Rice Farmers' Adoption of Good Agricultural Practices in Ayeyarwady Region, Myanmar: A Case Study of Myaungmya District

By

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DISSERTATION

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Acronyms and Abbreviations

AED	Agricultural Extension Division
ANOVA	Analysis of Variance
ARO	Ayeyarwady Regional Office
AVE	Average Variance Extracted
AW	Awareness
AWD	Alternate Wetting and Drying
BI	Balanced Inputs
CA	Cluster Analysis
CB-SEM	Covariance based Structural Equation Modeling
CF	Common Factor
CFI	Comparative Fit Index
CH	Combine Harvester
CR	Composite Reliability
DOA	Department of Agriculture
DSR	Direct-seeded Rice
FAO	Food and Agriculture Organization
FYM	Farmyard Manure
GAPs	Good Agricultural Practices
GDP	Gross Domestic Product
GFI	Goodness of Fit Index
ha	Hectare
ICM	Integrated Crop Management
IFI	Incremental Fit Index

INM	Integrated Nutrient Management
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
JICA	Japan International Cooperation Agency
KC	Knowledge Center
KMO	Kaiser-Meyer-Olkin
kyat	Currency of Myanmar
MAC	Ministry of Agriculture and Cooperative
MDO	Myaungmya District Office
MOAI	Ministry of Agriculture and Irrigation
MOALI	Ministry of Agriculture, Livestock, and Irrigation
MT	Metric Ton
NFI	Normed Fit Index
NNFI	Non-normed Fit Index
PCA	Principal Component Analysis
PD	Planting Depth
PDM	Pests and Diseases Management
PLS-SEM	Partial Least Square Structural Equation Modeling
PP	Plant Population
QS	Quality Seed
RMR	Root Mean Residual
RMSEA	Root Mean Square Error of Approximation
RMSR	Standardized Root Mean Square Residual
SCN	Systematic Care of Nursery

SEM	Structural Equation Modeling
SH	Seedlings per Hill
SRI	System of Rice Intensification
SS	Sparse Sowing
TPR	Transplanted Rice
US$	United States Dollar (Official currency of United States of America)
UT	Uprooting and Transplanting
YAU	Yezin Agricultural University

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Chapter 1: Introduction

1.1 Background of the Study

Myanmar is an agrarian country, and the agriculture sector is one of the major pillars of its economy. It accounts for more than a quarter of GDP (28.6 %) (Figure 1-1), one-fifth of export earnings, and almost two-thirds of the employment (61.2 %) (MOAI, 2016). Rice is a national crop and a priority crop for area expansion and yield increase in Myanmar. Since rice production is the most significant economic activity and source of national food security, Myanmar had exported up to 70 % of the national production from 1900 to 1940. Though Myanmar was one of the top rice-producing countries in total production terms among Southeast Asian countries before World War II, total production had gradually declined after the later 1960s, and it became a lower-scale exporter. The main reasons why rice export had declined were low production, a decline of surplus, and poor access to the international market of rice. Due to the decreasing amount of rice export, almost all of Myanmar farmers barely survive at meager income (Stiftung, 2012).

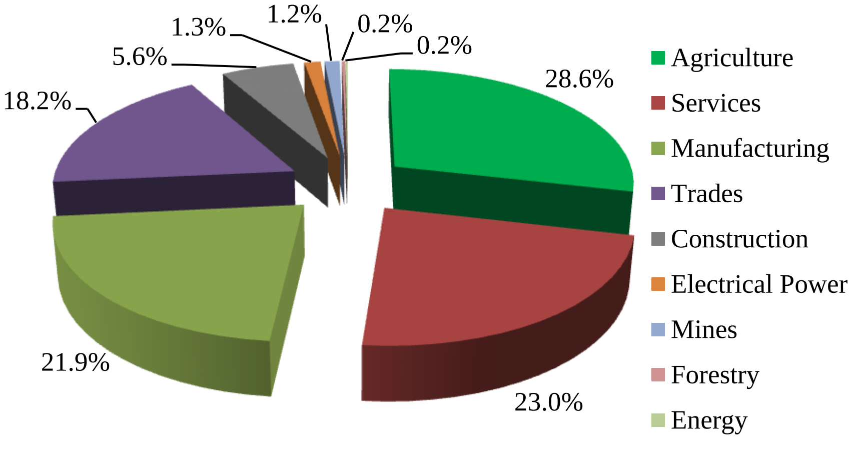

Figure 1-1 Gross Domestic Product in 2016

Source: MOAI (2016).

