various quality assurance	Certified seed, quality seed	Certified seed

Characteristics	Informal seed system	Intermediary seed system	Formal seed system	
	Farmer saved seed	Community-based	Public-private	Private
		mechanisms, including Participatory Guarantee System; certified seed and quality seed		
Seed dissemination	Gift; exchange with family, friends, neighbours	Farmer to farmer exchange and sales; development organisations and township offices linking seed producers and buyers; some schemes involving rice millers	Sales by contact farmer seed growers; township offices linking seed producers and buyers, and linking seed producers and millers	Closed rice value chain; company seed sales

Note: the table is adapted from the desk review

The seed systems can be generalised into three clusters: informal seed systems; formal seed systems; and intermediary seed systems with facilitated loose or temporary linkages to the formal system.

Informal seed system

The informal system is the main source of rice seed for farmers. Farmers are the key actors in this system. As well as saving part of their own grain harvest for the next crop production cycle, farmers source seed from family, friends and neighbours. Seed in this system is generally available close by and at low costs. Local markets were not mentioned as an important informal seed source during this study. In the informal system, both local and recycled improved varieties (second or higher generation recycled seed) are important. Other than a limited number of improved varieties, Pawsan group varieties are also very important local varieties in the delta. Most improved varieties were released a number of years ago (see the variety list in Annex 6).

There is no standard mechanism for seed quality control; farmers depend on their own practices and observations in managing and distinguishing seed quality. Farmers in the lower and upper Ayeyarwady delta select seed based on crop appearance in the field and at harvest, and store seed of different varieties separately. The general recommendation to farmers is to recycle certified seed for three generations, which will not result in significant quality deterioration. Despite the challenges farmers may face in this system, including varieties not withstanding changing climatic conditions such as shorter growing seasons, or seed related issues like seed-borne diseases, storage pests, seed admixtures, etc., the informal seed system appears to be a robust system. In marginal and remote areas it is often the only seed system or seed source available to farmers.

Formal seed system

The formal system can be divided into two sub-systems – the public-private system and the private system. Even though some crops in other parts of Myanmar are produced under a fully public formal seed system (Van den Broek *et al.*, 2015), certified seed production by DOA or DAR farms was not observed in this study. All five seed farms in Ayeyarwady (four DOA farms and one DAR farm) produce foundation and registered seed only. The farms get their breeder seed from the DAR headquarters in Yezin.

Formal public-private system
In the formal public-private system, government actors interact with and support contact farmers who produce certified seed; sometimes millers become involved as intermediaries, i.e. seed buyers and seed suppliers to the grain contract farmers. This system works with the local Pawsan varieties as well as with improved varieties. The improved varieties are public OPV varieties, most of them released a while ago; hybrid varieties are ignored.

In the public-private system, through township extension DOA seed farms provide contact farmers with registered seed which is multiplied into certified seed. In most cases, the farmers with seed production land along the road side are selected as contact farmers to produce certified seed. The township DOA extension office determines which farmer gets which variety based on farmer experience and the suitability of the land for seed production. Contact farmers sell seed to fellow farmers, mediated at times by the township DOA extension services. This public-private system is the main formal source of seed for farmers. To optimise the system, the government wants to bring contact farmers together in seed grower associations. The system of seed grower associations was kicked off in several selected townships this year; no results have been reported so far.

Seed in this system is subject to external quality assurance, and all seed is certified (C1 seed). Field inspection is done by staff of the regional and district agriculture office. In some cases, staff of the Yangon seed laboratory join the field inspection. One of the challenges to this system is that it needs a high level of support from government, and that despite the official quality control procedures, limited dedication of seed staff at the township level means seed is often not certified, and is of a similar quality to the seed farmers recycle themselves. Lack of inspection and certification contributes to seed quality issues.

Formal private system
The formal private system is run by private companies, which often work with seed contract growers. Private RSCs like Gold Delta produce certified seed with selected contract growers; this seed is sold to their grain contract growers as a service. Taking up the responsibility of in-house seed production allows quality control of this input used by contracted grain growers. In this way, a company like Gold Delta can also push new varieties into the system; in 2016 they added Hmawbi-3 to their variety portfolio, which may be a good alternative to Sin Thwe Latt. Similar to Gold Delta, the company Dagon International which also operates in the Ayeyarwady delta, produces quality seed for their own grain production.

One of the challenges to this system is the fact that rice seed business is not a highly profitable business. This is related to the reproduction mechanism of the crop (self-fertilisation) which allows farmers to grow seed for a number of generations without reduced performance. This is different for a hybrid crop, for which farmers have to buy new seed every year. However, due to the inferior quality of the rice hybrids as compared to the currently available OPVs, none of the companies active in the delta focus on hybrid rice seed production.

Intermediary seed system
The intermediary seed system links informal and formal seed systems. Several development organisations including LIFT partners support the intermediary rice seed system. In one way or another, farmers are supported in producing quality seed. Often, individual farmers are members of small groups for a shared mechanism of seed quality control. One of these systems is the Participatory Guarantee System (PGS) used by GRET, in which farmers check the quality of each other's seed, certified or not. Mercy Corps also involves millers as an intermediary to facilitate the linkage of seed producers with seed users. Farmers are trained in seed production of popular local and improved varieties. Radanar Ayar has also been involved with the International Rice Research Institute (IRRI) in participatory selection of new varieties, however, they do not use the prioritised varieties in their seed production schemes because the market is not guarenteed.

One of the challenges of community-based seed schemes is to make them sustainable. The rice grain market is highly volatile, and so is seed demand and the seed market. Some of the development organisations indicated that the seed produced is hard to sell; farmers do not always see the added benefit as compared to their own farm-saved seed, especially when the seed is not certified.

3.3.2 Seed value chains

Rice value chain and rice seed value chain

The *Myanmar Rice Sector Development Strategy* (Ministry of Agriculture and Irrigation and IRRI, 2015) describes the rice value chain in great detail. Seed is considered as one of the many inputs in the rice value chain, together with fertilisers, pesticides, finance, land, water, farm machinery, equipment, fuel and labour. As well as serving as an input component in a commodity value chain, seed has its own value chain, with specific configurations of operators, service providers and enablers. To understand the functioning of the seed sector, it is helpful to analyse the performance of these three different levels of the seed value chain (Audet-Bélanger *et al.*, 2013).

Seed value chain operations include plant genetic resource management, variety development, EGS production, seed multiplication, seed dissemination and finally, seed use. Farmers who use seed, drive the seed value chain. Operators in the value chain are supported by service providers. Seed value chain services include seed quality assurance, credit for seed producers and seed extension. Seed operators and service providers work in a specific context or enabling environment.

In this sub-chapter, the functioning of operations and services in the seed value chain are examined; the seed enabling environment is addressed in a separate sub-chapter. Figure 13 shows a generalised depiction of the seed value chain. This sub-chapter is based on information from the desk study (literature and project documents; see Thijssen *et al.*, 2016) complemented by information obtained through interviews with key informants.

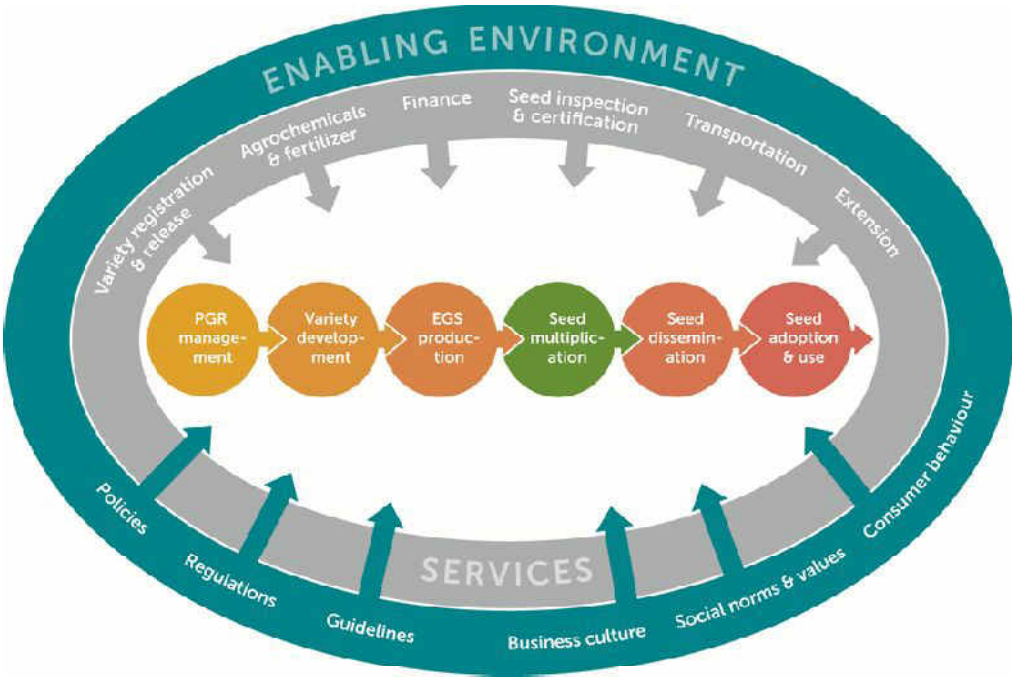


Figure 13 A generalised depiction of the seed value chain

Different seed value chains for different seed systems

Seed value chains differ between seed systems. In the informal seed system, the operations in the seed value chain are integrated in the commodity value chain; farmers select seed of preferred

varieties from their rice production fields to sow for the next season. Farmers either save their own seed or access new seed, and possibly new varieties, through neighbours, relatives and friends. In the intermediary and formal seed system, the various steps in the seed value chain operation are in the hands of different organisations. From the literature and confirmed by key informant interviews, we learned that the rice seed value chains in Myanmar in the intermediary and formal seed systems are very fragmented. We analyse the different functions of the seed value chain operations and services below, with reference to the different seed systems in operation. Table 66 summarises each of the operators and main issues faced by the different rice seed value chains.

Table 66 Main issues faced by rice seed value chain operators

Step in the SVC	Organisation	Main issues
Genetic resources management	IRRI, DAR, Meta, farmers	- Combat of genetic erosion - Promoting active use of germplasm - Understanding genetic diversity (Pawsan)
Variety development	DAR, IRRI	- Promoting variety turn-over - Creating variety awareness/popularizing new varieties - Building staff capacity
Breeder seed production	DAR	- Some quality issues/purification of specific varieties
Foundation/ registered seed production	DOA, DAR	- Division of tasks/coordination between DOA and DAR - Occasional quality problems - Occasional use of foundation seed for certified seed production - Inadequate of seed production and processing equipment at seed farms
Certified/ quality seed production	Contact farmers, contract farmers, farmer seed producers supported by development organisations, professional private seed producers	- Access to specific varieties - Access to sufficient quantity of quality registered seed - Access to seed inspection services - Sustainability community-based production schemes - Insufficient of business orientation - Insufficient of storage and processing facilities
Seed marketing and distribution	Seed producers with their supporters	- Market development for new varieties - Unstable demand for certified/quality seed - Seed quality

Genetic resources management

IRRI manages a large collection of rice germplasm. This germplasm, including newly developed varieties, finds its way to the research stations of DAR. DAR has a genebank with 726 rice accessions and 180 wild rice accessions used for variety development. The Thayaung Chaung seed farm of DOA in Pathein has a field genebank of a large collection of different rice varieties and a small seed museum on its premises. The Metta seed farm is engaged in a project displaying a large number of local and improved rice varieties in their fields; farmers are encouraged to take seed samples to try on their own fields.

Farmers manage their own genetic resources and local varieties in the field. The diversity of local varieties is important for farmers in relation to risk management and resilience. However, most of the farmers in the Ayeyarwady delta only grow one or two rice varieties per season. Local varieties, but particularly the aromatic Pawsan varieties, are of high importance in the lower Ayeyarwady delta.

Many different sub-selections exist from the original Pawsan Hmwe variety. Paysan Bay Kyar and Pawsan Yin are two such sub-selections made by farmers, which are only slightly photosensitive as compared to the highly photosensitive variety Pawsan Hmwe. Other Pawsan names refer to the locality in which the Pawsan variety is grown e.g. Shwebo Pawsan. DAR headquarters in Yezin is

currently engaged in a research project mapping the high diversity of Pawsan varieties in 20 different locations.

Variety development

DAR has its own rice breeding programme, manages variety adaptation trials, and is responsible for variety maintenance. IRRI is an important collaborator of DAR, and their collaboration has resulted in the development of more than 70 high yielding rice varieties that suit the various growing conditions of the country (Tin Tin Myint 2013). Variety tolerance to adverse growing conditions such as deep water, prolonged flooding, salinity, and drought are especially important. The breeding programme focusses on improving yield potential, yield stability, and food quality, but also disease resistance. Building the capacity of specialised rice breeders needs attention; the current DAR rice breeder will soon retire.

Presently, the variety list contains more than 90 varieties (see Annex 6). Many of them have shown their value in participatory variety selection (PVS) trials as organised by IRRI and DAR, with the involvement of farmers, millers and other stakeholders. However, only a limited number of varieties are commonly grown by farmers in the lower and upper Ayeyarwady delta. Key informants from different organisations indicated that farmers are only interested in those rice varieties that have a good market; and since it is hard to develop a new market (it takes at least 4-5 years) farmers tend to stick to their old local and improved rice varieties. Generally, farmers lack information on new varieties; to popularise new varieties it is important to combine research, demonstration and communication. For this purpose the PVS approach may be institutionalised, but always has to be combined with other activities to promote the uptake of new varieties.

The varieties with market potential get special attention from DAR. DAR is currently purifying the highly popular 90 Days variety. This variety was developed in Vietnam and entered the country informally. WHH looked into opportunities to support the improvement of the highly popular local Pawsan Bay Kyar Lay variety to overcome problems like lodging, stem borer attack, blast and bacterial leaf blight (Rana and Dhakal, 2015).

EGS production

In Myanmar seed production follows a 4 generation system of breeder's, foundation, registered and certified seed. DAR headquarters in Yezin is responsible for variety maintenance (nucleus seed) and the production of breeder seed. It is important that the breeder seed is produced at one location, to keep the variety true to type. Only DAR headquarters in Yezin is producing breeder seed of rice varieties for the Ayeyarwady region. Some quality issues with breeder seed have been reported, and JICA supported DAR with the purification of breeder seed of 13 popular varieties, and will continue to do so with nine additional varieties.

DAR research farms and DOA seed farms in the Ayeyarwady delta produce foundation and registered seed, which is supplied to a variety of seed producers for multiplication into certified seed. For our studies we have visited the Tagontaing Seed Farm in Hinthada, Thayaung Chaung Seed Farm in Pathein, and Myaungmya Research Farm in Myaungmya. The seed farms order breeder seed one year in advance and with few exceptions, generally receive seed of the requested varieties in the volumes demanded.

Breeder seed quality is checked for moisture content, purity and germination before multiplication. Foundation and registered seed quality are inspected in the field in house (by field supervisors) as well as by a team of the Nay Pyi Taw DOA seed division two to three times per season. Samples of all seed plots are inspected and tested for quality by the Yangon seed quality assurance laboratory. Key informants at the seed farms indicated to have no problems with EGS quality (no seed rejected by the Yangon laboratory); registered seed users indicated occasional quality problems.

Where DOA and DAR farms generally keep foundation seed for the next season, registered seed is sold to a variety of seed producers i.e. indirectly to contact farmers through the townships, and directly to other seed producers including the ones supported by development organisation projects and private companies. Foundation seed price is fixed by DOA in Nay Pyi Taw (more EGS production, seed sales and seed price data details can be found in section 3.2.1.).

Farm managers indicated that they cannot supply the requested amounts of registered seed because of labour shortages and lack of appropriate seed production and processing equipment. While World Bank (in the 80's), and FAO and JICA projects (over the past 5 years) have provided some equipment to selected seed farms, further mechanisation of seed production and upgrading of the seed production infrastructure (seed threshers, seed dryers and seed processing machines) is required to increase efficiency and be able to meet the demand of registered seed.

Seed multiplication

Seed is multiplied by a variety of seed producers in the different seed systems:

- In the informal seed system by farmers themselves, or their neighbours and relatives, generally without support from any other stakeholders
- In the intermediary seed system by farmer seed producers or seed producer groups with support from development organisations like GRET, WHH and Radanar Ayar, generally with linkages to DOA and DAR seed farmers for registered seed; with linkages to DOA for seed quality assurance; and sometimes with linkages to rice millers guaranteeing a market for the seed
- In the formal public-private seed system by DOA supported contact farmers. DOA provides registered seed, extension support, seed quality assurance services, and sometimes support in markets linkages
- In the formal private seed system by professional private seed producers like the Aye Than in Nay Pyi Taw, with linkages to DOA/DAR for foundation/registered seed and with DOA for seed quality assurance. These seed producers may produce their own EGS. They take care of their own seed marketing. A second type of seed producers in this system are the contract farmers for private companies including the RSC Gold Delta. Gold Delta ensures that seed producers get access to registered seed as well as other inputs and services needed for quality seed production. The company also provides a guaranteed price and buy back assurance to seed producers. In this system the seed producers are part of a closed value chain.

The different seed production and marketing business models as outlined above face different challenges. The challenges have been described in the former section on seed systems (section 3.4.1). Challenges relate to access to specific varieties required for seed multiplication, access to the required quantity and quality of the registered seed, access to seed inspection services, the quality of the certified seed produced, and problems in seed marketing. In all cases in the Ayeyarwady delta we have seen seed producers used local or publicly developed varieties for seed production. Well established private seed companies may also develop their own varieties, providing them a competitive advantage on the seed market.

Seed marketing and distribution

As indicated above, professional seed producers market their own seed but may be supported by the DOA township office or a development organisation project. Except for the closed value chains supported by RSCs like Gold Delta, seed marketing is one of the key problems. This may be related to the quality of the certified seed produced, but also to the fact that farmer seed producers do not have the opportunity to store seed after harvest and keep it for the next planting season, when fellow farmers purchase their seed. Generally farmer seed producers, as well as community-based seed schemes, are more supply than demand driven and lack market and business orientation. Our studies showed that agro-dealer shops in the Ayeyarwady Delta do not sell rice seed. They do sell seed of high value crops like vegetables as well as other inputs like fertilisers and pesticides. In the informal seed system seed is exchanged between neighbours, relatives and friends.

Table 67 Main issues faced by rice seed value chain service providers

Step in the SVC	Organisation	Main issues
Seed quality assurance	DOA regional, district, township offices, seed labs, DAR, development organisations, seed producers	- Insufficient capacity for seed inspection - Limited capacity and infrastructure of Yangon seed lab - Lack of internal quality control procedures of some seed producers
Seed extension	DOA, development organisations	- Insufficient capacity at DOA, seed only one of the issues to be addressed - Responsibility of variety promotion/market development for new varieties
Access to credit	DAR	- Lack of credit for seed production
SVC coordination	DOA Seed Division and other seed sector stakeholders	- Fragmented seed value chain with limited communication and collaboration between different stakeholders - Actors independently engaged in similar activities (EGS) - Responsibility of certain activities not taken up (variety promotion) - Experiences not exchanged (different certified/quality seed production models)

Seed quality assurance

In Myanmar the DOA is responsible for seed quality assurance however, within DOA two distinct systems are operational (Figure 14). All DOA seed farms are field inspected and seed samples are tested by three different seed testing laboratories located in lower Myanmar (Yangon), central Myanmar (Nay Pyi Taw) and upper Myanmar (Mandalay), operating under the seed quality control unit of the seed division. The seed testing laboratories employ technicians for both the laboratory and field seed inspection. The DAR research farms have their own seed quality assurance system which does not follow the DOA structure, however, seed testing is done in DOA/seed division seed unit laboratories.