Myanmar now has multifaced difficulties in its agriculture, especially low production, which has lessened its overall economy. Annual rice production had decreased from 32.68 million MT in 2010 to 28.09 million MT in 2017 (Figure 1-2) because of the decrease in total cultivated area and the average yield of rice (MOALI, 2019). Rice is grown in two seasons, the dry season (14 %) and wet season[1] (86 %) in terms of total cultivated area and is mainly grown in five regions[2]. In Myanmar, irrigated lowland area for rice cultivation accounts for only 20 %, while rain-fed area for rice cultivation represents 80 % (Favorable lowland[3] 48 % + Unfavorable land[4] 32 %) (Department of Agriculture [DOA], 2013).

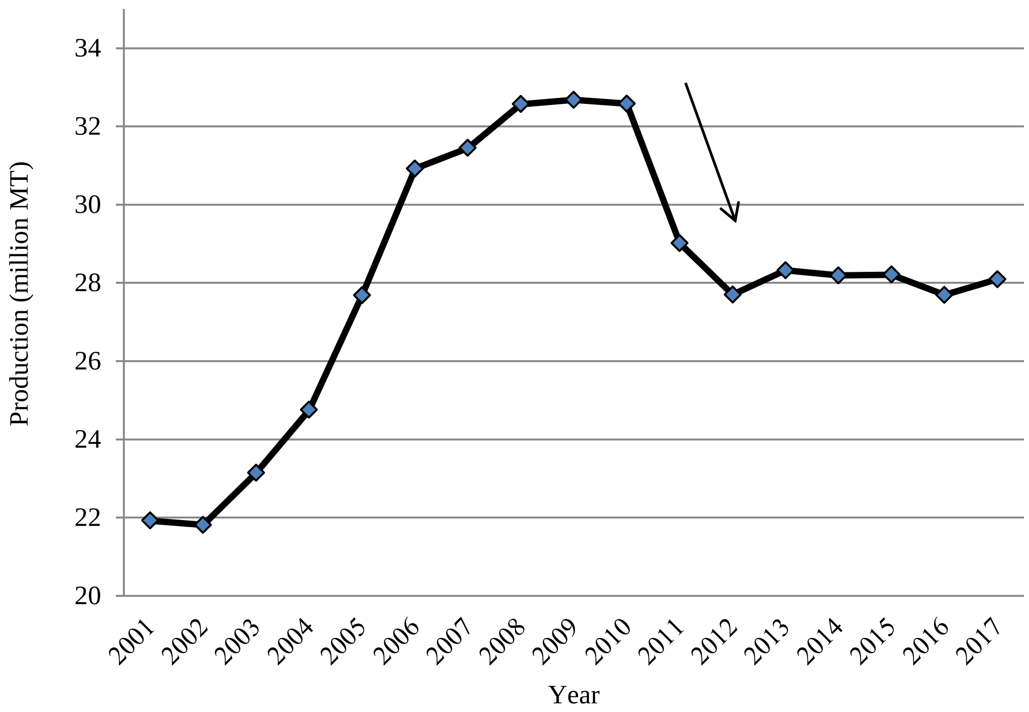

Figure 1-2 Annual rice production from 2001 to 2017

Source: MOALI (2019).

1 The wet season takes around five months from July to November and the dry season lasts approximately four months from December to March.
2 Ayeyarwady, Sagaing, Bago, Mandalay, and Yangon Regions.
3 Soil fertility and moisture condition are suitable for rice production.
4 Flooding occurs in the wet season while salinity and drought occur at the end of the wet season.

The total area of rice cultivation from 2010 to 2017 sharply decreased from 8.05 million ha to 7.26 million ha (Figure 1-3) because agricultural land was converted to non-agricultural uses, such as constructing buildings and roads for urbanization. Such urbanization does not enable increases in annual rice production via expanding the total cultivated area of rice in Myanmar.

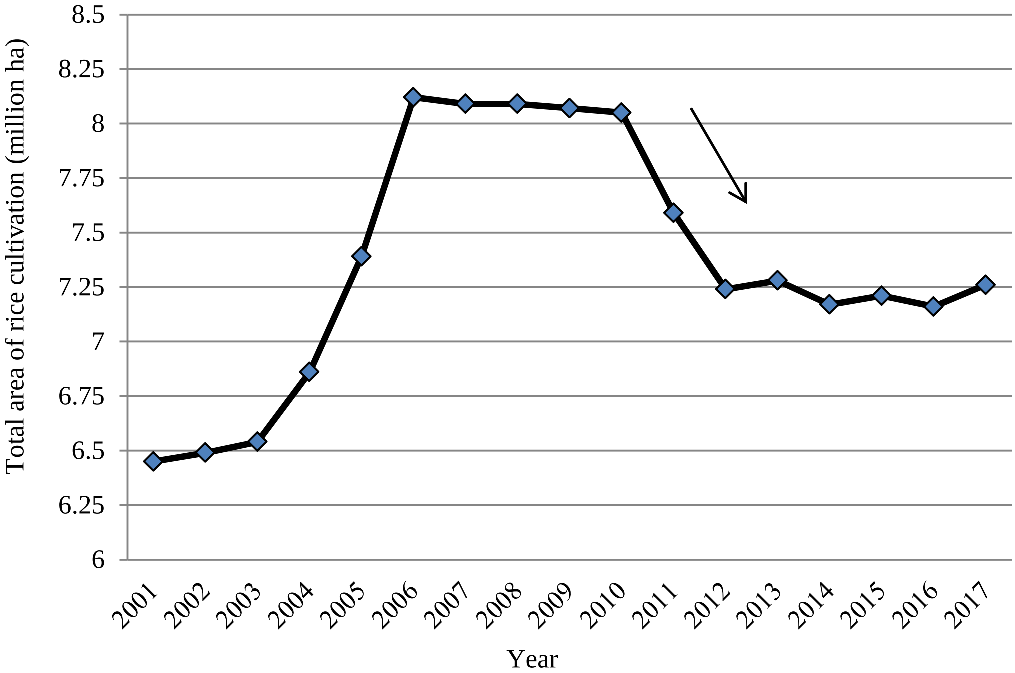

Figure 1-3 Total area of rice cultivation from 2001 to 2017

Source: MOALI (2019).

The second reason is likely to be a declining average yield of rice (Appendix 1). The average yield of rice has decreased below 4 ton/ha since 2011 (Figure 1-4).

The national average yield of rice in 2013 was the second-lowest in Asia even though Myanmar has enormous favorable water resources and production conditions for rice (Raitzer, Wong, & Samson, 2015). The Ministry of Agriculture and Irrigation (MOAI) had planned to foster the growth of the rural economy through the rice sector's development in a sustainable way. Therefore, MOAI established a target of 5 ton/ha of the national average rice