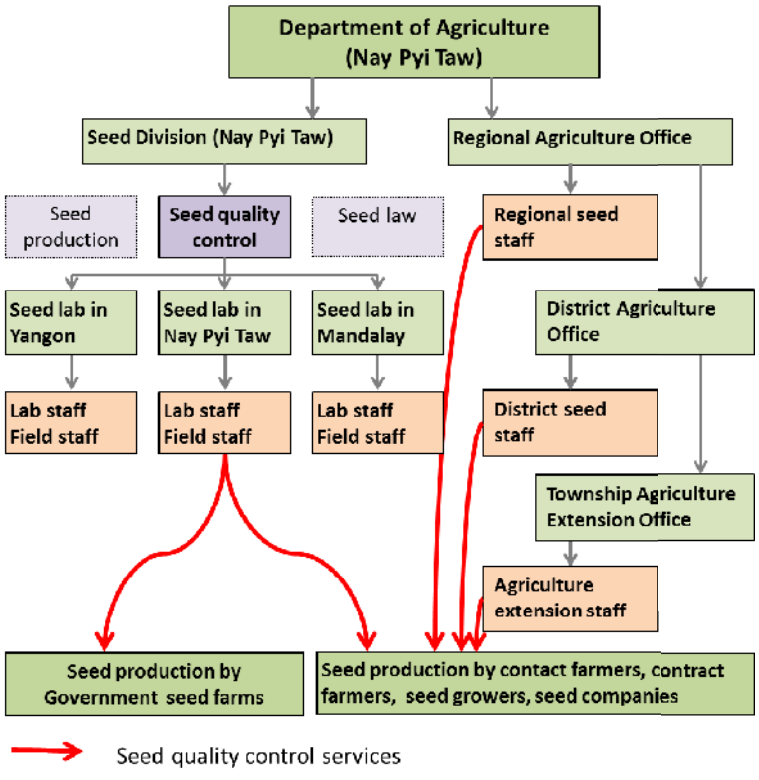


Figure 14 Institutional structure of seed quality assurance in Myanmar

The producers of certified seed including contact farmers, seed growers supported by development organisations, and private companies producing seed, are field inspected by seed staff of the regional agriculture office and the district agriculture office. In some cases, the laboratory seed technicians are also involved in field inspections. Seed testing is done by one of the seed laboratories operating under the seed division. Seed staff at the regional agriculture office and district agriculture office do not engage in field inspection of the government seed farms. Staff at the DOA township extension offices are engaged in field inspection but are not authorised to certify or reject seed production fields.

Key challenges in seed quality assurance are limited human resources at regional and district level, with five staff at the Ayeyarwady regional office, two staff at each of the district offices in Labuta, Maubin and Phyapon, and three staff at the Hinthada district office. Moreover, also at the township extension office, dedicated seed staff are lacking. The scattered distribution of seed producers further constrains field inspection. The seed laboratory in Yangon is facing problems with old equipment and a lack of specialised skilled staff. This affects the quality of seed in the market and the trust of farmers in quality or certified seed.

Seed extension
DOA township offices provide extension to farmers, with seed being only one of the issues that needs to be addressed. Human resources specific to seed production are lacking, and knowledge on quality seed production is limited. Development organisation projects have built the skills of seed producers in agronomic practices for quality seed production; the same applies for the RSCs which have taken up their own certified seed production.

Access to credit
Farmers do have access to credit for rice grain production through MADB which provides MMK 150,000 per acre for up to 10 acres; this grant is mainly used for fertilisers and labour. For rice seed production there is a lack of similar credit schemes. The RSC Gold Delta has its own bank providing similar arrangements to rice seed and grain growers. Generally, access to financial services are considered a limitation.

Seed sector coordination
Similar to the rice value chain (Ministry of Agriculture and Irrigation and IRRI, 2015) the rice seed value chain is very fragmented with limited communication and collaboration between the different seed sector stakeholders. DAR and DOA are independently engaged in similar activities in EGS production but the responsibility of certain activities like public variety promotion is not clearly taken up by DAR or DOA. Experiences of different certified/quality seed production models by the two organisations are not exchanged, and quality assurance and other services are insufficiently implemented. Further, whilst registered seed demand cannot be met, the sale of certified seed is problematic. The rice seed sector would therefore benefit from the establishment of a coordination mechanism for the sector, involving key seed sector stakeholders and a joint vision and common strategy for improving the performance of the sector.

3.3.3 Seed intervention landscape

Seed projects in Myanmar
To analyse the seed intervention landscape we have constructed a matrix (according to Heemskerk *et al.*, 2013). Based on project documents (final project reports and project proposals) of the Australian Centre for International Agricultural Research (ACIAR, 2016), IRRI (2015), FAO (Van den Broek *et al.*, 2015), Radanar Ayar (2016), Metta (2016), Mercy Corps (2016) and WHH (2016) as well as key informant interviews, Table 68 gives an overview of the activities of projects of the mentioned organisations with a relation to rice seed. In the matrix we assess seed system focus, intervention focus and target groups.

Seed system and seed value chain focus of the projects

The analysis shows that most of the seed interventions have been focussing on the intermediary seed system, while few have been targeting the formal public-private seed system. LIFT funded, and continues to fund, several projects that address seed as a major value chain component, as an integrated part of the rice value chain, and as part of a livelihood development project; the organisations implementing these projects are Radanar Ayar Rural Development Association, Metta Development Foundation, Mercy Crops and a consortium of WHH and GRET.

Various models of community-based seed production have been developed and tested including independent farmer seed producers only loosely linked for quality control, farmers organised into a farmer producer enterprise, association of farmer seed producers with rice millers, and contract farmers. Implementing organisations support certified/quality seed production by seed producers; they build capacities in agronomic practices of quality seed production and develop producers' internal quality control systems like the PGS (GRET) or comparable systems (Radanar Ayar). Moreover, they facilitate linkages to seed inspection services, access to registered seed, and access to seed markets. The IRRI project has been supporting LIFT implementing partners with PVS (best-bet approach) and capacity building activities on various seed and crop management practices. The projects focuses on seed value chain operations (mainly certified/quality seed production) and seed value chain services (mainly seed extension/capacity building, seed quality assurance).

Project seed sector studies

Considering the importance of quality seed as an input to the rice value chain, several of LIFT's implementing parners commissioned their own seed studies which provide interesting insights into the functioning of the seed value chain. Selected views and insights included in this study have been incorporated from:

- *Paddy seed study Ayeyarwady Delta* commissioned by GRET (Ferrand and Hla Min, 2013)
- *Ways to sustainably ensure small-holder paddy farmers' access to quality paddy seeds in Bogale township, Ayeyarwady delta, Myanma* commissioned by WHH (Koerner, 2015)
- *Feasibility study for supporting conservation and/or improvement of local paddy varieties using participatory crop improvement in project area of WHH Bogale, Myanmar* commissioned by WHH (Rana and Dhakal, 2015)
- *Laputta seed sector study* commissioned by Mercy Corps' (Zaw Win Min, 2015)

Key gaps identified by projects in the seed sector

Problems indicated in the project documents as well as by key informant interviews in the seed value chain are: insufficient volumes of registered seed; quality problems with registered seed; lack of access to registered seed or specific varieties (like the 90 Days variety); quality problems with certified seed; insufficient seed quality assurance services for certified seed; marketing problems of certified/quality seed; lack of interest of farmers in certified/quality seed production; lack of interest of farmers in uptake of certified/quality seed; lack of variety promotion; insufficiently productive crop cultivation practices (e.g. hand seed-transplanting is not widely practiced); lack of post-harvest technology, especially in seed processing before selling/distribution of the seed; and lack of seed storage facilities to store seed from harvest to planting.

Table 68 Projects related to rice seed in the Ayeyarwady delta

Name of project, project period (and donor)	Key partner	Geographical focus	Seed system focus	SVC – operations	SVC – services	SVC – enabling environment	Intervention focus	Target groups
Support to development of hybrid rice in Myanmar; 2013-2015 (FAO)	DAR, DoA	Ayeyarwady and other regions	Formal public-private seed system	X	X		Institutional capacity strengthening and demonstration of hybrid rice seed production	DAR & DoA staff, seed growers
Diversification & intensification of rice based system in lower Myanmar; 2012-2016 (ACIAR)	DAR, DoA, IRRI	Ayeyarwady and Bago	Formal public-private seed system	X			Promote adoption of new rice varieties and alternative crop management practices to increase rice productivity in rice-rice and rice-pulse cropping systems. Production of submergence-tolerant rice seed by DAR and distribution to flood-affected areas through DoA	Small-holder farmers
Improving livelihoods of rice-based rural households in the lower region of the Ayeyarwady Delta; 2012-2015 (LIFT)	IRRI	Lower Ayeyarwady delta	Interme-diary seed system	X	X		Participatory (best-bet) approach in variety selection and promotion, agronomy and post-harvest technologies demonstration, community seed banking, and capacity building	Small-holder farmers, millers, traders, develop-ment organi-sations
Development of participatory multiplication and distribution system for quality rice seed; 2012-2017 (JICA)	DOA, DAR	Yangon region and Ayeyarwady region	Formal seed system	X	X		Survey on rice variety requirements and variety purification, increasing DAR and DOA seed production capacity, improving rice seed quality assurance system, increasing farmers' capacity in quality seed production	DAR and DOA, farmers
Integrated agribusiness and rural development project; 2016-2019 (LIFT)	Radanar Ayar Rural Develop-ment Associa-tion	Bogale and Mawlamyine-gyun townships	Interme-diary seed system	X	X		Increase the use of quality seed production and supply, formal and informal seed system collaboration, post-harvest and market linkages, farmers pool, seed chain coordination	Smallhold er farmers, seed growers

Name of project, project period (and donor)	Key partner	Geographical focus	Seed system focus	SVC – opera-tions	SVC – ser-vices	SVC – ena-bling envi-ron-ment	Intervention focus	Target groups
Promotion of farmer managed schemes for inclusive growth and sustainable development; 2016-2019 (LIFT)	Metta Develop-ment Founda-tion	Labutta and Mawlamyine-gyun townships	Interme-diary seed system	X	X		Increasing access to quality rice seed production , farm advisory services, post-harvest management, collective storage, access to market, pro-poor policy	Small and medium farmers, seed growers
Linking Laputta to Markets: 2015-2018 (LIFT)	Mercy Corps	Labutta township	Interme-diary seed system	X	X		Seed is part of the rice value chain component of the project by facilitating farmers, millers and formal seed sector partnership	Smallhold ers farmers, vulne-rable farmers, millers
Delta rural intensification for sustainable economic development: 2015-2018 (LIFT)	WHH, Gret	Bogale and Mawlamyin-egyun Townships	Interme-diary seed system	X	X		Seed is part of the agriculture producers support and nutrition project. Seed component focus on expanding the seed growers model and promoting participatory guarantee seed system to improve seed quality	Small-holders and vulne-rable farmers

Note: Table from desk review, adapted based on key informant interviews

3.3.4 Seed enabling environment

National seed policy landscape

Myanmar has made significant progress over the last 3 years in the development and establishment of a national seed policy and regulatory framework (Table 69). A new national seed policy, drafted with technical support from FAO, was approved in 2016; the existing seed law enacted in 2011, was amended in 2015; the national seed regulations were approved in 2016; and the Plant Variety Protection (PVP) law was approved by the end of 2015. Also, the protection of the farmers' rights and enhancement of their benefits was enacted in 2013. In addition, Myanmar has enacted a number of policies that are supportive to the seed sector, which include the Plant pest quarantine law of 1993; the Fertiliser law of 2002; the Pesticide law of 1990; and the Farmland law of 2012. Moreover, based on the above mentioned policy framework and other strategic documents, in 2016 a seed road map was developed and approved by MOALI.

Table 69 Overview of Myanmar seed related policies, laws and regulations

	National seed policy landscape	Year of approval	Responsible agency	Key policy scope
1	National Seed Policy	2016	MOALI	Provide overall guidance to and institutional framework for national seed sector development

2	Seed Law	2011; amendment in 2015	MOALI	Provide legal basis to seed policy, and legal rules and provisions for variety release/registration, seed production, seed certification and seed marketing
3	Seed Regulations	2016	MOALI	Enforce seed law implementation through various guidelines, standards and procedures
4	Plant Variety Protection (PVP) Law	2015	MOALI	Provide intellectual property rights through Breeders Rights to owner of the new variety
5	Protection of the Farmers' Rights and Enhancement of their Benefits	2013	MOALI	Support farmers on seed production, new technologies, sales of produce, access to credit, and linkage with market

Note: This table has been slightly adapted from the desk review.

Seed policy

The Myanmar seed policy provides guidance to the development of the various seed systems and to the stakeholders involved in these systems. It provides a clear distinction between public and private sector roles and policy measures for supporting public and private actors. It places great emphasis on rice as one of the top priority crops of the 16 listed in the policy document. Prioritised policy objectives are the improvement of both the quantitative and qualitative aspects of rice export and obtaining a marketing advantage in the global rice market. We have analysed the national seed policy in relation to its support to the various seed systems with specific focus on rice (Table 70).

Table 70 National seed policy and its impact on various rice seed systems

Seed systems	Policy measures
Informal seed system	- Farmer-produced seeds remain the major seed source in Myanmar; suggestion to undertake efforts to improve on-farm seed management practices and facilitate the linkage between the formal and informal seed systems. - Authorisation of DAR and DICD, in cooperation with DOA, to test, purify, characterise and release local landraces as official varieties for which there is substantial and steady seed demand. - Envisioning a balance between Breeder's and Farmers' Rights. In this line, farmers will maintain their right to use, exchange, share or sell (in non-branded form) their farm-saved seed without any restriction.
Intermediary seed system	- Emphasis on the development of existing seed schemes at village level to become more commercial seed enterprises.
Formal public-private seed system	- The public sector role is to provide a catalytic role in seed research, breeder and foundation seed production, the overall seed quality assurance system and seed extension. - It is prioritised to increase the public capacity ensuring timely supply of sufficient breeder and foundation seed, increase the number of seed laboratories, and recruit additional field inspectors to achieve sufficient seed quality control coverage.
Formal private seed system	- The private sector is supported to gradually take up a greater role in terms of registered and certified seed production, as well as internal quality assurance. To achieve this, through various incentive schemes, private sector seed producers are progressively supported to expand the current certified seed production and marketing of the major crops, with specific focus on rice. - Further to this, the policy promotes support to elevate the private sector capacity in both research and foundation seed production to an acceptable level, by making available foundation seed produced by DAR and DoA.

Note: This table has been slightly adapted from the desk review.

Seed law

The Myanmar seed law covers topics such as variety release/registration, seed production, seed marketing, seed certification, and seed import and export. However, whereas the national seed

policy was guided by an integrated perspective on seed sector development, the seed law is strongly geared towards supporting the formal seed systems (both public-private and private). The main elements of the seed law that are important for rice seed sector development relate to the national seed committee, licencing and seed marketing.

The seed law provides for the establishment of a national seed committee for overall guidance to the seed sector in terms of policy directions, developing regulations for quality assurance and variety release, strategic guidance to research and seed division, as well as seed value chain coordination. A technical seed committee is tasked with the preparation of all technical reports and recommendations with respect to the release of new varieties, registration of seed businesses, and registration of seed testing laboratories.

The seed law provides a provision for any person to produce or introduce a new variety or establish a seed testing facility. For the registration of a variety for the purpose of seed production, a certificate of recognition is needed. For the establishment of a seed laboratory, a certificate of registration from the government is required. Also, any person interested in establishing a seed business needs to get a license through the government.

Seed labelling specifications for marketing purposes include: a trademark, variety name, weight and volume of seed, quality of seed, instruction for use, expiry date, number and date of license, and a warranty of seed quality.

Seed regulations
Seed regulations provide detailed guidelines to enforce the seed law. Myanmar seed regulations provide the procedures, contact points, forms, fees and specidic requirements for three important areas: (i) registration of a new variety; (ii) establishment of a seed laboratory; and (iii) establishment of a seed business.

In summary:

- Variety registration: To introduce a new variety in Myanmar it has to go through a one season adaptation trial in three different locations under the supervision of a seed committee.
- Seed laboratory establishment: New and existing seed quality testing laboratories need to obtain a certificate of registration from the government. The person registering the laboratory shall have at least a graduation certificate/degree from a university, and needs to obtain a training certificate on the methodology of analysing seed quality from the DOA seed division. The certificate of registration will be valid for 3 years. The seed regulations also provide guidelines for the construction of laboratory buildings.
- Seed business establishment: New and existing seed businesses need to get a Seed Business License for specific crops/varieties. Already established businesses which do not have a license yet, shall obtain a license within 90 days of approval of the seed law.

In addition, the regulations provide details on seed certification standards for breeder, foundation, registered and certified seed for 14 field crops and 18 vegetable crops (not all crops have complete data though). The certification standards for parental lines of hybrid rice seed production are also provided.

PVP law
The PVP law provides intellectual property rights over a number of years. To obtain variety ownership through Plant Breeders Rights (PBR) a variety must fulfil criteria for distinctness, uniformity, and stability (DUS) and novelty, as set out by the law. Once PBR have been awarded, the owner has exclusive rights on production or multiplication of the variety and can sell seed to the local market or export seed to international markets. The duration of PBR is 25 years for new perennial crops and vines and 20 years for new plant varieties of other crops.

The PVP law of Myanmar proposes the formation of a national committee for supporting its overall implementation. PVP regulations are planned to be developed in 2016 and 2017. The current PVP law is not in full compliance with the International Union for Protection of new Varieties of Plants (UPOV), but a process has been started to amend the law in order to make it UPOV compliant.

Seed road map

A final version of the seed road map of Myanmar has been developed by the Myanmar Agriculture Network in collaboration with MOALI, international development organisations and the private seed sector. It was extensively discussed during a national seed workshop organised in August 2016 in Nay Pyi Taw. The seed road map builds upon a number of previous studies and policy documents formulated in 2015 and 2016 with support from the Asian Development Bank, FAO, the International Food, Policy and Research Institute, IRRI, MOALI, the Netherlands Mission and the United States Agency for International Development (USAID). Our study team members have been involved in drafting the seed road map and facilitating the above mentioned workshop. The seed road map has developed a joint strategic agenda for the period 2017-2020, which describes the steps needed to transform the current sector into a vibrant, competitive seed sector, which is able to cater for the diverse needs of Myanmar's farmers.

Seed and regulatory framework in practice

The national seed policy provides an integrated perspective on the development of the seed sector and its various seed systems. Comparing it with other Asian and African countries, we consider it a well-balanced and visionary seed policy.

Both the seed law and seed regulations promote a pathway of liberalisation for the seed sector, decreasing the role of the public sector and increasing the role of the private sector. This provides opportunities for the private sector for variety registration, EGS production, internal seed quality control through in house laboratories, and control of fake seed in the seed market by enforcing mandatory information on seed labels. Further, the variety registration process has become more efficient by shortening it to 1 season and limiting it to three location trials.

However, the seed law and seed regulations have also created constraints to certain seed systems. In relation to seed certification, the seed law and regulations require a mandatory and full certification system. Considering the current capacity and various stages of the intermediary seed system in Myanmar, it would be beneficial to allow alternative quality assurance systems like a system of Quality Declared Seed (QDS; developed by FAO), or a system of truthfully labelled seed (like in Bangladesh, India and Nepal). The quality control system PGS, applied for community-based seed production by a number of LIFT implementing project partners, may be considered as an alternative system to support small-scale, farmer-based and decentralised seed production schemes.

The national seed policy mentions that local landraces, with a substantial and steady seed demand, may be released as official varieties. However, both the seed law and seed regulations mention that value for cultivation and use (VCU) and testing for DUS are required for the release of new varieties. It is not clear from the seed regulations to what extent flexibility is provided in the registration of local landraces. For example, PVP and the Farmers Right Act, 2001 of India provides flexibility in the 'uniformity' criteria for local landraces' registration. This means that the Indian law allows a higher percentage of 'off-types' which is generally the case with landraces as compared to varieties developed by professional breeders. Further, the registration fee for local landraces is fully subsidised (free) in India when submitted by farmer groups, while in Myanmar, the estimated cost for registration of one variety is around MMK 300,000-500,000 (USD 236-394 USD depending on the crop type).

The seed law and seed regulations allow a stronger private sector role in the production of EGS (e.g. breeder seed, foundation seed and registered seed). However, there is a need to define the division of roles between the public and private sector for EGS production. The private sector is

profit oriented and therefore not interested in seed production of all types of crops and varieties. DAR and DOA may give priority to these less profitable crops, including rice. A recent study carried out in various countries in Africa on EGS production may provide relevant options for Myanmar to divide public and private sector roles in this area (Lion *et al*., 2015).

Business and investment climate in Myanmar

The recently launched World Bank Group report *Enabling the Business of Agriculture* (EBA) measures and monitors regulations that affect the functioning of agriculture and agribusiness in 40 countries. It covers all regions around the world and includes all income groups. Myanmar is included and its agricultural and seed sector have been analysed. Next to Myanmar, the report analyses other ASEAN countries viz. Cambodia, Lao PDR, the Philippines and Vietnam; from the South Asia region Bangladesh, Nepal and Sri Lanka are also included. The World Bank EBA project used 18 indicators covering the six topics viz. seed, fertiliser, machinery, finance, transport and markets; see Figure 2.

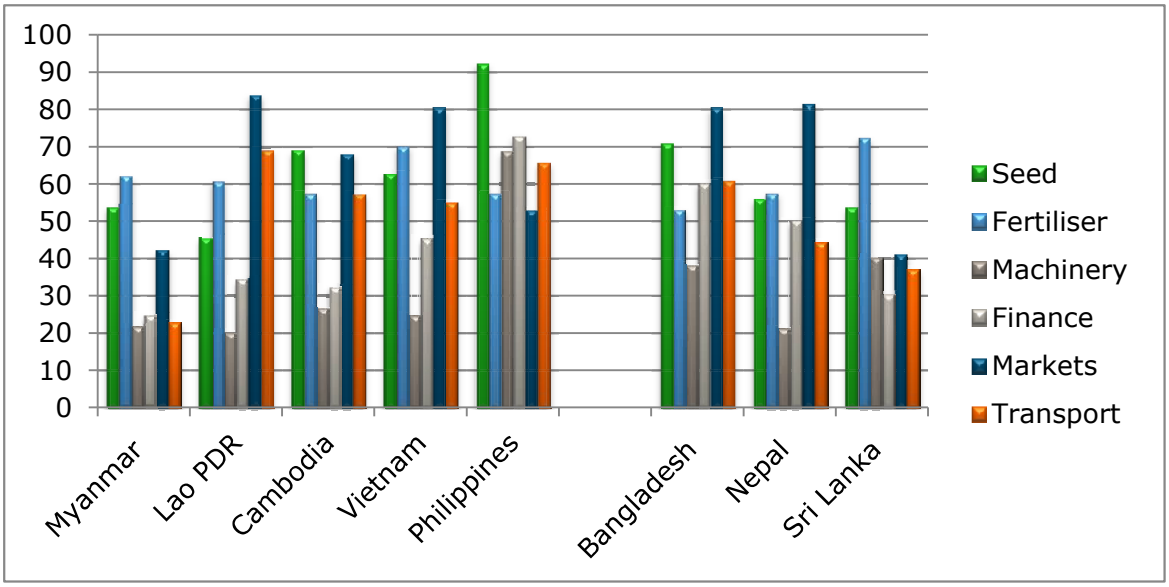


Figure 15 Six key topics affecting the business environment of agriculture and seed in Myanmar and other countries

Note: Figure reproduced from World Bank Group, EBA report 2016 – analysis of selected countries.

Among the six key areas analysed by in the EBA report, Myanmar is ranking lowest as compared to its neighbours/ASEAN countries, in finance, transportation and markets, while it is second lowest in machinery and seed (Figure 15). Myanmar ranked second highest after Vietnam in fertiliser. The finance topic included an analysis of indicators on laws and regulations on microfinance institutions, credit unions, agent baking, electronic money and warehouse receipts (or use of agricultural commodities as collateral). For the transportation topic, two sets of indicators have been analysed, namely truck licenses and cross-border transportation. Under the topic of market obstacles faced by agribusiness, plant protection, production and sales, and agriculture exports were measured. Three indicators were analysed to rank machinery, namely tractor dealer requirements, tractor standard and safety, and tractor import requirements. For the seed topic, variety/seed registration, seed development and certification were analysed. The fertiliser topic analysis included issues of fertiliser registration, fertiliser quality control and fertiliser import requirements.

For the seed topic the following indicators were used; the scoring ranged from 0 and 100:

- Variety/seed registration: efficiency of variety release committee, the content, availability and frequency of the variety catalogue update; time and cost to register a new variety

- Seed development and certification: measures of protection of PBR, access to EGS and germplasm; licensing systems for public varieties; additional testing requirements for materials imported for research and development; official fee for certification; and third party certification

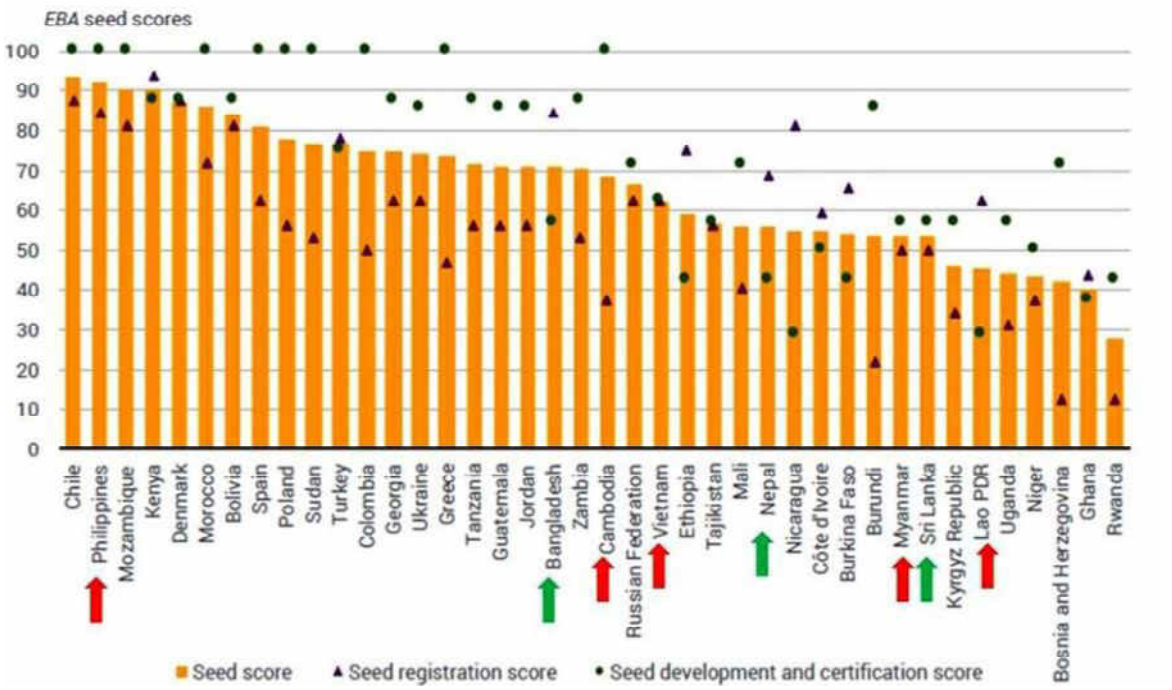


Figure 16 Seed sector performance in Myanmar and other countries related to business environment

Note: Seed sector performance measured by seed registration and seed development and certification. Figure reproduced from World Bank Group, EBA report 2016. Red arrows indicate Myanmar and ASEAN countries; green arrows indicate South Asian countries.

Figure 16 shows that Myanmar ranked in fourth position among the five ASEAN countries for seed sector performance. Cambodia and the Philippines were found to have better enabling environments for seed development and certification indicators, while seed regulations were found to be an issue across all analysed countries.

The final draft version of Myanmar's seed road map, which was discussed during the National Seed Workshop in August 2016, has pointed out some additional enabling environment issues:

- Intellectual property rights are not well protected in Myanmar. International companies indicate that strong breeder rights and membership of UPOV would be an advantage for embarking on seed production in Myanmar
- The regulations for establishing a seed production company in Myanmar are unclear and cumbersome. Some companies that tried setting up a production company quit the process due to the long list of requirements and conditions demanded. In addition, varieties of 100 per cent re-exported seed require testing and registration which is not common in other countries in the region
- There is a lack of skilled labourers, especially for the technical aspects of seed production and quality assurance
- For export, seed companies indicate that the phytosanitary system has difficulties in providing adequate services for testing for specific organisms and accurately formulating the necessary certificates for destination countries
- There is a limited private sector interest to invest in the production of OPV rice, oilseed and legume seeds due to lack of capital, expertise and regulatory challenges

4. DISCUSSION

FGD as part of seed use survey (Audet-Bélanger, Royal Tropical Institute, 2016)

The current section tries to link the information gathered from the study on variety and seed use and supply with estimations of seed demand, as well as elaborate different seed production business models. We also address the main differences between the two study sites.

4.1 Farmer preferred varieties and variety turn-over

Number of varieties grown per farmer
Our seed use survey shows that 50 per cent of farmers in the lower Ayeyarwady delta grow one rice variety per season; 32 per cent cultivate two varieties and 16 per cent cultivates three in the same season. In the upper Ayeyarwady delta, 55 per cent of farmers grow two varieties in 1 season, whereas 40 per cent use one variety only. Rice is considered an important (cumulative 99.6 per cent) to very important (88.1 per cent) crop for food security by the farmers who participated in the seed use survey. Being such an important food security crop, and with the diversity of local varieties available in the region, we had expected that farmers would grow a larger amount of varieties per season. Growing several varieties per season is a way for farmers to address diverse weather conditions and as a function of risk management.

Risk of genetic erosion
For crops that are important for creating household income, farmers tend to focus on one or two varieties which are produced in bulk. The seed use survey showed that rice is considered important for income by 90.1 per cent of farmers, whereas it is very important for 72.8 per cent of farmers. In environments with increased opportunities for commercialisation, a reduction in the number of varieties grown per season tends to occur (Witcombe *et al.*, 2001), which results in farmers mostly abandoning their local varieties. With the strong focus of the Myanmar Government on promoting further professionalisation of rice growers, and increasing commercialisation of rice for internal as well as export markets (Ministry of Agriculture and Irrigation and IRRI, 2015; Ministry of Commerce, 2015), it is important to consider this risk of genetic erosion and take measures for ensuring the conservation of local rice diversity.

Preferred local and improved varieties
Forty one per cent of the farmers in the lower delta region grow a local variety as their main variety; the aromatic Pawsan varieties are very important in the monsoon season. In the upper Ayeyarwady delta, the percentage of farmers growing a local variety is only 3 per cent. Six varieties dominate in the lower Ayeyarwady delta, with Thee Htet Yin and Pawsan the most important; Pawsan is in fact a mix of local varieties of the Pawsan group. Seven improved varieties dominate in the upper Ayeyarwady delta, of which the most important are Sin Thukha, Shwe War Htun, Sin Thwe Latt and Hmawbi-2. It is clear that the different agroecologies in lower and upper Ayeyarwady delta require varieties adapted to different conditions.

Important variety characters
Yield potential, adaptation to soil conditions, market price, maturing cycle, and tolerance to waterlogging are mentioned by farmers as the most important characteristics for variety selection. Sin Thukha is the most appreciated improved variety; farmers like it since it is not too soft (so you eat less), tolerant to water logging, fetches a good market price, traders are interested in it, and yields are good. Farmers appreciate varieties with a high market price and without a market, farmers are reluctant to adopt a variety. Our studies revealed that even within one development organisation, varieties prioritised by farmers in PVS trials were not prioritised by the same development organisation in seed production schemes because farmers were not sure about the market for these varieties.

Local varieties and government support
The aromatic Pawsan varieties are of high importance in the lower Ayeyarwady delta. Even if the yield is not as high as improved varieties, the rice grain fetches a high market price and is preferred for its grain texture, aroma and flavour. Within the Pawsan variety group, many

different sub-selections made by farmers exist from the original variety Pawsan Hmwe. Several of these varieties like Pawsan Bay Kyar and Pawsan Yin (improved Pawsan) are recognised by research, and DAR and DOA produce official breeder seed, foundation seed and registered seed of these varieties. Other names, like Shwebo Pawsan, refer to the location in which the variety is grown, giving the rice a recognised and appreciated flavour. DAR headquarters in Yezin is currently analysing the diversity within the group of Pawsan varieties. WHH is looking into options for improving the highly preferred Pawsan Bay Kyar variety (Rana and Dhakal, 2015).

Importance of and challenges with variety turnover

A number of popular varieties in the delta were released quite some time ago (Table 71). High variety turnover rates contribute to sustaining yield gains over time, providing farmers with new varieties with high yield potential, pest and disease resistance, tolerance to adverse growing conditions, adaptability to advanced cropping systems, and improved characteristics in terms of processing and consumption quality. Accelerating variety change among smallholder farmers is a challenge that many countries are struggling with, and that has many different angles (Rwomushana and Heemskerk, 2015). On the one hand, farmers may not be interested in new varieties because they do not fit with their preferences but on the other hand, farmers might be interested but have restricted access. Access restrictions may relate to a lack of incentives for breeders in making the varieties available to seed producers, including companies as well as community-based seed schemes; lack of EGS production; limited incentives for seed producers; as well as a lack of information on new varieties.

Farmer satisfaction with their varieties and variety renewal

Farmers in the lower and upper Ayeyarwady delta mentioned that they are generally satisfied with the varieties that they grow, and often indicate that they are willing to use the same variety again in the next season (84 per cent and 68 per cent in the lower and upper Ayeyarwady delta, respectively). On the study question 'How often do you seek a different rice variety?', 42 per cent of farmers indicated to do so every 3 seasons. This percentage seems very high and comes close to the most common rate of seed renewal (52 per cent of the farmers renewed their seed stock every 3 seasons). We assume that farmers work with a portfolio of varieties, from which they choose the most appropriate every 3 seasons at the moment they also renew their seed stock. It is important to realise that even when farmers try a completely new variety, they may not come back to the formal seed source the following season. This may sugest that farmers do not appreciate the variety whereas the opposite is true; they come back for seed of the same variety after 3 seasons. An example of this was provided by the DAR Myaungmya Research Farm manager.

Variety demonstration: seeing is believing

It is critical to also involve important market players like millers in demonstrations and evaluations, since they have an important say in determining the market demand for new varieties. In the upper Ayeyarwady delta, farmers can learn about new varieties through extension demos. Some varieties are highly appreciated by farmers such as the 90 Days variety. This variety is a Vietnamese variety that entered the country without official release; farmers and millers like it and DAR headquarters in Yezin is currently purifying it for official release. For selecting new varieties, farmers indicated that they are mainly relying on their own observations and on their informal network; only approximately 15 per cent of farmers get information about new varieties from formal sources. This implies a gap in access to variety information that needs to be addressed.

Tools for variety promotion

A lot of information on farmers' interests and needs for new varieties can be found in the informal system for example through community networks, farmers' meetings on seed and varieties, and seed fairs, which may support breeders in ensuring that their crop improvement efforts meet the demands of the farmers. Breeders and seed producers may also use tools to promote new varieties that reach many people but are often not linked to the formal sector, like community radio. Better integration of different sources of information may promote the adoption of new varieties.

Comparing variety use and variety supply

Based on information from the seed use survey and the seed supply survey we can compare how variety use matches with variety supply; Table 71 shows the data segregated per township. The table shows that variety priorities differ between the lower delta (Bogale and Labutta townships) and the upper Ayeyarwaddy delta (Hinthada and Danphyu townships), which is no surprise since the agroecologies are different. Even if the majority of farmers in the lower delta source their seed from the informal system (96 per cent), the table still shows that DOA prioritises certified seed production of the farmer-preferred varieties Thee Htet Yin (Bogale) and Pawsan Yin (Labuta). The DOA also supports seed production of the variety Swarna Sub-1, which is not found in the seed use survey. The Meedome group of local varieties in this survey is unique to Labutta.

Table 71 Prioritised varieties in the seed use and certified seed supply survey per township

Variety	Year of variety release	Bogale		Labuta		Hinthada		Danuphyu	
		Seed use	Certified seed sold	Seed use	Certified seed sold	Seed use	Certified seed sold	Seed use	Certified seed sold
Hmawbi-2	2003					5		3	3
Manaw Thukha	1978	3		5	6	3	5		4
Meedome (group of local varieties)	-			3					
Pawsan (Pawsan Hmwe/Pawsan Bay Kyar/Pawsan Yin; group of local varieties)	1944/ 1960	2	3	1	1*				
Shwe War Htun	1974					1	2	5	6
Sin Thukha	2007	4	4	4	4	2	1	1	2
Sin Thwe Latt	2003		1	5	2		6	2	1
Swarna Sub-1	2011		5		3		4		
Thee Htet Yin (IR-13240)		1	2	2	5	5	3	4	5
Yarkyaw-2	Before 1980					4			

Note: Other: * the variety is Pawsan Yin; data on priority varieties for sale concern DOA supported certified seed production in the 2015-2016 season; numbers indicate priority, with '1' being the highest priority.

In Bogale and Labutta, LIFT's implementing partners Radanar Ayar, GRET and WHH have been supporting seed production schemes. These schemes focus on the same varieties as per the table above. An additional variety produced through these schemes is the highly popular 90 Days variety, which has now been taken up by DAR Yezin for purification and official release.

In the upper Ayeyarwady delta where formal seed sources seem more important than in the lower Ayeyarwady delta (31 per cent from a formal source in the upper delta), prioritised varieties by farmers and by the DOA matched well. The main varieties grown by farmers in the last production season in Hinthada were Shwe War Htun and Sin Thukha; these are also prioritised for seed production by DOA; in Danuphyu, we see the same pattern for the varieties Sin Thukha and Sin Thwe Latt (Table 71).

In Danuphyu Township, RSC Gold Delta is also a key provider of certified seed (30,000 baskets produced and distributed for the grain contract growers in the 2016/17 season versus 60,372 baskets of DOA supported certified seed sold in the same season). Gold Delta produced seed of the varieties Sin Thwe Latt and Hmawbi-2.