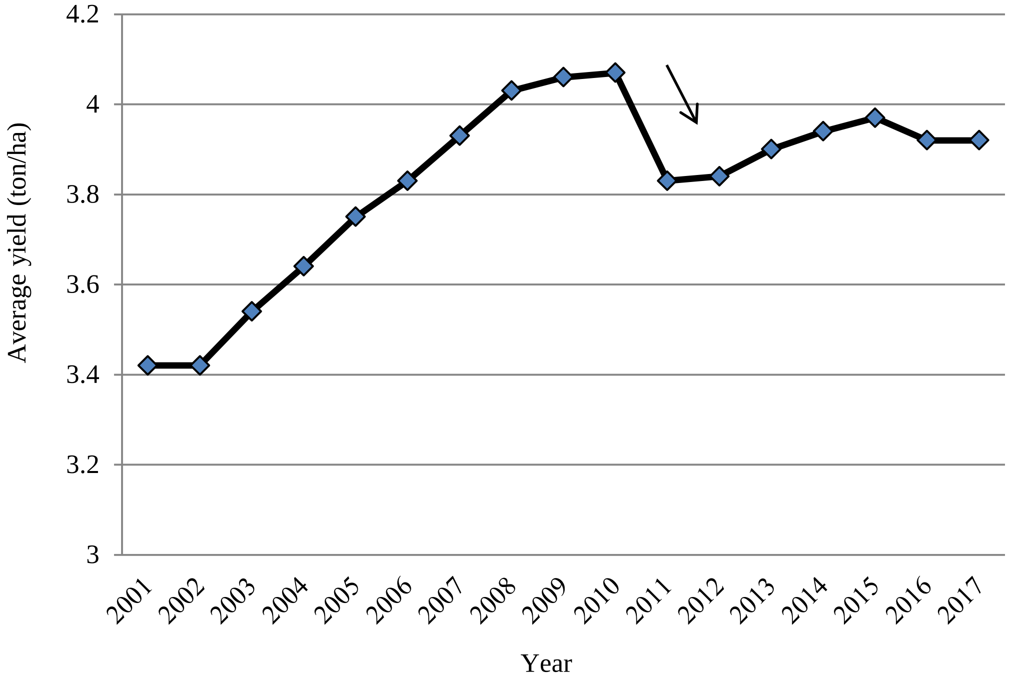

Figure 1-4 Average yield of rice from 2001 to 2017

Source: MOALI (2019).

yield in 2007 (MOAI, 2013). To achieve this targeted yield (i.e., 5 ton/ha), MOAI introduced the set of Good Agricultural Practices (GAPs) in rice production as the agricultural policy in 2008.

GAPs were originally created by Food and Agriculture Organization (FAO) in 2008 and have been implemented in many countries (Wannamolee, 2018). Takahiro, Sarah, and Johnson (2014) defined GAPs as a set of agricultural practices that bring social, economic, and environmental sustainability to on-farm processes. GAPs are composed of many improved component technologies and boost rice yield (IRRI, 2010).

1.2 Problem Statement

It is said that low rice yield has mostly resulted from low yielding varieties, soil fertility degradation, flooding, weed infestation, and the outbreaks of pests and diseases. As one of the strategies for enhancing rice yield, GAPs in rice production were launched by the

Ministry of Agriculture and Irrigation in 2012. The Department of Agriculture (DOA) organized the training programs for GAPs in rice production for new village extension workers at the State Agricultural Institute, Nay Pyi Taw, in 2013. Township officers, deputy township officers, village tract extension workers, and village extension workers meet each other every 15 days at an agricultural education camp[5] where they discuss their performance of extension activities, farmers' agricultural problems collected, and recommendable solutions to these problems. Township officers have to report all agricultural information collected from their townships on monthly basis to respective district officers (Figure 1-5).

Due to the government's intervention, the adoption rate sharply increased from 4.71 % (2012) to 16.45 % in 2014 (Figure 1-6). After 2015, despite not only MOAI's extension efforts regarding GAPs in rice production but also the benefits of GAPs in rice production, the adoption rate of GAPs in rice production in terms of cultivated area in 2017 remained stagnant and low (15.41%). Because of some limiting factors, most farmers likely cultivate rice by conventional farming practices (DOA, 2018), leading to low yield and a decrease in rice production.

1.3 Objectives of the Dissertation

Hence, it is needed to investigate why farmers do not adopt GAPs in rice production to improve the yield of rice and total production.

There are likely many reasons for the low adoption of GAPs in rice production. One reason could be attributed to the decision adopt GAPs in rice production. In other words, due to various reasons, farmers cannot smoothly and adequately go through the process of decision making regarding the adoption of GAPs in rice production.

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[5] It is located in the village tract. The sequence of administration units from top to bottom is state or region, district, township, and village tract. The village tract is the lowest unit of administration.

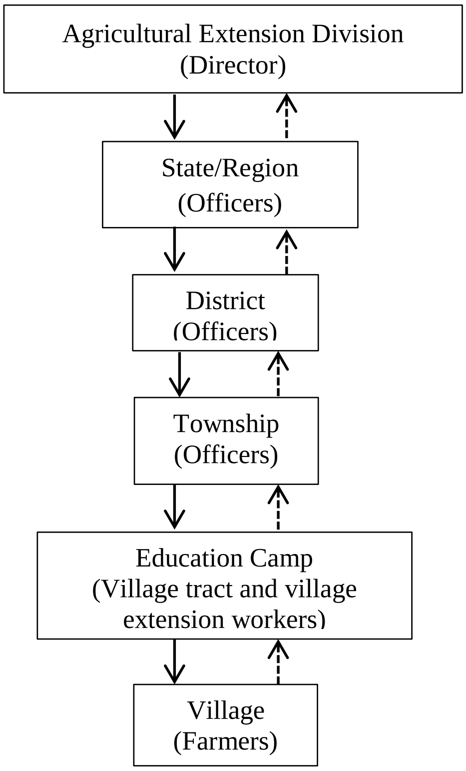

Figure 1-5 Diffusion of new technology and feedback to the Agricultural Extension Division

Source: DOA (2018).
Note: ⟶ = Diffusion of new technology.
------> = Report of problems and needs of farmers.