4.2 Use and supply of quality seed

Breeder seed demand and supply
Over the years, DAR in Yezin has provided sufficient volumes of breeder seed of adequate quality to the four different foundation seed producing seed farms located in the Ayeyarwady delta – Myaungmya Research Farm in Myaungmya, Myanmar Rice Research Centre in Hmawbi, Tagontaing Seed Farm in Hinthada, and Thayaung Chaung Seed Farm in Pathein. Orders for breeder seed are usually made 1 year in advance with DAR in Yezin. There was only one case mentioned by the Tagontaing Seed Farm for the 2015/16 production season, in which the requested breeder seed of the variety Yadanar Toe was not available; this variety was replaced by the variety Sin Thwe Latt.

Foundation seed demand and supply
The four above mentioned seed farms produced a total of 1,208 baskets of foundation seed of 11 rice varieties in the 2015/16 cropping season (Table 46). In the 2016 monsoon season, foundation seed production substantially increased to 2,292 baskets. Varieties such as Thee Htet Yin, Paw San Yin, Ayar Min, Sin Thukha and Sin Thwe Latt are in high demand. Seed farm managers mentioned in interviews that the demand for foundation seed was only met for 20 per cent to 50 per cent for the varieties Ayar Min, Sin Thukha and Thee Htet Yin. Orders for foundation seed are usually made 6 months to 1 year in advance.

In general, farms producing foundation seed do not sell all volumes of foundation seed to other registered seed producers. A total of 63 per cent of foundation seed produced in the 2015/16 season was sold to various customer types. This means a total of 37 per cent of foundation seed was retained by seed farms to produce their own registered seed for the next season. These data are not common for all seed farms; the Myanmar Rice Research Centre fully sold its foundation seed, while the Tagontaing and Thayaung Chaung Seed Farms retained most of their foundation seed to produce their own registered seed.

The seed farms have two types of foundation seed customers, government seed farms, and township offices. These customers are from the Ayeyarwady and many other regions (Table 46). From the available data it is not clear what the percentage is for foundation seed sales to different customers, but government seed farms are found to be major buyers of foundation seed. Some volumes of foundation seed are directly sold to township offices, which generally supply the seed to contact farmers. This indicates that some volumes of foundation seed are also directly used for certified seed production. This practice of selling foundation seed to produce certified seed should be avoided.

Registered seed demand and supply
Both DAR research farms and DOA seed farms are involved in registered seed production and supply in the Ayeyarwady region. In recent years, development organisations like Metta and Radanar Ayar were also involved in registered seed production and supply. In the 2015/16 season, a total of 23,657 baskets of registered seed for nine different varieties was produced and sold to different customers. In the 2016 monsoon season, a total of 19,472 baskets of registered seed was produced (Table 49 and Table 50).

The Varieties Sin Thuka, Sin Thwe Latt, Paw San Yin, Thee Thet Yin, Ayar Min and Hnan Kar represent approximately such as Thee Htet Yin, Paw San Yin, Ayar Min, Sin Thukha and Sin Thwe Latt are in high demand. During the interviews, seed farm managers indicated that the demand for registered seed was only met by 20 per cent for the Ayar Min and Sin Thukhavarieties varieties, while demand was met by 50 per cent for Thee Htet Yin registered seed. Registered seed is sold to four different types of customers: (i) township offices, (ii) development organisation projects, (iii) private companies and (iv) and contact farmers. Registered seed produced by the government seed farms in the Ayeyarwady region was also supplied to other regions including the Bago, Mandalay and Sagaing regions. The available seed data do not provide clarity on the percentage of registered seed supplied to customers in Ayeyarwady region only.

Six months in advance, just before planting time, customers have to officially place their demands for registered seed. In practice, township offices provide seed demand data 3 to 6 months before the planting season, while individual contact farmers for development organisation projects and private companies place seed demand on an ad-hoc basis. The result is that in many cases the registered seed is requested just weeks before the planting season. This is one of the key reasons why it is hard for registered seed producers to meet demand; the actual period in which seed demands are placed is too short and the system is not well-organised.

Certified seed demand, supply and use

The volumes of certified seed production and sales in the Ayeryarwaddy region show an increasing trend from 2012 to 2015 of at least 6.5 per cent each year (Table 51). In most cases, certified seed is sold immediately after the harvest and the certification process. Seed producers sell on average 60 per cent of their total amount of certified seed to different customers every year. The remaining 40 per cent is saved for the next season to produce a new generation of certified seed (CS-2). Certified seed is sold to three distinct customers: (i) farmers linked with the DOA township extension offices or development organisation projects, (ii) individual farmers, and (iii) rice millers. Demands for certified seed are made on an ad-hoc basis. Generally, certified seed producers base their production volumes on the seed production and seed sales data of the previous year, whilst also considering the weather conditions of the current production season.

We compared the certified seed supply by formal and intermediary seed systems in four study townships. The results show that there are significant gaps in certified seed supply for the study sites with informal seed systems (farmer saved seed) contributing over 95 per cent of farmer seed needs in lower delta, and 60-84 per cent in the upper delta.

Table 72 Comparison of formal seed supply and gap from 2013 to 2017 production seasons in four study townships

Production year	Lower Ayeyarwady delta		Upper Ayeyarwady delta	
	Formal seed supply (certified seed) in %	Informal seed supply (farmer saved seed) in %	Formal seed supply (certified seed) in %	Informal seed supply (farmer saved seed) in %
2013/14	3.2	96.8	15.4	84.6
2014/15	3.9	96.1	13.3	86.7
2015/16	5.2	94.8	15.7	84.3
2016/17	4.4	95.6	39.8	60.2

Note: Seed supply data are from Table 56, Table 59, Table 61 and Table 64 of this report. Informal seed systems data have been calculated based upon 100 per cent minus the percentages of seed supply and seed use from formal and intermediary seed systems.

4.3 Estimations of seed demand and supply

4.3.1 Introduction

The rice production area in the Ayeyarwady region was reported to be 5 million acres in 2016/17, of which approximately 4 per cent was planted with certified seed of improved varieties. Within the region, the four townships of Bogale, Danuphyu, Hinthada and Labutta grow some 1 million acres of rice (Table 73). Most of this (about 806,000 acres) is grown in the lower delta townships of Bogale and Labutta. The rice cultivation area appears to have remained relatively constant in recent years and significant increases in rice production areas are not expected in the near future. The amount of certified seed use across the four townships is relatively low, averaging 148,367 baskets over the last 4 years, which is 5.7 per cent of the total seed sown. On average, therefore, farmers are replacing their farm-saved seed with certified seed at a very low frequency. However, there are marked differences in certified seed use amongst the four study sites.

Table 73 Rice area and seed coverage in the four townships of Bogale, Labuttta, Hinthada and Danuphyu over the period of 2013/14 to 2016/17

Year	Total rice production area (acres)	Certified seed used (baskets)	Total seed (certified plus retained) sown (baskets)	% of rice production area covered by certified seed
2013/14	1,057,612	120,372	2,591,149	4.6
2014/15	1,060,803	116,586	2,598,967	4.5
2015/16	1,063,104	175,394	2,604,605	6.7
2016/17	1,063,104	181,117	2,604,605	7.0
Average	1,061,156	148,367	2,599,832	5.7

Danuphyu is the township with the largest certified seed use, averaging 72,000 baskets *per annum* over the last 4 years and making the proportion of land planted with certified seed on average, 23 per cent (Figure 17). Presently, despite having the largest rice areas, Bogale and Labutta have very low certified seed use of around 2.4 per cent. Nevertheless, in these two townships the quantity and proportion of certified seed sown in 2015/16 and 2016/17 was greater than in earlier years. Hinthada Township has had an average certified seed use of 6-11 per cent over the last 4 years, with a similar rice production area to Danuphyu.

To increase the productivity of rice production, the use of certified seed is considered a fundamental pre-requisite. Thus, certified seed use needs to increase to a level where farmers are replacing their seed every 3 to 4 years to maintain crop vigour, uniformity, quality and benefit from new and improved varieties. A goal of achieving 25 per cent seed purchase rate in the townships of Bogale, Labutta and Hinthada is feasible, based on the evidence from Danuphyu. But this is likely to involve a long process of convincing farmers of the benefits of certified seed, and establishing a viable seed system to deliver certified seed to progressive farmers.

The capacity of seed producers in the four townships to produce certified seed does not appear to be inadequate at present, with about 60 per cent of the produced seed disseminated in Bogale, Danuphyu and Labutta, while about 20 per cent is distributed in Hinthada (Figure 18). Consequently, it appears that increasing certified seed use in the short term is a matter of improving seed distribution, promotion and farmer adoption, rather than increasing seed production *per se*. Nevertheless, as the demand for certified seed grows, production will also need to increase.

The difference in certified seed use between the lower delta (Bogale and Labutta) and the upper delta (Danuphyu and Hinthada) seems to be associated with a greater concentration of extension services, agri-mechanisation and land improvement in the upper delta. The lower delta is more prone to floods caused by frequent cyclones, which may make farmers more risk-averse and less willing to purchase certified seed. Furthermore, extension services and agri-mechanisation are less available in the lower delta due to the greater number of farmers and larger rice production areas, so farmers are generally less informed about the benefits of certified seed.

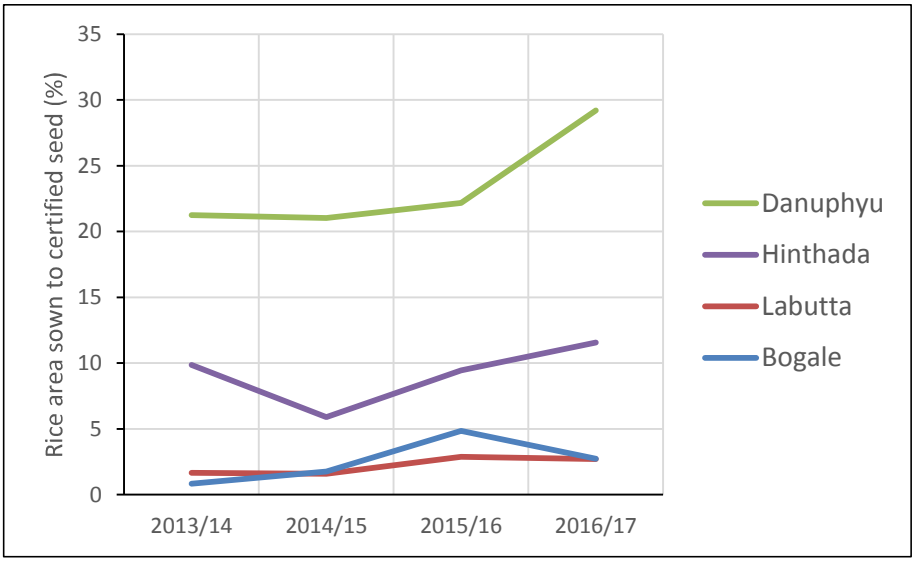


Figure 17 The proportion of the total rice area sown to certified seed in the period of 2013/14 to 2016/17

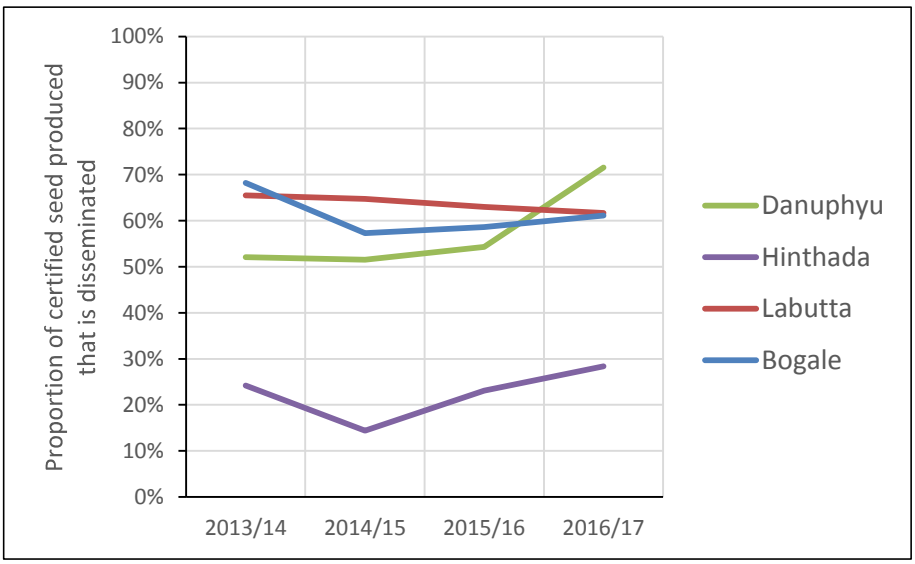


Figure 18 The proportion of certified seed that is disseminated in the four townships over the four-year period of 2013/14 to 2016/17

4.3.2 Methodology used to estimate seed demand

A simple excel-spreadsheet model was developed to estimate future seed demand with or without significant intervention in developing the seed sector. This model was based on assumptions of rice area cultivated, seed rate (2.45 baskets per acre), and proportion of certified seed use. This seed rate is relatively high for commercial production, but it represents the present practice of farmers. The cultivated rice area was assumed to increase at a rate of 1 per cent *per annum* for all scenarios, while the certified seed use without any significant interventions to promote certified seed use, was also set at 1 per cent *per annum*. This is a status quo situation, where the proportion of certified seed use does not change, but the quantity of certified seed sown increases in proportion to the area of rice grown – but at a low rate. For the scenarios where significant interventions to develop the seed sector were considered, and based on the foregoing introduction, the assumptions differed according to the region or individual townships under consideration.

For the Ayeyarwady region, a more global approach was taken. The proportion of certified seed use for 2016/17 was estimated as 4.25 per cent. Without intervention, this was considered to

remain constant as there would be little incentive to seed producers to produce and market certified seed. However, with intervention in seed sector and value chain development, an annual increase in certified seed use of 5 per cent was considered feasible, such that the proportion of land sown with certified seed would increase to 5.3 per cent in 5 years. This is still a low percentage, but there are marked differences in rice production characteristics between the lower and upper delta environments.

In the case of Danuphyu Township (upper delta) where there is already a relatively high proportion of land sown with certified seed (29 per cent), modest levels of growth in certified seed use were used (3 per cent), with the aim of achieving a 33 per cent certified seed use by 2021/22. For Hinthada Township (upper delta) where recent certified seed use is at around 10 per cent, a higher annual rate of growth (5 per) cent was used, since the township has a relatively small area of rice production and extension services and agri-mechanisation are relatively well developed. In Hinthada, the aim is to achieve 20 per cent certified seed use in the next 5 years.

Bogale Township and Labutta Township (lower delta) are quite similar in their present rice production characteristics and environmental conditions, and therefore the two townships were combined. From 2012 to2016, certified seed use in the two townships averaged 2.4 per cent of total rice area, equal to about 47,000 baskets of seed and covering just under 20,000 acres. With intensive efforts to improve the seed sector through wider distribution, seed promotion, farmer adoption of certified seed varieties, and value chain development, it was considered that the demand could be doubled over the next 5 years. This would require an annual increase in certified seed use of 15 per cent which, if achieved, would result in about 5 per cent of the land area for rice cultivation being planted with certified seed after 5 years.

Following the calculation of the certified seed requirements in the region and four townships, estimates of registered, foundation and breeder seed requirements were calculated using the assumptions of a seeding rate of 1 basket per acre, and a yield of 70 baskets per acre. The lower seed rate for certified seed and EGS is justified because farmer attention to agronomy is higher than for commercial grain production. The certified seed was calculated to be produced in the year of use, while the registered, foundation and breeder seed was calculated to be produced in the year before use. In addition, seed reserves of 15 per cent, 25 per cent 100 per cent and 200 per cent were incorporated for certified, registered, foundation and breeder seed, respectively. This would ensure that there would be sufficient certified and EGS to cover contingencies of increased demand or seed losses from catastrophes.

4.3.3 Results and discussion on seed demand estimation

Regional seed demand and scaling up

At the Ayeyarwady region level, 522,835 baskets of certified seed were disseminated in 2016-2017, sufficient to cover 4.2 per cent of total rice area. With minor annual increases (1 per cent) in rice area and seed production, and without interventions in seed sector development, the quantity of certified seed is estimated to increase to 550,000 baskets over the next 5 years (Table 74). However, with investment in seed sector development and with a 4 per cent annual rate of increase in certified seed purchase, the seed market is expected to grow to 667,500 baskets, and certified seed to cover nearly 5 per cent of total rice area by 2021-2022. This is still a modest seed purchase frequency, but represents an additional 118,000 baskets of certified seed which would cover 48,000 acres. The certified seed production area would need to increase from 9,142 to 11,218 acres, requiring significant organisational infrastructure with seed growers and market development. Similarly, the EGS system would need to increase modestly to facilitate the growth in certified seed production. This forecast growth in the seed market would need to be strategically planned, and hence a more focussed approach at the township-level is required.

Table 74 Estimation of certified seed demand for Ayeyarwady region without or with market intervention, and the certified and EGS production requirements

Demand estimation	2017/18	2018/19	2019/20	2020/21	2021/22

Projected rice area (/1000 acres)	5,077	5,128	5,179	5,231	5,283
Seed market projection without intervention (/1000 baskets)	528.2	533.5	538.8	544.2	549.7
Proportion of rice area planted to certified seed without intervention	4.25%	4.25%	4.25%	4.25%	4.25%
Seed market projection WITH intervention (/1000 baskets)	549.2	576.6	605.4	635.7	667.5
Certified seed purchase rate with intervention (expanding market)	4.25%	4.46%	4.68%	4.92%	5.16%
Additional volume due to new sales of certified seed (/1000 baskets)	20.9	43.1	66.6	91.5	117.8
Seed production					
Certified: Production (/1000 baskets)	646.1	678.4	712.3	747.9	785.3
Area (acres)	9,229	9,691	10,175	10,684	11,218
Registered: Production (baskets)	12,921	13,567	14,246	14,958	
Area (acres)	185	194	204	214	
Foundation: Production (baskets)	388	407	427		
Area (acres)	5.54	5.81	6.11		
Breeders': Production (baskets)	17.46	18.33			
Area (acres)	0.249	0.262			

Upper delta seed demand and scaling up

The Danuphyu Township has the most well-developed seed sector of the four townships under consideration, as evidenced by the proportion of land area sown with certified seed (29.2 per cent in 2016/17). Nevertheless, the township has a relatively small rice production area (126,000 acres). With a modest increase in certified seed demand of 3 per cent *per annum*, the amount of certified seed would increase from 90,000 baskets in 2016/17 to 105,000 baskets in 2021/22 (Table 75). With such an increase, nearly one third of the land would be planted with certified seed, which is likely the upper limit for seed purchase frequency for self-pollinated rice (i.e., farmer seed replaced every 3 years). The area of land required to grow this certified seed would increase from 1,500 acres to 1,761 acres, and the EGS system supporting this is not excessive, requiring about 34 acres of registered seed, 1 acre of foundation seed and 3 baskets of breeder seed.

Table 75 Estimation of certified seed demand for Danuphyu Township without or with market intervention, and the certified and EGS production requirements

Demand estimation	2017/18	2018/19	2019/20	2020/21	2021/22
Projected rice area (/1000 acres)	128	129	130	131	133
Seed market projection without intervention (/1000 baskets)	91.3	92.2	93.1	94.1	95.0
Proportion of rice area planted to certified seed without intervention	29.21%	29.21%	29.21%	29.21%	29.21%
Seed market projection WITH intervention (/1000 baskets)	93.1	95.9	98.8	101.7	104.8
Certified seed purchase rate with intervention (expanding market)	29.21%	30.09%	30.99%	31.92%	32.88%
Additional volume due to new sales of certified seed (/1000 baskets)	1.8	3.7	5.6	7.7	9.8
Seed production					
Certified: Production (/1000 baskets)	109.5	112.8	116.2	119.7	123.3
Area (acres)	1565	1612	1660	1710	1761
Registered: Production (baskets)	2,149	2,214	2,280	2,348	
Area (acres)	31	32	33	34	
Foundation: Production (baskets)	63	65	67		
Area (acres)	0.90	0.93	0.96		

Breeders': Production (baskets)	2.79	2.88
Area (acres)	0.040	0.041

The Hinthada Township has a recent seed purchase frequency history of 6-11 per cent, and therefore considered to have a good possibility of increasing certified seed use in the coming 5 years with strategic investments in seed sector development. Consequently, an annual growth rate of 5 per cent in the use of certified seed was considered feasible. This would double the certified seed demand from 37,000 baskets in 2016/17 to 74,400 Baskets in 2021/22, giving a seed purchase rate of 20 per cent (Table 76). To achieve this increase, certified seed production area would need to increase from 700 acres to 1,250 acres, requiring significant organisation of the seed production and processing system. The supporting EGS system for this would be modest, amounting to 24 acres of registered seed, two-thirds of an acre of foundation seed, and 2 baskets of breeder seed.

Table 76 Estimation of certified seed demand for Hinthada Township without or with market intervention, and the certified and EGS production requirements

Demand estimation	**2017/18**	**2018/19**	**2019/20**	**2020/21**	**2021/22**
Projected rice area (/1000 acres)	132	133	134	136	137
Seed market projection without intervention (/1000 baskets)	37.4	37.7	38.1	38.5	38.9
Proportion of rice area planted to certified seed without intervention	11.57%	11.57%	11.57%	11.57%	11.57%
Seed market projection WITH intervention (/1000 baskets)	42.6	48.9	56.3	64.7	74.4
Certified seed purchase rate with intervention (expanding market)	11.57%	13.31%	15.30%	17.60%	20.24%
Additional volume due to new sales of certified seed (/1000 baskets)	5.2	11.2	18.2	26.2	35.5
Seed production					
Certified: Production (/1000 baskets)	50.1	57.6	66.2	76.1	87.6
Area (acres)	715	822	946	1088	1251
Registered: Production (baskets)	1,097	1,261	1,450	1,668	
Area (acres)	16	18	21	24	
Foundation: Production (baskets)	36	41	48		
Area (acres)	0.51	0.59	0.68		
Breeders': Production (baskets)	1.78	2.04			
Area (acres)	0.025	0.029			

Lower delta seed demand and scaling up

The Bogale and Labutta Townships were considered together as they share many similarities in rice production and certified seed-use characteristics. In this scenario, where the present (2016/17) certified seed use is very low (2.7 per cent) and the area of rice is very large, there is a tremendous challenge, but also a great scope to increase the proportion of land sown with certified seed. Consequently, an ambitious growth rate in certified seed use of 15 per cent was used to increase the proportion of land planted with certified seed to 5 per cent by 2021/22. This translates as doubling the demand from 54,000 baskets in 2016/17 to 108,000 baskets in 2021/22 (Table 77). Significant investments in seed systems, seed distribution, certified seed use promotion, commercial rice production and value chain development will be required to achieve this increase. The certified seed production area will need to increase from the present 1,000 acres to 1,800 acres. The EGS system to support this is not onerous, requiring 35 acres of registered seed, 1 acre of foundation seed, and 3 baskets of breeder seed. Nevertheless, establishing the seed grower network, maintaining a quality assurance system, and gathering, processing, and distributing seed will need to be carefully thought out and implemented to ensure efficiency and sustainability.

Table 77 Estimation of certified seed demand for Bogale Township and Labutta Township combined without or with market intervention, and the certified and EGS production requirements

Demand estimation	2017/18	2018/19	2019/20	2020/21	2021/22
Projected rice area (/1000 acres)	814	822	831	839	847
Seed market projection without intervention (/1000 baskets)	54.3	54.8	55.4	55.9	56.5
Proportion of rice area planted to certified seed without intervention	2.72%	2.72%	2.72%	2.72%	2.72%
Seed market projection WITH intervention (/1000 baskets)	61.8	71.1	81.7	94.0	108.1
Certified seed purchase rate with intervention (expanding market)	2.72%	3.13%	3.60%	4.14%	4.76%
Additional volume due to new sales of certified seed (/1000 baskets)	7.5	16.3	26.4	38.1	51.6
Seed production					
Certified: Production (/1000 baskets)	72.7	83.6	96.2	110.6	127.2
Area (acres)	1,039	1,194	1,374	1,580	1,817
Registered: Production (baskets)	1,593	1,832	2,106	2,422	
Area (acres)	23	26	30	35	
Foundation: Production (baskets)	52	60	69		
Area (acres)	0.75	0.86	0.99		
Breeders': Production (baskets)	2.58	2.97			
Area (acres)	0.037	0.042			

4.4 Developing market oriented and sustainable local seed businesses in the Ayeyarwady region

4.4.1 Business capacity of seed producers in the four study townships

In this section we discuss the opportunities for rice seed business. Hybrid rice is currently not promoted in the Ayeyarwady region so we focus on OPV varieties. Since farmers can easily save and recycle seed of OPV rice varieties by themselves, the development of commercial and profitable seed businesses for this crop is challenging. This is the reason that larger private seed companies are generally not interested in rice seed businesses.

Throughout the developing world of Asia and Africa, various local/community based seed production schemes for seed crops with low profit margins, including rice, have been promoted. These local schemes allow a reduction of production costs with the seed still to be sold to local farmers at a profit. Although many of these farmer- and community-based efforts have proven to be unsustainable, success stories have also been reported (ISSD Ethiopia 2014b, ISSD Uganda 2015), in which seed growers are able to produce and locally market quality seed as a commercial business. These may serve as examples for the development of market oriented and sustainable rice seed business models in the Ayeyarwady region.

In our study we have used a framework with four key performance areas to assess 16 selected seed producers in the Ayeyarwady region on their current seed business capacity. The key performance areas are: (i) seed producers are technically well equipped; (ii) seed producers manage their business well; (iii) seed producers are market oriented; and (iv) seed producers are strategically linked with key seed value chain actors. Each key performance area has its own critical success factors; these are depicted in Figure 19 and described and analysed in Table 78. Comparable frameworks have been used to assess the business status of seed producers in Cambodia, Ethiopia, Ghana and Uganda and determine appropriate entry points for strengthening

seed producer capacities. The 16 seed producers interviewed in the Ayeyarwady region included contact farmers supported by DOA, seed growers supported by development organisations and contract farmers supported by the RSC Gold Delta.

Table 78 Analysis of key performance areas and success factors of existing seed producers in Ayeyarwady region

Key performance areas and success factors	Current status
A. Seed producers are technically well equipped	
1. Access to improved varieties and variety portfolio	- Average of 3 varieties, 2 varieties, 1 variety and 3 varieties used for seed production by per seed producers in Bogale, Labutta, Hinthada and Danuphyu townships respectively - Many of the improved varieties are old; many of them were released before 1985
2. EGS source and supply	- DOA seed farms, DAR research farms, DOA township office, development organisations and private seed company (in Danuphyu township) - 90% of seed producers mentioned that EGS supply was sufficient; further, EGS provision is supply and not demand driven
3. Pre-harvest production skills	- Own capacity on field preparation, seed sowing and rouging; generally skills are sufficient
4. Post-harvest seed production skills	- Own capacity on harvesting and drying - All seed producers depend on DOA for seed processing and cleaning facilities - In Danuphyu township seed producers also get services from Gold Delta on seed processing and seed cleaning
5. Capacity of internal seed quality control	- Own capacity on seed production, and isolation - Do not have own capacity on seed germination, seed moisture and seed purity testing - 80% of the seed producers check the quality of registered seed by soaking in salt water before use for multiplication
B. Seed producers manage their seed business well	
6. Sufficient land for seed production	- On average 3.5 acres, 4 acres, 1.5 acres, 6.5 acres of seed production land used by individual seed producers in Bogale, Labutta, Hinthada and Danuphyu townships respectively
7. Sustainable source of supplementary irrigation	- 50% seed producers uses supplementary irrigation in Bogale and Labutta townships - Seed producers are completely rain-fed in Hinthada township - 25% with supplementary irrigation in Danuphyu township
8. Machinery for seed production management	- Three seed producers reported with thresher in Bogale township - Three seed producers reported with power tiller and one seed producer reported with a seed ware house with 500-1200 baskets capacity in Labutta township - Three seed producers reported with power tiller, tractor, thresher and water pump in Hinthada township - All seed producers reported with power tillers, pump, and thresher in Danuphyu township; one seed producer with a ware house with capacity of 2,250 baskets
9. Seed business plan	- None of the seed producers has a seed business plan document (vision, forward seed production and scaling plan, forward EGS seed demand system) - 80% seed producers make seed production and sales planning based on previous years' experience - 20% seed producers make ad-hoc seed production and sales planning
10. Sourcing external seed quality assurance services	- On average two field inspections done per season by DOA district seed staffs and DOA township extension staffs - Services provision feedback mainly given on rouging and systematic application of fertiliser and agro-chemicals - DOA seed laboratories in Yangon mainly sourced as official seed testing and seed certification

Key performance areas and success factors	Current status
11. Well organised record keeping and financial management system	- All seed producers maintained figures on seed production, seed sales and fertiliser use - Only seed producers in Hinthada and Danuphyu maintained the records of agro-chemical use - None of the seed growers has a book keeping system to record income and expenditures - None of the seed growers has a separate bank account for seed business management - None of the seed growers organises (internal and external) audits
12. Access to credit	- All seed producers from Bogale and Labutta township accessed credit from MADB - All seed producers only got credit for working capital - 70% seed producers from Hinthada township accessed credit from MADB - 80% seed producers from Danuphyu accessed credit from Gold Delta - None of the seed producers has a separate bank account for seed business
13. Self-finance investment	- 60% seed producers re-invested on average 55% profit to expand their seed business
14. Skilled human resources	- All seed producers were involved themselves and hired seasonal labourers to manage seed production
C. Seed producers are market oriented	
15. Seed producers customers	- In Bogale and Labutta townships 90% of sales to farmers linked with DOA and 10% of sales to farmers supported by development organisations - In Hinthada township 50% of sales directly to the farmers linked with DOA, 40% to independent farmers and 10% to rice millers - In Danuphyu township 50% of sales directly to the farmers linked with DOA, depending upon the variety 40-95% direct sales to Gold Delta contract farmers
16. Seed packaging and own brand	- None of the seed producers has their own seed package and brand name - All seed producers used seed bags purchased from the local market and other sources - None of the seed producers is planning to develop own seed packages and branding in the near future
17. Seed promotion	- None of the seed producers organises seed promotion activities
D. Seed producers are strategically linked with key seed value chain actors	
18. Collaboration and linkages	- All seed producers reported collaboration with DOA, support from development organisations (in Bogale and Labutta townships) and link strongly with individual farmers - In Danuphyu township, Gold Delta and rice millers are mentioned as for strong collaboration - EGS and external seed quality assurance was done through the support from the DOA extension office, development organisations and RSC Gold Delta

In the current study we found that seed producers in the Ayeyarwady region are performing at a satisfactory level in relation to some of the critical success factors such as technical skills on seed production, record keeping system for inputs, self-financing to expand their seed business, and seed sales to farmers. Seed producers in Danuphyu Township also performed well in regards to machinery access for seed production management.

However, seed producers were found to be performing poorly in several other areas. These include the use of old seed crop varieties (even though there are newly released varieties available), small seed production area, inadequate internal seed quality control capacity, lack of a seed business plan, inadequate seed production machinery, packaging, branding and seed

promotion activities. The producers depend on DOA and development organisations for sourcing of EGS and external quality assurance.

We suggest that targeted interventions are provided to seed producers to strengthen them in the areas in which they are currently performing poorly. This will support the transformation of these producers into more professional, market oriented and sustainable, local seed businesses.

4.4.2 Different organisational models for local seed business

Based on the key performance area analysis for the interviewed seed producers; the developmental stage of the seed sector in the Ayeyardwaddy region; and considering the existing seed policy and seed regulatory framework, we propose four different organisational models for strengthening/developing market oriented and sustainable, local rice seed businesses.

Private seed entrepreneurs

Private seed entrepreneurs are seed producers currently working as contact farmers, contract farmers or independent seed growers. Many of these seed producers are small-scale, but there are large-scale seed growers as well. To allow rice seed businesses to reach a commercial scale, the existing larger seed producers can be selected to develop rice seed as professional, private seed entrepreneurs. One example from our study is U Aye Than from Nay Pyi Taw, a professional seed producer with excellent EGS linkages with the DOA/DAR, who is producing his own registered seed to an excellent quality. Because of the high quality, he is able to sell 100 per cent of the certified seed to various customers in the different regions of Myanmar. This shows that with further capacity building, private seed entrepreneurs can play a role in registered seed production and supply in the Ayeyarwady region.

Seed producer cooperatives

The *Rules on Formation of Agriculture and General Cooperatives of Myanmar* allow the formation of agricultural cooperatives. Under these rules, the formation of seed producer cooperatives (SPCs) is a feasible option. This has to be done under the cooperative department of MOALI. Existing seed producers (contact farmers or independent seed growers), new seed producers at the cluster of village tracts, or villages within a township, can form an SPC. An SPC is a successful model when individual seed producers with limited land available for seed production, and limited access to credit and seed services (public seed extension, public seed certification, and seed processing) pull their resources together.

The Kyun Ayeyar cooperative of AVSI in Labutta Township which works with smallholder farmers may serve as an SPC model (LIFT, 2016). Seed growers groups mobilised by GRET under the PGS may be transferred into SPCs. A situation comparable to the Ayeyarwady region was found in Ethiopia, where SPCs are formed as specialised cooperatives under the existing general agriculture cooperative. In Ethiopia, over 258 specialised SPCs involving 20,555 farmers as seed producers supplied 13,217 t quality seed for 24 crops and 132 varieties in the 2012/13 season (ISSD Ethiopia, 2014b). This example shows that SPCs can be a successful organisational model for commercial local seed businesses. However, support in capacity building for organisational management, in addition to technical, financial and marketing management for seed businesses is required.

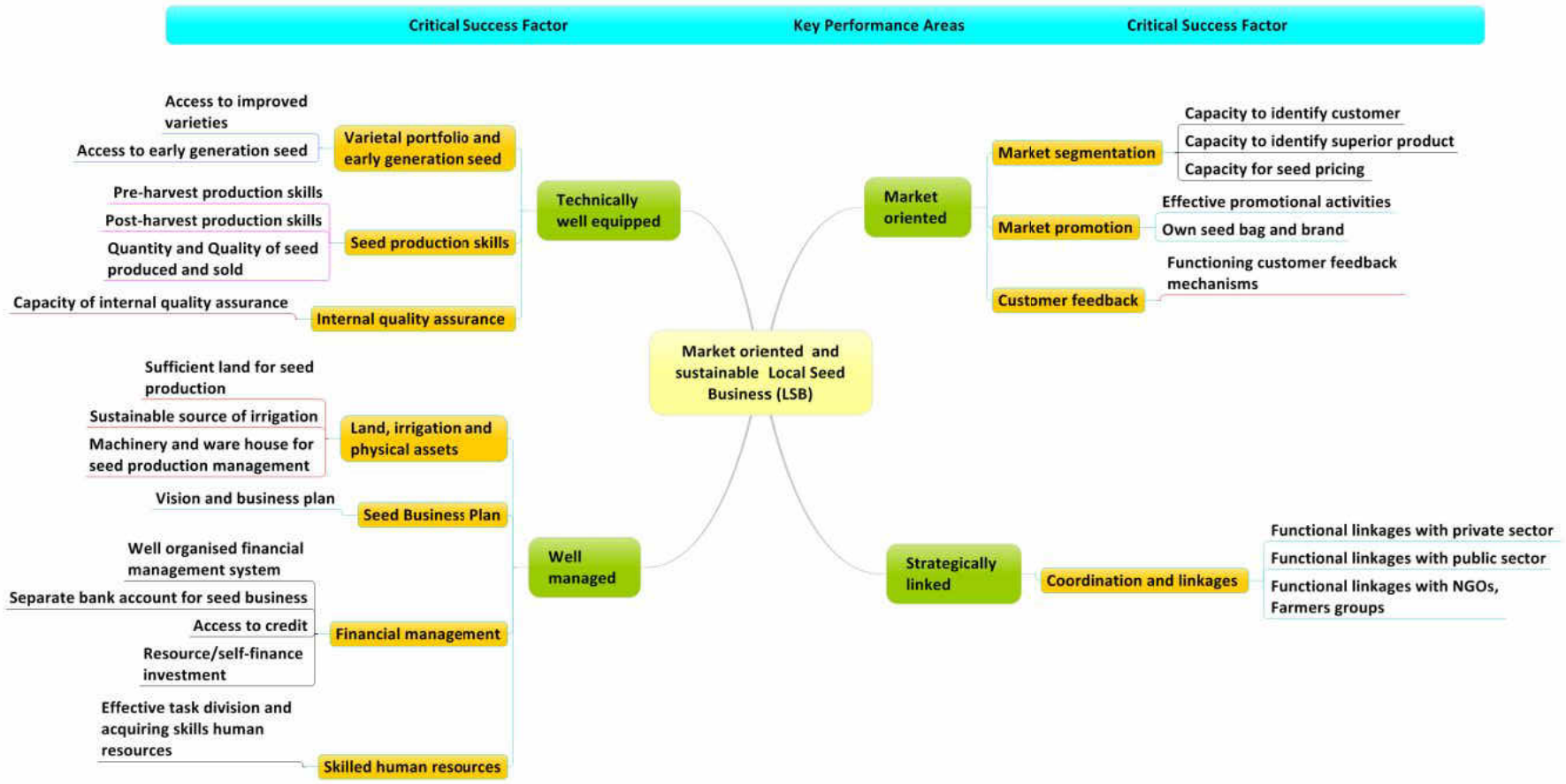


Figure 19 Proposed model to develop market oriented and sustainable local seed business in Ayeyarwady region.

In Myanmar, the cooperative rules state that a person who has less than 10 acres of farm land can become a cooperative member. This may be a limiting factor to achieve economy of scale for seed businesses; or has to be solved by increasing member numbers of an SPC. Further, policy incentives should be provided to SPCs to develop their business, such as the legal recognition of 'PGS seed' and QDS as an additional class under seed certification, and allowing SPCs to produce and market quality seed of local varieties.

Farmer producer enterprises

This model of farmer producer enterprises entails seed production and marketing as one of the activities integrated within the larger rice value chain for high value markets. Large-scale rice millers play a central role in this model to provide access to quality seed from the DOA, private seed producers and private seed companies. Millers provide quality seed as credit to the farmers assuring a buy-back guarantee of grain. This model is being promoted by Mercy Corps in their project in the lower Delta (Mercy Corps, 2016). The strength of this model is that the rice seed demand is created by marketing through the rice millers, and that seed the business will be more sustainable. The limitation of this model is that only a limited number of rice varieties targeting high value markets will be promoted for seed production and marketing.