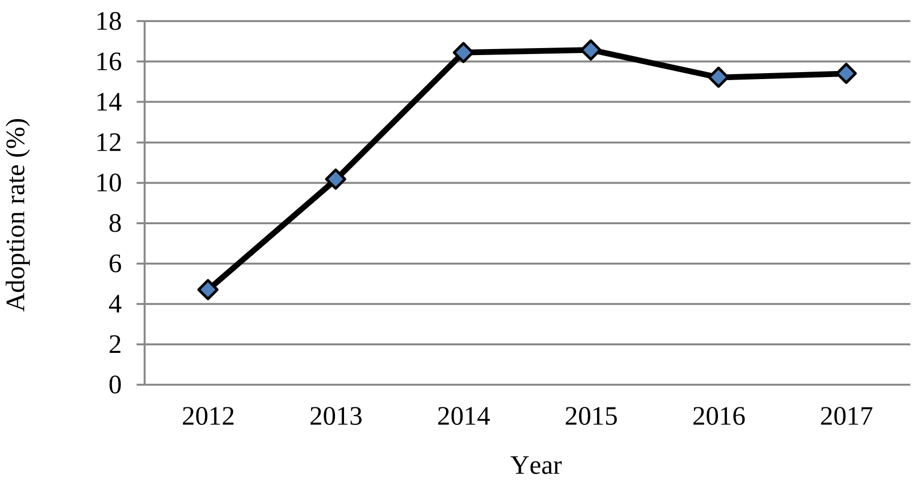

Figure 1-6 Adoption rate (%) of GAPs in rice production in terms of the cultivated area from 2012 to 2017

Source: DOA (2018).

Most of the studies on agricultural technology adoption were conducted with a focus on awareness and adoption, perception and adoption, or attitude and adoption (Bagheri et al., 2008; Hassan, Ghazi, Umar, Masri, Jamil, Zaleha, & Safian, 2015; Simon, Ndaghu, & Yohanna, 2013). However, they have covered only part of the adoption process, considering farmers' awareness, perceptions, and attitudes that play a vital role in technology adoption (Adageba, Danso, Adusu- Donkor, & Ankobea- Kokroe, 2008; Sichali & Banda, 2017). To ensure the sustainability of adopted technology as well as enhance the adoption of technology (GAPs in rice production), the linkage or sequence of awareness, perception, attitude, and adoption as a process must be a focal point. It enables us to identify which segment of the decision-making process could have trouble.

Therefore, this dissertation aims to clarify the structure of the adoption process and the features of farmers' awareness of, perception of, and attitude to GAPs in rice production. The followings are specific objectives.

(i) To examine the features of farmers' awareness and their determinants of awareness of low yield of conventional rice production;

(ii) To clarify the features and determinants of farmers' perception of GAPs in rice production, and;

(iii) To analyze the structure of the adoption process of GAPs in rice production through the linkage of awareness, perception, attitude, and adoption.

1.4 Significance of the Dissertation

Farmers' awareness, perception, attitude, and adoption of GAPs in rice production play an important role in improving the yield of rice and total rice production. This could be one of the critical areas that will help the MOAI attain the targeted yield (5 ton/ha) and boost the production of rice.

If farmers are aware of the causal factors for the low yield of rice under their conventional practices, they will find the proper solution for these reasons. Characteristics of technology are one of the major driving forces behind farmers' adoption decisions (Jamal, Kamarulzaman, Abdullah, & Ismail, 2014). Tatlidil et al. (2009) state that farmers' perception and farmers' characteristics are influential in the initial step of extending the agenda to promote sustainable adoption by farmers. A better understanding of farmers' perception of technologies and their impacts on technology adoption will provide valuable information to technology providers (Thompson et al., 2018). Comparing with previous studies having analyzed socioeconomic factors, which influence the new technology adoption, this dissertation emphasizes the structure of the adoption process.