Seed producers association (SPA)

The SPA model was implemented in Ghana in 2002. In SPAs, individual seed producers do their own seed business with registration at the Ministry of Agriculture as formal seed producers. More than 800 seed producers are currently scattered throughout different parts of Ghana producing mainly OPVs of cereals, food legumes and vegetatively propagated crops. The seed producers are mainly small-scale managing from four to 10 acres of land for seed production; however, some have over 100 acres of land for seed production. Those individual seed producers are federated at regional level to form a regional SPA and elect executive members. A number of regional SPAs are federated into a national SPA. The main role of the regional and national SPAs is policy advocacy with the government and other seed value chain actors on issues such as seed price setting, seed subsidies and seed sector development efforts. A representative from the national SPA is represented in the national seed council and the national variety release committee. In this way, seed producers have policy influence and a decision making role at the national level. A key benefit of being a member of the SPA is that any seed subsidy promoted by government goes only to registered seed producers. Key constraints observed in this model is that the association has more of a representative and policy function, so is not necessarily responsible for building the business management capacity of its members. Further, too many scattered seed producers of various size/scale create constraints to the public sector seed service provision which is already stretched.

In Myanmar, the DOA seed division is currently planning to form seed growers associations at the township level, facilitating a concentrated effort on certified seed production. A clear vision and strategy for this approach has yet to be developed.

5. RECOMMENDATIONS

Seed museum at Thayaung Chaung Seed Farm in Pathein (Subedi, Wageningen Centre for Development Innovation, 2016)

5.1 Sector transformation

Simply focussing on the development and release of new improved varieties and the increase in production of quality seed, will not improve the performance of the rice seed sector. The entry point for developing the seed value chain is a strong demand for quality seed of well-performing varieties. Beginning with the seed buyer (demand-pull) avoids the problem of trying to sell a product the market does not want. To fulfil a seed demand, a well performing seed sector needs a strong base of professional, well-organised and market-oriented seed producers. These producers need demand-driven services along the seed value chain including a well-functioning seed quality assurance system and seed extension service. In addition, the seed sector requires a clear governance role of the public sector, especially in areas where the market fails to regulate. Moreover, it needs well established mechanisms of sector coordination involving the key seed sector stakeholders, who share a joint vision and work on a common strategy for improving the performance of the sector. In their model on sustainable sector development, Molenaar and co-workers (2015) call these issues the five building blocks of sector transformation: (i) strengthening the demand; (ii) organisation of the production base; (iii) organisation of the service sector; (iv) public sector governance; and (v) sector alignment and accountability (see Figure 20).

Figure 20 Five building blocks for sustainable sector transformation

Reproduced from Molenaar *et al.*, 2015

Based on our study we have formulated recommendations to support rice seed sector transformation with specific focus on the Ayeyarwady region. We relate the recommendations to the five afore mentioned building blocks of seed sector transformation. Based on the results of the seed use survey and the seed demand estimations we have formulated recommendations for strengthening seed demand (block 1). The seed supply survey and analysis of seed business models guided us in the formulation of recommendations for strengthening the organisation of the seed production base (block 2). The analysis of seed systems and seed value chains helped us in the formulation of recommendations for improving the organisation of the service sector (block 3). The analysis of the seed enabling environment guideded a recommendation for strengthening public sector governance (block 4). And finally, the seed interventional landscape analysis supported the formulation of a recommendation on improving sector alignment and accountability (block 5).

For each strategy we describe the current situation and the change envisaged. We shortly describe actions contributing to the strategy, who should be involved in its implementation, and how LIFT may potentially contribute. In specific cases, we also give examples related to the strategy, either encountered in Myanmar or in other countries.

5.2 Strengthening of demand

1. Promote the uptake of new varieties through providing farmers with adequate information on these varieties

Situation: When selecting new varieties, farmers mainly depend on their own observations and information from informal networks, as is shown by our study. This means that farmers lack access to information on new varieties. It is important to educate and inform farmers on the benefit of new varieties, and thereby create a demand for these varieties. Specific effort has to be put on variety promotion

Vision: Farmers do have information on new, recently released improved varieties in the Ayeyarwady region which leads to the broader use of these varieties

Actions contributing to strategy:

- Implement PVS trials, involving farmers and other stakeholders to select well performing varieties which fulfil their demands
- Institutionalise the PVS approach within DAR, making it part of the crop improvement process
- Organise large-scale demonstrations of new varieties within the community
- Organise farmers' field days for farmers within the community and beyond. Farmers' field days have proven to be an excellent tool to show the value of new technologies in practice and to promote technology adoption
- Implement seed kit activities distributing certified seed of new varieties to farmers. This seed kit could consist of a 1 kg package just for creating variety awareness among farmers
- Explore and use new communication tools which are popular with farmers for creating awareness on new varieties
- Ensure that quality seed of appreciated varieties is available, keeping in mind that farmers generally refresh their seed stock once every three cropping seasons

Who to involve: Farmers, rice millers, DOA extension, DAR, IRRI, LIFT implementing partners, organisations strong in community communication

Potential contribution of LIFT: LIFT may support DAR and possibly IRRI to continue PVS experiments and implement large-scale demonstrations of farmer-preferred varieties in collaboration with LIFT implementing partners, with added activities to communicate the results through tools appreciated by farmers, for example, community radio programmes, short movies, leaflets in local language, etc.

Examples:

- IRRI has supported LIFT implementing partners like Radanar Ayar in PVS (best-bet approach) as well as capacity building on improved crop and seed management practices (LIFT, 2015). However, to promote the uptake of new selected varieties and reach larger numbers of farmers, PVS experiments need to be accompanied by a number of other activities like large scale variety demonstrations, farmer field days, community radio programmes, etc.
- In Nepal the seed kit has been regularly used to disseminate newly released rice varieties resulting from participatory plant breeding. This has created variety awareness, and resulted in a high seed demand for these varieties and a rapid spread in the Terai region

2. Promote the uptake of new varieties through market creation

Situation:	Farmers grow many varieties that were released a long time ago even when newer and possibly better alternatives are available. Farmers generally appreciate their current varieties for which there is market demand. A key issue for promoting the uptake of new varieties is creating a market for them
Vision:	Increased market demand for new recently released improved varieties in the Ayeyarwady delta
Actions contributing to strategy:	- Implement market research to be able to respond to what is happening in the field - PVS trials with focus on characters important for the market, including milling properties, grain quality, price, etc. - Develop marketing strategies for promoting the use of newly released varieties - Strengthen value chain linkages by promoting arrangements between farmers and rice millers. Millers have an important voice when it comes to determining which varieties are suitable for processing and can make arrangements with rice producers for buy-back of production, diminishing the risk for farmers to grow a (new) variety. Millers can increase the quality of the rice grain they receive from farmers by providing grain producers with quality seed - Encourage RSCs like Gold Delta to take up new improved varieties in their seed contract growing and grain contract growing model - In coordination with DOA, initiate smart seed subsidies for an initial 5 years for newly released varieties until there is a clear market response and understanding of farmer preference - This strategy may also include seed kit activities contributing to farmers' awareness on new varieties
Who to involve:	Farmers, rice millers, traders, rice and seed companies, DOA extension, DAR, IRRI, organisations specialised in market analysis and development of agricultural marketing strategies
Potential contribution of LIFT:	- LIFT may initiate a dialogue with DOA on smart seed subsidies for new varieties for a specific time period - Encourage Golden Delta to scale its seed contract growing model in the lower Ayeyarwady delta - Encourage LIFT's implementing partners to learn from each other's experiences of working with rice millers (Mercy Corps)
Examples:	- The 90 Days variety is highly demanded by farmers and millers and is now purified and under release trials at DAR headquarters in Yezin; this example shows how a popular variety, even if not officially released yet, creates farmer demand - Arrangements that exist between millers and farmers in Bogale and that are supported by Mercy Corps, for example - Gold Delta works with its own rice seed growers to ensure the company's access to quality seed. The company is currently testing the variety Hmawbi-3 as an alternative for Sin Thwe Latt. Contract rice growers of Gold Delta are sure that the company buys the grain of the varieties it provides them with, so they have a guaranteed market - Since grain of new varieties often gets a reduced price at the market, the Government of India promoted smart seed subsidies for newly released

varieties, including rice varieties; this was found to be effective in creating a demand for these varieties

3. Strengthen the demand for quality seed by showing its value to farmers

Situation: Farmers in the Ayeyarwady region generally renew their seed once in every 2 to 3 seasons. This study shows that farmers are relatively satisfied with the quality of their own seed, however, the use of first generation certified/quality seed may increase crop productivity. In the lower Ayeyarwady delta, access to quality seed is more of an issue due to the geography

Vision: Farmers appreciate quality seed and are willing to invest in it; this leads to increased productivity and higher rice grain quality

Actions contributing to strategy:

- Implement a study to better understand farmers seed renewal practices
- Educate farmers on the value of quality seed; they currently have limited understanding on what constitutes quality seed, let alone the added value of certified seed
- Show farmers the value of quality seed in the field; farmers are hesitant to buy seed from an unknown source of which they do not know the performance
- Work with farmers who are recognised in the village as a source of quality seed for local interventions on strengthening the demand for quality seed
- Professionalise contact farmers and ensure they produce quality seed so as not to disappoint grain producers following investments in quality seed

Who to involve: DOA extension, development organisations, farmers

Potential contribution of LIFT: LIFT may encourage its implementing partners to establish quality seed demonstration plots in the project villages

Examples:

- By visiting farmers and discussing the advantages of quality seed, Gold Delta was able to convince farmers to use quality seed (Gold Delta interview)
- At the GRET/WHH learning centre, farmers can see the difference between farmer saved seed and quality seed in trials in the field (GRET interview)
- In Myanmar, private seed companies such as the East-West Seed Company, organise field demonstrations showing the value of quality seed of vegetable varieties

4. Strengthen the demand for quality seed by differentiating for quality in the grain market

Situation: The use of quality seed leads to increased crop performance and high quality grain. If higher prices are paid for higher quality grain, rice growers will also be more willing to invest in quality seed, and rice millers to invest in better performing rice mills. Currently, local markets do not reward better quality. Investment in improving grain quality may support the establishment of a trademark for Myanmar rice

Vision: Price differentiation for quality of rice grain pulls a market for quality seed

Actions contributing to strategy:

- Promote appropriate rice crop management practices and post-harvest technologies for producing high quality grain
- Upgrade rice mills including replacement of outdated equipment and improving power supply systems

- Organise farmer groups and link them to traders in the wholesale market in Yangon, who are willing to pay for high quality rice
- Link farmers to advanced rice millers, who are willing to invest in quality rice
- Discuss issues related to the introduction of a trademark for rice from Myanmar

Who to involve: The Myanmar Rice Federation, MOALI, DOA rice division, rice millers, traders, development organisations, IRRI

Potential contribution of LIFT: Initiate a discussion around price differentiation for rice quality. The strategy may be discussed in a seed sector platform

- Build upon lessons learned from IRRI's project 'Improving livelihoods of rice-based rural households in the lower region of Ayayarwady Delta', which invested in improving rice crop management practices, including the development and demonstration of new post-harvest technologies (IRRI, 2015)
- Build upon the experiences of Mercy Corps and WHH in the Ayayarwaddy delta in upgrading rice mills (Interview with Mercy Corps)

5.3 Organisation of the production base

5. Strengthen the informal seed system for increased access to farmer preferred varieties and quality seed

Situation: The informal seed system is very important as a source of seed for farmers. Recycling newly acquired seed for a number of seasons, all farmers consider themselves as seed producers. Farmers are not aware of practices that may improve the quality of seed they recycle from their own fields and lack information on new improved varieties. There are only a few farmers in each community who are aware of and have a higher interest and linkage to sources of new varieties. They share seed with many other farmers in the community. In Ethiopia, India and Nepal, they are called nodal farmers. These nodal seed farmers in the informal seed system are currently not formally recognised in the four study townships

Vision: Farmers will continue to recycle their own seed, and informal networks will continue to be important, but the quality of seed offered through recycling and informal networks will be improved

Actions contributing to strategy:

- Conduct a social seed network study in each township where LIFT is operating to identify the nodal seed farmers and understand their informal seed network. To reach thousands of informal seed producers (farmers) directly through project interventions is costly and unrealistic; disseminating seed-related improved management practices through nodal seed farmers is a less costly and more efficient strategy. The nodal farmers can be entry points to promote the uptake of new improved varieties in their community
- Support rice seed producers within the community in accessing quality EGS of local and improved varieties suitable for their agroecology and link this with PVS and demonstration trials
- Study the past experiences of community seed banks in Myanmar as joint storage structures of varieties and seed, with a specific focus on

sustainability. Generally, community seed banks are found to be successful when the poverty ratio is very high and the community is highly vulnerable to climate change impacts such as floods and droughts
- Organise seed fairs before the planting season in which farmers can have access to quality seed and new varieties
- Establish communal seed drying floors, especially where floods are the most limiting factor in timely seed drying

Who to involve: The DOA township extension office, local development organisations, local seed producers and grain producers, rice millers (who will buy the grain and set criteria for quality). Farmers recognised within the community for producing quality seed and community networks as entry points

Potential contribution of LIFT:
- Support the implementation of a social seed network analysis in the LIFT delta programme townships
- Through LIFT's implementing partners, coordinate with DOA's regional/ district seed staff and other development organisations, to organise seed quality management training for nodal farmers
- Support a study on the sustainability of community seed banks based on past experiences in Myanmar

Examples:
- In Nepal, social rice seed network analysis was conducted leading to the identification of the nodal seed farmers and his/her seed networks. These nodal farmers were involved in PVS, demonstration trials and trainings resulting in a rapid spread of new varieties in the community. It was also found that when having more nodal seed farmers in the community with well-connected seed networks, these communities are more climate resilient than communities with diffuse seed networks and few nodal seed farmers
- In the case of local varieties of maize in Chiapas, Mexico, a local network promotes seed selection in the field and after harvest for varieties which are very important in the diet of many indigenous producers. It also supports communities in identifying valuable local varieties and in the conservation of local varieties. In this case, it is not about making profit on seed, it is about access to quality seed in the communities where there are limited prospects for improved varieties and access to formal seed sources (Audet-Bélanger *et al.,* 2016)
- A study by Shrestha and co-workers (2013) shares valuable experiences of community seed banks and their role in biodiversity management, and strengthening community resilience in different parts of the world

6. Strengthen the business orientation of seed producers in intermediary seed systems

Situation: DOA is working with seed contact farmers to support certified seed production and supply in the townships. These farmer seed producers are in a nascent stage of commercial seed production and are highly dependent on DOA or development organisations in accessing register seed, seed production management, seed quality control, and seed marketing. Their business scale is very small producing on average a 1-2 acre seed crop per variety in Bogale, Hinthada and Labutta and up to 5 acres in Danuphyu. Also several LIFT-IPs implementing partners work with small-scale farmer seed producers

Vision: Increased amount of professional and entrepreneurial seed producers providing their communities with quality seed of farmer-preferred varieties in the Ayeyarwady region

Actions contributing to strategy:	- Train specialised seed producers not only in the pre- and post-harvest practices of seed production, but also in the basics of seed business planning such as setting up a long-term seed business vision, moving away from ad-hoc seed production planning to forward seed production planning, targeting at least three production seasons. And also, build capacity on how to establish a well-maintained account and record keeping system, and promote re-investment of profit to expand the seed businesses - Train specialised seed producers on seed promotion and marketing, with seed producers using their own labels, packaging materials and brand name. These seed producers should be linked with rice millers and rice traders for a greater certainty on the purchase of their certified seed. Gradually these seed producers should start their own field demos to popularise their product - Cluster seed production land at the village level. Contact farmers' seed production land is small and scattered, which results in difficulties for service providers such as field inspectors. In this case, the clustering of seed production land can be an important step to increase production scale as well as increase efficiency of seed services - Support the organisation of farmers in seed production and commercialisation. The organisation may take different forms, including farmer cooperatives or farmer seed enterprises - Promote and scale internal seed quality control systems of seed producers, like PGS; production of quality seed starts with adequate internal systems of seed quality control. Seed producers need to be able to ensure their own seed quality in addition to external public seed quality assurance
Who to involve:	The Myanmar Rice Federation (rice millers, rice traders), DOA extension, development organisations, seed business specialists, financial institutions, seed producers
Potential contribution of LIFT:	Encourage LIFT implementing partners to focus on the technical aspects of seed production, seed quality assurance, and marketing and business aspects when working with seed producing farmers
Examples:	- In Ghana, staff of the USAID Feed the Future Agriculture Technology Transfer project first assessed the key performance areas of seed producers, analysing their technical, financial and marketing management skills. Based on this analysis, the project designed tailored intervention strategies for different seed producers to support them in their development towards commercial seed businesses - The ISSD project in Ethiopia successfully supported farmer seed producer cooperatives in becoming more market and business oriented in their operations, and to run the cooperative as a sustainable local seed business (ISSD Ethiopia, 2014) - The ISSD project in Uganda took a similar approach and successfully supported farmer groups to produce seed as a business for a local market (Adong, 2015; see also local seed business training manual: ISSD Uganda, 2015)

7. Upgrade the seed production infrastructure of the public seed farms

Situation:	The DAR and DOA seed farms are providing a key public function in supplying EGS to certified seed producers in the Ayeyarwady region. Our studies show that while doing their best to fully utilise the available seed farm equipment, seed farms face challenges in efficiency due to broken or only partly functioning equipment. The trends of increasing labour shortages and climate change (such as flooding and droughts) are putting seed farms under pressure to meet the growing demand for EGS seed
Vision:	Increased production and supply of high quality EGS to certified seed producers through upgraded public seed farm infrastructure
Actions contributing to strategy:	- A detailed study reviewing the current status of equipment at seed farms, and identifying gaps. This study should also review the labour skills needed to operate seed farm equipment. The current study resulted in a provisional list of required equipment, including: mini combine harvester, mobile seed dryer, seed packaging machines, deep tubels for supplementary irrigation, drying floor, a modern seed lab, cold storage facilities for foundation seed storage, a well ventilated ware house, small embankment to control floods, and a cemented drainage system - Based on the findings of the study, a business model can be developed to support and upgrade the seed farms' infrastructure, and with a mix of public and private funding, ensure the production of sufficient volumes of EGS while making the seed farms less dependent on government funding. This means that farms should become more autonomous with the introduction of a form of cost recovery or contracting - Reviewing the division of responsibilities of DOA and DAR seed farms, to most efficiently ensure the provision of quality registered seed to private seed producers in the Ayeyarwady delta - Build capacity of seed farm staff to use new equipment effectively
Who to involve:	DOA, DAR, the Agriculture Machinery Department, LIFT, JICA, FAO, the private sector and other development partners active in the region's seed sector development
Potential contribution of LIFT:	Support the implementation of a study on equipment and share investment of upgrading seed production infrastructure at public seed farms, and support capacity building on the operation of new equipment
Examples:	- The Agriculture Development Support Project (ADSP) of the World Bank. ADSP together with WUR, developed guidelines to review the seed farms' infrastructure in Dry zone of Myanmar in 2016. Based on the study recommendations, ADSP resources will be strategically allocated to upgrade the infrastructure of selected seed farms in Dry zone - In Ghana, the USAID Feed the Future Agriculture Technology Transfer project established a competitive grant facility. Through this grant facility, public seed laboratories in Norther Ghana were upgraded to meet the standards for quality testing in a fast growing market

5.4 Organisation of the service sector

8. Upgrade capacity and infrastructure of the Yangon seed quality control laboratory

Situation:	The Yangon seed quality control laboratory checks the quality of rice breeder seed, foundation seed, registered seed and certified seed. Ninety eight per cent of the seed tested concerns rice. With experienced staff temporary away and new staff joining, the laboratory faces limited trained manpower on seed testing. The laboratory is not International Seed Testing Association (ISTA) accredited yet
Vision:	Well-equipped, ISTA accredited and professional seed laboratory recognised for high quality seed testing services for seed producers
Actions contributing to strategy:	- Short staff training on different aspects of seed testing, allowing for staff members to become specialised in different areas - Support to the process of ISTA accreditation; the laboratory follows the ISTA guidelines but is not accredited yet - Asses problems with current seed laboratory equipment and upgrade where necessary
Who to involve:	The Yangon seed laboratory, DOA seed division, World Bank, ISTA, development partners from Japan and Korea. The latter two development partners are already involved in seed sector development in Myanmar
Potential contribution of LIFT:	Coordinate with development partners and the DOA seed division
Examples:	JICA has recently provided the laboratory with a new moisture meter and balance; however, renewal of additional equipment is needed

9. Develop a township level seed quality assurance unit

Situation:	Seed producers are scattered over large areas in various district and townships, and the existing seed staff at the regional level (five staff) and at district level (two to three staff), are constrained in seed inspection capacity. Also, at the township level there is lack of seed staff, and township extension staff need to provide extension support to farmers as well as seed producers. Further, township extension staff are not permitted to approve or reject seed production fields. The result is that a number of seed production fields are never inspected or are not inspected sufficiently, therefore substandard seed is not rejected resulting in the provision of low quality seed to farmers
Vision:	Strengthen the decentralised seed quality assurance system at township level for effective and efficient seed quality assurance service provision to seed producers
Actions contributing to strategy:	- Work with the DOA seed division to develop a township level seed quality assurance unit with dedicated seed staff. The DOA seed division has been providing regular training to township extension staff on quality seed production. These selected staff could serve as dedicated seed staff minimising the conflict of interest with general agriculture extension work - Establish tailored seed laboratories for regular seed testing (seed purity, germination, moisture) at the township level - Upgrade the required capacity of proposed seed staff to provide high quality services to seed producers

Who to involve:	DOA seed division, regional/district/township agriculture offices, development partners (JICA, IRRI, Korea Seed and Variety Service, and others), seed producers
Potential contribution of LIFT:	Facilitate the dialogue with DOA and other development partners on the establishment of seed quality assurance units with dedicated staff at the ownship extension office level
Examples:	- During the project period of the World Bank Seed Development Project (1984-1986) there were dedicated seed staff at the township level, which functioned quite well - The ISSD Uganda project introduced a system of Quality Declared Seed (QDS) for seed produced and sold by farmer groups, and trained extensionists at district level to provide field inspection services to these seed producers (Otim, 2015)

10. Strengthening seed processing and storage facilities

Situation:	One of the major bottlenecks affecting seed quality in study townships is the lack of seed processing equipment for threshing, cleaning and bagging. Most seed producers thresh and clean their seed manually
Vision:	Ensured local production of high quality seed through improved seed processing and storage facilities at township level
Actions contributing to strategy:	In this case, two different strategies are suggested: - Groups of seed producers within a cluster of villages purchase mobile seed processing equipment through bank credit, inventory credit or co-funding support from the government and development partners - An inventorisation with rice millers, rice traders or other private sector actors for interest to establish such facilities at township level, with seed producers paying for the service The same two strategies should be explored for the establishment of seed warehouses for effective seed storage
Who to involve:	Seed producers, LIFT, LIFT implementing partners, the Myanmar Rice Federation (millers and traders), DOA
Potential contribution of LIFT:	- Provide co-funding investment to entrepreneurs interested in establishing a service unit for seed processing - Provide co-funding investment to a private sector player interested in building and managing a seed storage facility
Examples:	- Gold Delta manages an agri-machinery service park, which provides farmers – either Gold Delta contract growers or independent farmers – with services of land preparation, harvesting, etc. on demand - In Ghana, the USAID Feed the Future Agriculture Technology Transfer project established a competitive grant facility with a co-funding arrangement. Through this grant facility, three private domestic seed companies in Northern Ghana were able to access the matching grant to establish seed processing equipment for their companies. In addition to the co-funding requirement of seed companies, the other condition was that private seed companies shall provide seed processing services to other seed producers in the region on a cost-payment basis.

5.5 Public sector governance

11. Support an enabling seed regulatory framework for emerging private seed producers

Situation:	Within a short period of time, Myanmar has recently enacted the national seed policy, amended the seed law, and developed new seed regulations. Within the rapidly evolving policy space, a careful strategy needs to be developed in order for the new seed law and regulations to be supportive to the development of emerging private seed producers. Targeted policy incentives, stimulus and flexibility to these seed producers should be provided
Vision:	The seed policy and regulatory framework are supportive to the businesses of emerging private seed producers
Actions contributing to strategy:	- For seed trade, the new seed regulations prescribe mandatory seed certification through a government approved authority. As the public seed quality assurance system is constrained by human resources to provide an efficient service, alternative and decentralised seed quality assurance systems such as the PGS, should be supported through policy provision - The national seed policy mentions that local landraces with a substantial and steady seed demand may be released as official varieties. However, both the seed law and seed regulations mention that VCU and testing for DUS are required for the release of new varieties. In order to promote commercialisation of local varieties, it is suggested that for the registration of landraces, some flexibility on DUS testing is provided
Who to involve:	The DOA seed division, DAR, development organisations/partners, private seed sector
Potential contribution of LIFT:	Support policy dialogue with DOA and seed sector stakeholders on the above indicated issues
Examples:	- In Bangladesh, India and Nepal, seed regulations allow truthfully labelled seed to be marketed by private seed producers or community based seed production groups. In Tanzania and Uganda, QDS has been legally promoted for seed producers (Otim, 2015; Association for Strengthening Agricultural Research in Eastern and Central Africa/KIT, 2014) - The PVP and Farmers Right Act, 2001 of India provides flexibility in the criteria of uniformity for the registration of local landraces. This means that the Indian law allows a higher percentage of 'off-types', which occur more frequently with landraces as compared to varieties developed by professional breeders. Further, the fee for the registration of local landraces in India, when submitted by farmer groups is free, while in Myanmar the estimated cost for the registration of just one variety is around MMK 300,000-500,000 (USD 236-394 depending on crop type)

5.6 Sector alignment and accountability

12. Establish a seed sector platform for dialogue, alignment and coordination for the Ayeyarwady region

Situation:	In our current study, we observed a lack of coordination between rice seed sector stakeholders in the Ayeyarwady region. Several key informants

	interviewed indicated the need for improving collaboration to increase efficiency, and to avoid overlap of interventions
Vision:	Improved coordination and collaboration in the seed sector in the Ayeyarwady region
Actions contributing to strategy:	- Based on the current platform for LIFT's implementing partners, establish an Ayeyarwady delta seed sector platform, bringing together not only LIFT's implementing partners but other key public, private and civil society organisations with a stake in the seed sector - Develop a joint vision and strategy for strengthening the Ayeyarwady region rice seed sector - Discuss the division of roles and responsibilities between different stakeholders - Discuss alignment of investments and activities, avoiding overlap and aiming for complementarity - Ensure alignment of the new government supported seed grower association set-up with development organisation initiatives supporting farmer-based seed production and supply - Use the platform for sharing successful innovations and exploring opportunities for scaling - Use the platform for making seed data available to seed stakeholders, and linking seed demand and supply
Who to involve:	Representatives of key seed sector stakeholders in the Ayeyarwady region, including the Ayeyarwady regional and district agriculture offices and the township agriculture extension offices; DOA seed farms; DAR research farms; LIFT implementing partners supporting interventions in the rice seed sector; rice millers; rice traders; RSCs and seed companies; Myanmar Rice Federation; farmer organisations; LIFT and other development partners such as JICA and IRRI
Potential contribution of LIFT:	LIFT may provide support for establishing a functional platform for at least the first 2 years. The Ayeyarwady regional agriculture office is suggested as the organisation for taking ownership and playing the coordination role. In consideration of long-term sustainability right from the start, the DOA regional agriculture office has to engage in this strategy in order to develop the seed platform as part of their regular activities
Examples:	- The recently established taskforce for accelerating the Myanmar horticulture sector development, which brings together key public and private sector players is a good example of such a platform (Joosten and Van Koesveld, 2015). It aims to steer the development of the horticultural sector and support improved cooperation between value chain partners and the realisation of end-market opportunities; the development of support markets; and the upgrading of horticultural farming practices - The Integrated Seed Sector Development Project in Ethiopia (ISSD Ethiopia) supported the establishment of four regional seed sector stakeholder platforms to discuss and solve key institutional bottlenecks that hamper the development of the seed sector. The regional bureau of agriculture, which is the leading public organisation in agriculture, coordinates and facilitates the seed sector platform meetings; the project provides secretarial and management support. The platforms were able to create major breakthroughs in a number of institutional seed sector bottlenecks, related to seed marketing, EGS production and seed quality assurance (ISSD Ethiopia, 2014)

- Upon demand from seed sector stakeholders in Northern Ghana, a seed sector platform was established to increase sector coordination and improve certified seed uptake rates of improved varieties of maize, rice and soy by smallholder farmers from 10 per cent in 2015 to 40 per cent in 2019. The platform was established and facilitated by the International Fertilizer Development Center/WUR within the USAID Feed the Future Agriculture Technology Transfer Ghana project. The project covered the cost for biannual platform meetings and funded the regional annual seed demand and supply study. From 2017 onwards, the National Seed Trade Association of Ghana will coordinate the platform and develop a funding strategy to guarantee its sustainability (Duodo, 2017)

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ANNEX 1: Field study programme from day to day

<table>
<tr><th>Date</th><th colspan="3">Programme activities</th></tr>
<tr><td>22 October</td><td colspan="3">- Travel – AS, MT & GA</td></tr>
<tr><td>23 October</td><td colspan="3">- Arrival in Yangon</td></tr>
<tr><td rowspan="3">24 October</td><td colspan="3">- Meeting of study team with LIFT team in the morning (AS, MT, GA, TM & NL)</td></tr>
<tr><td colspan="2">Group A</td><td>Group B</td></tr>
<tr><td colspan="2">- Orientation and training of enumerators and supervisors by GA & NL
- Overnight stay in Yangon</td><td>- Meeting with Myanmar Rice Federation
- Overnight stay in Yangon</td></tr>
<tr><td rowspan="2">25 October</td><td colspan="2">- Travel to Pantanaw township, Delta region, in the morning (all)
- Pre-testing of survey questionnaire (all)
- Adaptation and finalisation of survey tools (GA & NL)
- Follow up orientation/training of enumerators and supervisor
- Overnight stay in Yangon (all)</td><td rowspan="2">- Travel to Bogale township in the morning
- Meeting with GRET in Bogale township
- Meeting with Radanar in Bogale township
- Return to Yangon and overnight stay</td></tr>
<tr><td>Team 1
- 5 enumerators and one supervisor
- GA & NL travel across the survey townships to conduct FGD</td><td>Team 2
- 5 enumerators and one supervisor
- GA & NL travel across the survey townships to conduct FGD</td></tr>
<tr><td>26 October</td><td>- Travel to Bogale in the morning and survey in Bogale township with seed users
- Interview with seed producers and agro-dealers shop
- FGDs with agriculture extension township office and seed users (GA & NL)
- Overnight stay in Bogale</td><td>- Travel to Labutta township (E & S)
- Overnight stay in Labutta</td><td>- Travel to Nay Pyi Taw in the morning
- Meeting with DOA – Seed Division, Rice Division, Agriculture Extension Division
- Meeting with DAR – Rice Breeding Division, Yezin
- Meeting with Yezin Agricultural University
- Visit to Seed grower Aye Tan, Nay Pyi Taw
- Overnight stay in Nay Pyi Taw</td></tr>
<tr><td>27 October</td><td>- Survey in Bogale township with seed users and seed producers
- Survey with agro-dealers shops
- Overnight stay in Bogale (E & S)
- GA & NL travel for Labutta township</td><td>- Survey in Labutta township with seed users
- Survey in Labutta township with seed producers
- Overnight stay in Labutta (E & S, GA & NL)</td><td>- Travel to Yangon
- Meeting Mercy Corps
- Meeting with FAO
- Overnight stay in Yangon</td></tr>
<tr><td>28 October</td><td>- Survey in Bogale township with seed users
- Interview with Ko Aye Than, Kyeik Latt township (S)
- Travel to Yangon and overnight stay (E & S)</td><td>- Survey in Labutta township with seed users and seed producers
- Survey with agro-dealers shop
- GA & NL join the survey-FGDs with</td><td>- Travel to Hinthada township
- Visit to DOA Tagontaing Seed Farm, Hinthada
- Visit to seed processing and distribution site of Rice company Gold Delta, Danuphyu
- Return to Yangon and overnight stay</td></tr>
</table>

Date	Programme activities		
		agriculture extension township office, seed users and seed producers - Overnight stay in Labutta	
29 October	- Travel to Danuphyu township via Yangon (E & S) - Survey in Danuphyu township with seed users - Overnight stay in Yangon (E & S)	- Survey with seed users in Labutta - Travel to Yangon and overnight stay (E & S, GA & NL)	- Rice company Gold Delta
30 October	- Survey team 1 and 2 sharing meeting (E & S, GA & NL) - Overnight stay in Yangon (all)		- Visit to DOA Thayaung Chaung Seed Farm in Pathein - Travel to Myaungmya township and overnight stay
31 October	- Travel to Danuphyu township in the morning - Survey continue in Danuphyu township with seed users and seed producers - Survey with agro-dealers shop - FGDs with agri-extension township office and seed producers (GA & NL) - Overnight stay in Yangon	- Travel to Hinthada township in the morning - Survey in Hinthada township with seed users and seed producers - Overnight stay in Hinthada	- Visit to DAR Myaungmya seed farm, Myaungmya - Visit to Metta seed farm, Pathein - Return to Yangon and overnight stay
1 November	- Survey in Danuphyu township with seed users and producers (E & S) - Travel to Hinthada township and joining the survey team 2 in afternoon (E & S) - GA & NL join the debrief meeting with LIFT	- Survey with seed users and seed producers in Hinthada township - Survey with agro-dealers shop - Overnight stay in Hinthada township	- Visit to WHH, Yangon - Visit to seed testing laboratory - Visit to IRRI - Debrief meeting with LIFT team in the afternoon (AS, MT, TM, GA & NL)
2 November	- Survey with seed users in Hinthada township in the morning (Team 1 & Team 2 enumerators and one supervisor) - FGDs with agriculture extension township office and seed users (NL & S) - Wrap-up meeting and conclusion of survey (NL, E & S)		

GA – Genevieve Audet-Bélanger**, NL** – U Naing Lin Oo, **E** – Enumerators, **S** – Supervisor of enumerators
AS – Abishkar Subedi, **MT** – Marja Thijssen, **TM** – U Tin Mang Shwe

ANNEX 2: Consent text

INFORMED CONSENT AND INTRODUCTION

Informed consent: it is necessary to introduce the household to the survey and obtain the consent of the household head or decision maker. Ask to speak with a responsible adult in the household who knows about the rice production of the household.

Hello. My name is _____. I am working with Centre for Development Innovation – Wageningen University in the Netherlands. We are conducting a survey to determine a prospective survey on the rice seed sector in the Ayeyarwady Delta for the Livelihoods and Food Security Trust Fund (LIFT) managed by UNOPS and funded by various donors.

We are interviewing approximately 250 households in 20 villages across the Ayeyarwady delta in townships of Labutta, Bogale, Danubyu and Hinthada. The households in each village have been selected randomly so that we can collect information on the livelihoods and agricultural practices related to rice production in order determine where the LIFT program can be most effective. Your household is among these households selected in your village and we would like to ask you as head of the house-hold or spouse some questions about your household and its livelihoods and rice production practices. In total this should take a maximum of 40 minutes of your time.

Your information will help know how best to provide support, to the development of the rice seed sector in the Delta. We ask for your open and honest information. The results will be summarised for the 250 households interviewed. I hope you will assist us and the LIFT program so that it can work more effectively to support the poor and vulnerable people of Myanmar.

We can return later today if you don't have time to finish all the questions now. All of the answers you give will be confidential and will not be shared with anyone other than members of our survey team. By no means your personal information will be shared or associated with the data of the survey.

You don't have to be in the survey, but we hope you will agree to answer the questions since your views are important. If I ask you any question you don't want to answer, just let me know and I will go on to the next question or you can stop the interview at any time. Survey participation is not remunerated and does not guaranteed further participation in a future project on rice seed sector development.

Do you have any questions about the study or about your participation?