To find out the reasons for the low adoption rate of farmers, awareness, perception, attitude, and adoption are essential aspects in the decision on adopting new technology. The findings of this dissertation can point out how they link each other, which is important for understanding the adoption process of new technology. Furthermore, the findings of determinants of farmers' awareness and perception of GAPs in rice production will help stakeholders to make informed decisions for increasing rice production. Consequently, this will help improve food security, and reduce poverty among farmers. This research will point out the new findings such as awareness of reasons for the low yield of conventional rice production, perception of the characteristics of GAPs in rice production, and structure of adoption process. Empirical results of this dissertation will help policymakers and agricultural extension workers to disseminate new technology.

1.5 Structure of the Dissertation

As shown in Figure 1-7, the dissertation consists of seven chapters.

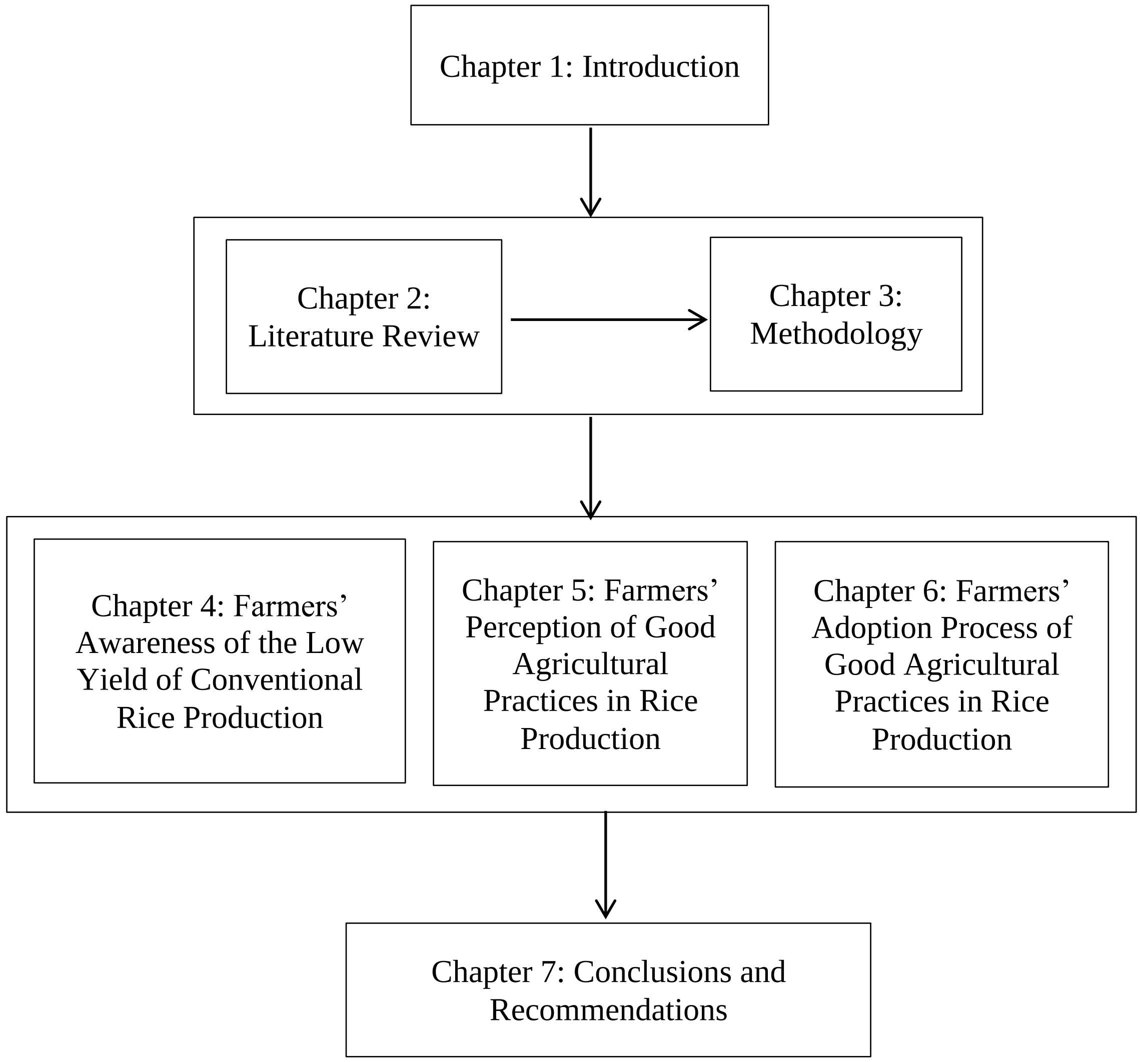

Figure 1-7 Structure of the dissertation

Source: Author.

Chapter 1 is devoted to background information regarding GAPs in rice production, the problem statement, objectives of the dissertation, significance of the dissertation, and structure of the dissertation. Chapter 2 is the literature review, focusing on the concept of GAPs, benefits of GAPs to farmers, as well as awareness, perception, attitude, and adoption of new technologies. Chapter 3 explains the study site, data collection (sampling and measurement), and analytical methods.

Chapter 4 deals with the first specific objective: features and determinants of low yield of conventional rice production. The features cover not only descriptive analysis but also awareness patterns among farmers. Determinants are analyzed by the quantitative method. Chapter 5 aims to clarify features and determinants of farmers' perception of GAPs in rice production (i.e., the second specific objective) with methods similar to those of Chapter 4. Chapter 6 contributes to the third specific objective, examining the linkage and structure of the adoption process of GAPs in rice production by Structural Equation Modeling (SEM).

Finally, Chapter 7 provides concluding remarks and recommendations to effectively intervene in the improvement and sustainability of adoption of GAPs in rice production in Myanmar.

Chapter 2: Literature Review

2.1 Concept of Good Agricultural Practices

Good Agricultural Practices (GAPs) consist of different component technologies, and these should be regarded as a basket for keeping various good cropping practices, out of which farmers can choose the most suitable practices for their farming environment (Mkanthama, 2013). The concept of GAPs is not new to rice production. GAPs are a voluntary codified system that is related to the efficient production of crops and aims towards sustainability and equality for small scale farmers (Mausch et al., 2006; Ministry of Agriculture and Cooperatives [MAC], 2009; Ryan, Erickson, & Young, 2003; Salakpetch, 2007; Van, 2006). Many studies have focused the adoption of GAPs have been conducted in many countries. Even though influencing factors for the adoption of GAPs might be varied from country to country, the ultimate goal is to produce more products, which are safe for eating, in an environmentally friendly way while the workforce is kept in economic viability and safety (IRRI, 2010).

GAPs include the integrated use of new production systems (e.g., Integrated Crop Management (ICM), Integrated Pest Management (IPM), and Integrated Nutrient Management (INM) for commercial agricultural production (Akkaya, Yalcin, & Ozkan, 2006). According to the Food and Agriculture Organization, GAPs apply advice and accessible knowledge to bring social, economic, and environmental sustainability to on-farm production and post-production processes, leading to healthy and safe agricultural products, including both food and non-food products (Akkaya et al., 2006). A global goal of GAPs is to be internationally competitive and sustainable farm products within the framework of long-term commercial agricultural production. There are many potential challenges and benefits in adopting GAPs for almost every crop, yet GAPs' norms and standards are often entirely new concepts for farmers (Pandit, Nain, Singh, Kumar, & Chahal, 2016).

2.2 Benefits of Good Agricultural Practices

GAPs are management activities in agricultural production to ensure various sustainability components, including food safety, environmental conservation, and worker safety (Ministry of Agriculture, Forestry, and Fisheries [MAFF], 2017). Three groups receive benefits from GAPs. The first group is farmers and their families. This group will consume safe and high-quality food. The second group is the consumers. They will be supplied with healthy and better-quality food that is produced by the sustainable production. The last group is the general population. They will enjoy a better environment (Food and Agriculture Organization [FAO], 2004).

GAPs increase the chances that farmers will gain higher profits and produce safer harvests (IRRI, 2010). Higher productivity can be attained with more appropriate agronomic practices like timely planting or weeding to improve efficiency with using the available resources – water, nutrients, and labor (Giller, Witter, Corbeels, & Tittonell, 2009). The adoption of GAPs in rice production promotes sustainable agriculture (Banzon, Mojica, Angela, & Cielo, 2013). GAPs also bring another economic benefit that result from reducing some production costs. Improved agricultural cropping practices, reducing wastage, or better efficiency of labor use or application of other farm inputs can decrease average costs; this provides farmers with an economic incentive to adopt such practices. GAPs in rice production also provide products in a safe environment. Higher revenue will be generated by the adoption of GAPs in rice production (Hobbs, 2003). This is another benefit that GAPs bring to farmers by enhancing the efficiency of the utilization of resources like water, fertilizer, and labor. Therefore, through the adoption of GAPs in rice production, farmers can receive higher yield of rice that will eventually increase their income (IRRI, 2009).