ANNEX 3: PPI questions

Question	Answers
1. How many members does the household have?	Eight or more
	Seven
	Six
	Five
	Four
	Three
	One or two
2. What is the highest standard/diploma/degree that the female head/spouse has passed?	No female head/spouse
	None, KG, or first standard
	Second standard
	Third to fifth standard
	Sixth standard or higher
3. How many rooms does the household occupy, including bedrooms, living rooms, and rooms used for household businesses (do not count toilets, kitchens, balconies, nor corridors)?	0
	2
	3
	4
	5+
4. What is the major construction material of the floor (observe, do not ask)?	Earth/sand, palm/bamboo, combination earth and wood/palm/bamboo, or other
	Wood planks, parquet or polished wood, tongue-and-groove wood, cement, wood with covering, cement with covering, or a combination of cement/finished wood and something else
5. What is the major construction material of the external (outer) walls (observe, do not ask)?	Thatch/large leaves/palm/dhani, or tarpaulin
	Bamboo, or rudimentary wood
	Unbaked brick and mud, finished wood, or other
	Baked brick and cement, or pucca cement
6. What type of stove is used most often for cooking food in the household?	Open fire, open stove, rice-husk stove, or traditional closed stove
	A1 improved stove, other improved stove, stove using electricity, gas, kerosene/diesel, or biofuel, or other
7. Does any member of your household own or have access to a cupboard or a food-storage cabinet (including one rented to others or pawned)?	neither
	one but not both
	both
8. Does any member of your household own or have access to a black-and-white or colour TV (including one rented to others or pawned)?	yes
	no
9. Does any household member own or have access to a bicycle or non-motorised boat, a motorcycle, power tiller, trishaw, motorboat, trawlarjee, three-wheeled motor vehicle, motorcar (4 wheels or more), or tractor (including one rented to others or pawned)?	No, none of these
	Only bicycle or non-motorised boat
	Motorcycle, power tillller, trishaw, motorboat, trawlarjee, three-wheeled motor vehicle, motorcar (4 wheels or more), or tractor (regardless of bicycle or non-motorised boat)
10. If any household member's main job is	Landless agricultural household

Question	Answers
connected with agriculture, hunting, forestry, fishery, mining, or quarrying, and if any household member owns or has the right to use land for agriculture, forestry, pasture, livestock breeding, or water surfaces, then does the household own any non-draught oxen, non-draught buffalo, cows, mythun, horses, or donkeys/mules (including ones rented to others or pawned to others)?	Non-agricultural household
	Agricultural household with land, but no non-draught large animals
	Agricultural household with land and with non-draught large animals

ANNEX 5: Participants focus group discussions seed use survey

Participants seed sector workshop in Bogale Township

Name	Organisation
U Saw Mahm Htaw	Township officer, DOA
U Win Tun	Seed grower
U San Tint Oo	Seed grower
U Naing Win	Seed grower
U Thein Hla	Seed grower
U San Thaung	Seed grower
U Phyo Thet Wai	Agri-officer, GRET
U Soe Myint	Yadanar Ayar Association
U Ohn Myit	Yadanar Ayar Association
U Thet Naung Soe	SATO
U Ye Nyi Nyi Lin	Rice miller
U Myo Min Aung	Rice miller
Daw Amy Aung	Yadanar Ayar Association

Participants of seed users FGD in Koe Eain Tan village

Name
U Hla Than
U aung Kyi
U mya Myint
U than Aung
U Zaw Lin Oo
U Tin Mu
U Than Lwin

Participants of seed sector workshop in Labutta Township

Name	Organisation
U Tin Maung Win	District officer, DOA
U Thein Zan	Township officer, DOA
Daw Zar Zar Aung	DOA
Daw Nwe Nwe Aye	DOA
U Yan Naung Zaw	DOA
Daw Myint Myint San	DOA
Daw Thida Aye	DOA
U Aye Naing	Cooperative Department
U Kyaw Min Myat	Mercy Corps
U Thet Oo Aung	Agro-dealer
U Tin Latt	Agro-dealer
U Khin Win	Farmer
U Maung Htay	Farmer
U Khin Maung Yi	Farmer
U Tin Shwe	Farmer
U Aung Naing Win	Farmer
U Kyi Hlaing	Farmer
U Htun Hlaing	Farmer

Name	Organisation
U Kan Hla	Farmer

Participants of seed users FGD in Nyaung Lein village

Name
U Hla Yee
U khin Ohn
Daw Nyunt Win (woman)
U Nyam Tin
U mya Aung

Mixed interviews in Danybyu Township, Nom Daw Gone village

Name	Organisation
U Yin Maung	DOA
U mya Thein	DOA
U aye Htun	DOA
U Soe Win	Gold Delta farmer
U Kyaw Khin	Gold Delta farmer
U min Khin	Farmer
U thien Htun	Farmer
Chiit Win Naing	Extension officer

Participants of seed sector workshop in Hinthada Township

Name	Organisation
U Myo Min Lwin Oo	Township extension officer, DOA
U Hla Myint	Rice Miller (Yone Min rice mill)
U Than Soe	Seed grower
U Kyaw Shein	Seed grower
U Thein Aung	Seed grower
Daw Myint Myint Thein	Seed grower
U Tint Aung	Seed grower
U Maung Maung Htay	Seed grower
U Khin Soe	Farmer
U Hlaing Myo Min	Farmer
U Zaw Win	Farmer
U Cha Myay Thu	Farmer
U Ye Win Htut	Farmer

Participants of seed users FGD in Inn Dawei village

Name
U Aye Naing
Daw San San Win
Daw Htay Htay

ANNEX 5: Mapping of interviews seed study

Location	Name of respondent	Organisation	Operator	Service provider	Enabler
Bogale	U Tun Kyi	Agro-dealer shop		X	
Bogale	U Yan Aung Myin	Yan Aung Myin agro-dealer shop		X	
Bogale	U Aung Soe	Farmer seed producer	X		
Bogale	U Kyaw Oo	Farmer seed producer	X		
Bogale	U Myint Mg	Farmer seed producer	X		
Bogale	U Tin Win	Farmer seed producer	X		
Bogale	U Kyaw Saing (Agri coordinator) and colleagues	GRET		X	
Bogale	U Zaw Htet Aung (Partnerships coordinator) and colleagues	Radanar Ayar Association		X	
Danuphyu	U Zarni Maung Maung	Daung Thiri agro-dealer shop		X	
Danuphyu	U Htain Lin Aung	Su Par Aung agro-dealer shop		X	
Danuphyu	U Kyaw Shin	Farmer seed producer	X		
Danuphyu	U Myint Thein	Farmer seed producer	X		
Danuphyu	U Than Sein	Farmer seed producer	X		
Danuphyu	U Thein Tun	Farmer seed producer	X		
Hinthada	U Nay Win	Aung Myay agro-dealer shop		X	
Hinthada	U Lin Lin	Pan Myintzu agro-dealer shop		X	
Hinthada	U Kyi Mya	Farmer seed producer	X		
Hinthada	U Maung Hlaing	Farmer seed producer	X		
Hinthada	U Nyunt Win Hlaing	Farmer seed producer	X		
Hinthada	U Pauk	Farmer seed producer	X		
Hinthada	Daw Ni Ni Hlaning (Farm manager) and colleagues	Tagontaing Seed Farm	X		
Labutta	U That Oo Aung	Agro-dealer shop		X	
Labutta	U Tin Latt	Agro-dealer shop		X	
Labutta	U Maung Htay	Farmer seed producer	X		
Labutta	U Myint Lwin	Farmer seed producer	X		
Labutta	U Tin Shwe	Farmer seed producer	X		
Labutta	U Win Shwe	Farmer seed producer	X		
Myaung Mya	U Htain Lin Tun (Farm manager)	Myaung Mya Research Farm	X		
Nay Pyi Taw	U Thet Zin Maung (Director Seed Division) and colleagues	Department of Agriculture	X	X	X
Nay Pyi Taw	U Aye Than	Private seed grower	X		
Pathein	U Khin mg Latt (Programme coordinator) and colleagues	Metta seed farm	X		
Pathein	Daw Khin Htay Oo (Farm manager) and colleagues	Thayaung Chaun Seed Farm	X		
Yangon	U Yo Khaung (Programme officer forestry) and colleague	FAO		X	X
Yangon	Jongsoo Shin (IRRI Myanmar	IRRI	X	X	X

Location	Name of respondent	Organisation	Operator	Service provider	Enabler
	Representative) and colleague				
Yangon	Daw San San Aye (Laboratory head)	Lower Myanmar Seed Quality Control Lab		X	
Yangon	Mark Munoz (Programme manager Delta programme) and colleagues	Mercy Corps	X	X	
Yangon	U Aung San (CEO) and colleagues	Myanmar Rice Federation			X
Yangon	U Aye Lwin (Deputy Managing Director) and colleagues	Rice Specialization Company Gold Delta	X	X	
Yangon	Peter Hinn (Country director) and colleague	WHH		X	
Yezin	U Maung Maung Tar (Director) and colleagues	Department of Agricultural Research	X		X
Yezin	U Than Myint Htun (Lecturer) and colleague	Yezin Agricultural University, Department of Plant Breeding, Physiology and Ecology		X	

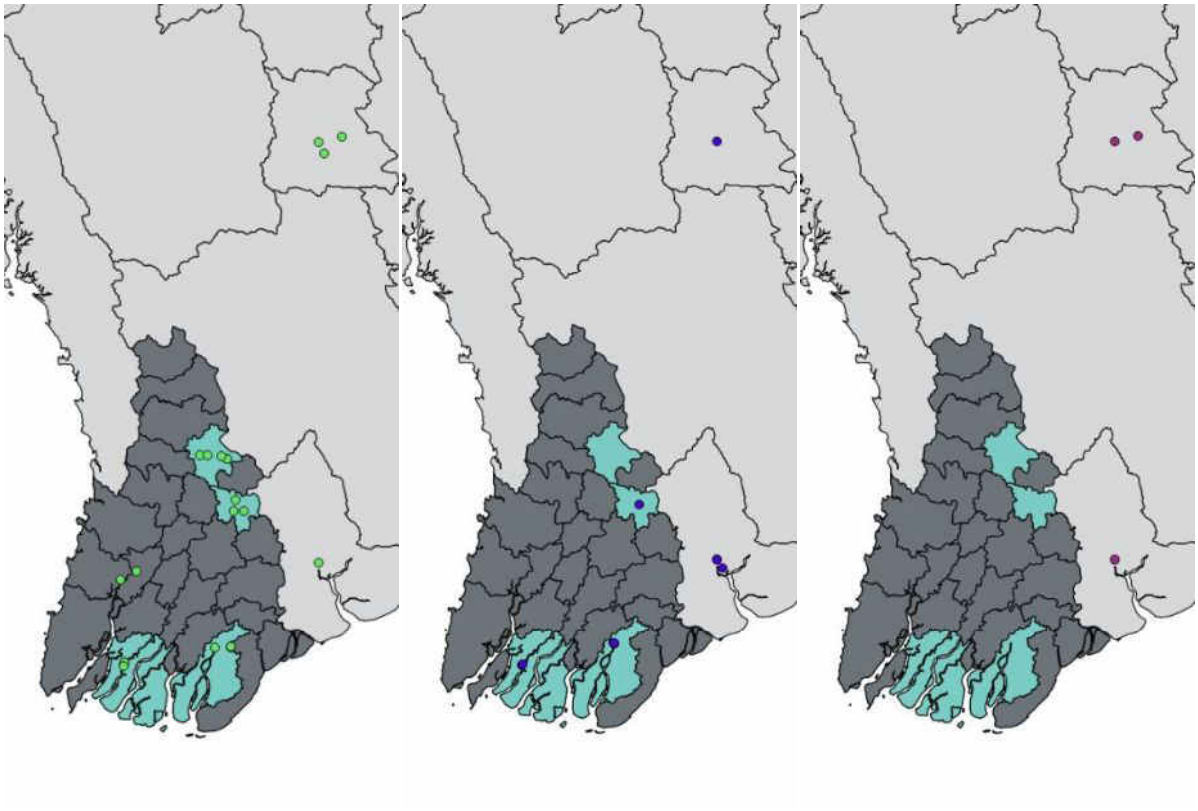

Figure 21 Maps with interview and survey data points

Note: Green is value chain operators, blue is service providers and purple is policy enablers; one organisation may take up more functions in the seed value chain.

ANNEX 6: Variety list

No	Variety name	Line number/original name	Release year
1.	Shwe Wah Htun	IR-5 Mutant	1974
2.	Shwe Ta Sote	Local	1979-80
3.	Si Lay	C4 – 63	1970
4.	Sein Ta Lay	X69-2-27	1975
5.	Shwe Wah Yin	IR-24	1973
6.	Shwe Wah Lay	IR-28	1981
7.	Sin Theingi	BR-51-91-6	1978
8.	Sin Thiri	BG-90-2	1978
9.	Ngway Toe	C 53-39	1953
10.	Shwe Thwe Lay	IR 751-592	1979
11.	Ayar Min	Machando	1977
12.	Hmawbi-1	IR 42	1984
13.	Hmawbi-2	IR 21836-90-3	1985
14.	Sin Shwe Thwe	IR-34	1981
15.	Manaw Hari	Mahsuri	1974
16.	Manaw Thukha	Mahsuri (M)	1978
17.	Shwe Thwe Htun	IR-24 m4-17	1980
18.	Kyaw Zeya	X70-18-32 (Yarkyaw-2 x Aung Zeya)	1980
19.	Pale Thwe	Pelita 1-1	1979
20.	Sin Akri-1	X72-8-22 (Shwe Wah Yin x Kauk Hmwe)	1984
21.	Lone Thwe Hmwe	KDML-105	1986
22.	Ye Baw Yin	Local	-
23.	Ye Baw Latt	Local	-
24.	Ye Baw Sein	A 52-21, Local	1952
25.	Ye Baw Yoe Sein	Local	-
26.	Inn Ma Ye Baw	Local	-
27.	Ehma Hta Amagyi	A 28-8	1928
28.	Shwe Din Gar	A 56-11	1956
29.	Hnan Wah Mee Kauk	A 36-3	1936
30.	Pin Toe Sein	A 29-20	1929
31.	Hmaw Nga Sein	A 15-10	1915
32.	Man Nga Sein	C 40-1	1940
33.	Shwe Shay Kyin	C 33-18	1933
34.	Shan Nyein	C 24-47	1924
35.	Hnan Kar	B 57-7	1957
36.	Mee Kauk	B69-1	1969
37.	Paw Sann Hmwe	D 44-8	1944
38.	Paw Sann Bay Kyar	D 60-8	1960
39.	Nga Kywe	D 25-4	1925
40.	Nga Kywe Taung Pyan	-	-
41.	Thee Htat-1	X 72-7-1	1985
42.	Thee Htat-2	X 72-7-10	1985
43.	Thee Htat-3	X 72-7-15	1985
44.	Yay Nak-1	BKN-6986-108-3 (Thailand)	1976
45.	Yay Nak-2	BKN-6986-167 (Thailand)	1976
46.	Yay Nak-3	RD-17 (Thailand)	1983
47.	Yay Nak-4	X 73-20-19 (C4-63-Nga Kywe Phyu)	1983
48.	Yay Nak-5	BH-2 (Africa, Ceyarliyun country)	1984
49.	Yay Nak-6	RD-19 (Thailand)	1985

No	Variety name	Line number/original name	Release year
50.	Yay Nak-7	B-922-CMR-118 (Indonesia)	1985
51.	Maykhalar-1	BKN-6986-51-1 (Thailand)	1980
52.	Maykhalar-2	BKN-6986-59-12 (Thailand)	1980
53.	Maykhalar-3	BKN-6986-30-1 (Thailand)	1980
54.	Maykhalar-4	BKN-6986-108-2 (Thailand)	1980
55.	Maykhalar-5	BKN-6986-66-2 (Thailand)	1980
56.	Yezin Yar-1	C-22 (Philippine)	1976
57.	Yezin Yar-2	KN-96 (Indonesia)	1977
58.	Yezin Yar-3	KN-117 (Indonesia)	1977
59.	Yezin Yar-4	LG-240 (Philippine)	1977
60.	Yezin Yar-5	IR-1529-680-3	1984
61.	Yezin Yar-6	YN-91-45 (C-22-IR-2035)	1984
62.	Yezin Yar-7	YN-92-7 (C-22-IR-2153)	1985
63.	Sar Ngan Khan-1	X73-3-9 (Shwe Wah Yin-Lone Ni)	1985
64.	Sar Ngan Khan-2	X 73-3-18 (Shwe Wah Yin-Lone Ni)	1985
65.	Sar Ngan Khan-3	X73-12-8 (C4-63-Yaythuma)	1985
66.	Sin Shwe Po-1	IR 72	-
67.	Sin Shwe Po-2	Aster Nak Gaw Yee	-
68.	Hybrid rice-6201	-	2001
69.	Hybrid rice-6207	-	2001
70.	Hmawbi-3	MR-219	2003
71.	Hmawbi-4	Q-50	2003
72.	Oakthar Hmwe	Royal Thai Rice	2003
73.	Shwe Myanmar	RP-1674-690-39-14	2001
74.	Thukha Yin	MNTK M4-10 (Manawthukha Htun)	2001
75.	Yezin Lone Thwe	LTH M4-14 (Lone Thwe Hmwe Htun)	2001
76.	Shwe Pyi Tan	PSBR C-68	2002
77.	Yar-2 Htun	H -18	1999
78.	Sin Thwe Latt	IR-53936-60-3-2-3-1	2003
79.	Hmawbi-5	6201-R	2006
80.	Hmawbi Kauk Hnyin Hmwe	CNS-1	2009
81.	Pakhan Shwe Wah	PSC RC-18 (51672-62-2-1-1-2-2-3)	2004
82.	Sin Thukha	IR Yn1068-7-1	2007
83.	Yadanar Toe	Thai-1-9-3 E	2008
84.	Sin Nwe Yin	Yn 2883-12-2-1	2008
85.	Shwe Pyi Htay	Yn 2841-B-1- UL 26	2008
86.	Shwe Manaw	Taminadu	2005
87.	Shwe Padaytha	Xiang Zao Xian 19	2007
88.	Yay Anelo-1	IR 55423-01	2008
89.	Pyi Lone Hmwe	Supharburi-1 (SPRLP85163-5-1-1-2)	2007
90.	H-6444 (Hybrid rice)	930214201	2006
91.	Dhani 07002 (Hybrid rice)	930215210	2007
92.	Pale Thwe-1 (Hybrid rice)	-	2013
93.	Hmawbi-6	IR 13240-108-2-2-3 (Mutant)	2010
94.	Hmawbi-7	IR 13240-108-2-2-3 (Mutant)	2010
95.	Myaung Mya May	PRAM BEI KOUR	2011
96.	Yay Myoke Khan-1	Swarna-sub 1	2011
97.	Sar Ngan Khan Sin Thwe Latt	Yn 3220-MAS-62-2-4	2011
98.	Yay Anelo-2	UPLRI-7	2011
99.	Thukha Hmwe	Yn 3248-BC4F2-33	2011
100.	Akari Hmwe	IR 78525-150-1-3-1	2011
101.	Pale Thwe-4 (SL-8H-ISMSA) (Hybrid rice)	-	2011

No	Variety name	Line number/original name	Release year
102.	Dagon-1 (IR-123)	PSB-RC-82	2012
103.	Dagon-2 (IR-421)	IR-75581-12-3-2-2	2012
104.	Dagon-3 (IR-150)	IR-30AA-433) A-2258	2012
105.	Thiri Thukha	RMNTK-1-UL 16	2006
106.	Yay Anelo-3	WAB-880-SG-6	2005
107.	Shwe Pyi Hmwe	IR 66233-151-1	2013
108.	Ayar Hmwe	1268	2014
109.	Shwe Toe Lay	IAC/P 001 PAC 807	2013
110.	Shwe Moe Lay	IAC/P003 PAC 835	2013
111.	Shwe Toe Gyi	IAC/P004 PAC 837	2013
112.	GW 1 (Hybrid rice)	818	2014
113.	Yezin Pale Thwe-1 (Hybrid rice)	Yn HR-1	2014
114.	Yezin Pale Thwe-2 (Hybrid rice)	Yn HR-2	2014
115.	Manaw Thukha -2	Bio-NSS-4-3a-28	2014
116.	Shwe Nan Thar Paw Sann-1	Bio-PSM-24-3-1-29-15 AM-1-4	2015
117.	Shwe Nan Thar Paw Sann-2	Bio-PSM-24-3-1-29-15 AM-7-1	2015
118.	Shwe Wut Hmone	DH 5-Bio N2	2015
119.	Yay Myoke Khan-2	BR 11-Sub 1	2014
120.	Sin Thiri May	TEPHANA-170-DB	2013
121.	Pyi Taw Yin	IR 77542-90-1-1-1-5	2013
122.	Pyi Myanmar Sein	IR 10T 107 (IR 834-B-B-3-1-1-1)	2014
123.	Yay Anelo-4	IR 87707-446-B-B-B	2014
124.	Shwe ASEAN	CSR 36	2014
125.	Sin Shwe Se	SRL-MS-300-K2	2014
126.	Theingi Pale Thwe (Hybrid rice)	-	2016
127.	Yezin Pale Thwe-3 (Hybrid rice)	-	2016
128.	Arize 6444 Gold (Hybrid rice)	Arize 6444 Gold	2016
129.	Arize Tej Gold (Hybrid rice)	Arize Tej Gold	2016
130.	S 6001 (Hybrid rice)	S 6001	2016
131.	Yay Anelo-5	IR 87705-44-4B	2016
132.	Yay Anelo-6	IR 87707-182B-B-B	2016
133.	Yay Anelo-7	IR 87705-83-12-B	2016
134.	JAPAN RICE SEEDS	HITOMEBORE	2016

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