In Myanmar, the primary purpose of implementing GAPs in rice production is to reach the targeted yield of rice (5 ton/ha). By adopting the component technologies of GAPs in rice production, farmers can receive higher yield of rice (Appendix 2), and leading to higher income. Thus, GAPs in rice production help rice farmers to fight against hunger and poverty. Since GAPs in rice production comprise different component technologies, each of them has a different benefit to farmers. For example, the detailed description of the guideline and benefits of GAPs in rice production in Myanmar is shown in Table 2-1. Practices of 14 component technologies of GAPs in rice production are shown in Appendix 3.

Table 2-1 Guidelines and benefits of GAPs in rice production

Component technology	Guideline	Benefit
GAP1 (*Quality seeds*)	Farmers are raising healthy and robust seedlings by using seedbed with the recommended amount of high-quality seeds (19.29 kg of seeds for one hectare of rice farm).	The required seeds rate will be reduced, and robust seedlings are produced.
GAP2 (*Sparse sowing*)	The sprouted seeds are sowed sparsely on the seedbed (2.54 cm apart between seeds).	Sparse sowing will provide consistent growth of seedlings.
GAP3 (*Covering*)	Farmers cover the pre-germinated seed with well-decomposed manure or ash to protect the rained splash and be destroyed by birds.	Covering will conserve moisture and easy for uprooting.
GAP4 (*Systematic care of nursery*)	Providing systemic care for the nursery and keep soil moisture without flooding over the seedbed surfaces.	Healthy and vigorous seedlings will be provided by systematic care of the nursery.
GAP5 (*Uprooting & transplanting*)	Farmers transplant the seedlings with natural soil right after uprooting from the nursery within one day.	The seedlings will be quickly recovered by transplanting with natural soil.
GAP6 (*Planting depth*)	Farmers transplant the seedling not deeper than 3.8cm.	Shallow transplanting will induce healthy roots and easy tillering.
GAP7 (*Seedlings per hill*)	Transplant one to two seedlings per hill.	Transplanting with one to two seedlings per hill will reduce seed rate and the cost of production.
GAP8 (*Plant population*)	It ensures the proper population density of 296400 to 370500 hills per hectare with one skip row after transplanting ten rows with the spacing of 20 cm x 15 cm or 15 cm x 15 cm.	Using the recommended population will provide an optimum population and proper ventilation.
GAP9 (*Alternate wetting & drying*)	Providing alternate wetting and drying to ensuring the maximum effective number of tillers.	Intermitted irrigation will reduce water utilization and enhance tillering.
GAP10 (*Pest & disease management*)	Farmers properly manage water & nutrients, pests, and diseases.	Pest and disease infestation will be escaped.
GAP11 (*Balanced inputs*)	Fertilizers and manure were applied at the right time and method.	The balanced application will increase the efficiency of fertilizers.
GAP12 (*Submerging*)	It is controlling weeds and non-effective tillers by submerging.	Submerging will reduce ineffective tillers.
GAP13 (*Drainage*)	Farmers use timely drainage when the grains are getting the ripening stage for ease of harvest.	Timely drainage will induce even ripening and easy harvesting.
GAP14 (*Combine harvester*)	Use combine harvester to minimize crop losses at the time of harvest.	Using combine harvester will minimize post-harvest and quality losses.

Source: DOA (2011).

In general, there are two types of crop establishment methods: direct-seeded rice and transplanted rice. Transplanting is a valuable cultural practice for rice in the lowland. It is especially recommended for lowland and irrigated rice. The advantages of transplanting are saving water and seeds, facilitating weeding, and other management of crop interventions compared to direct-seeded rice. Transplanting is beneficial to the plant and results in an increased yield of rice (Grist, 1986). A summary of conventional farming practices and GAPs in rice production is shown in Table 2-2.

In conventional farming practices in rice production, 25 to 30 days old seedlings are used to transplant. In reality, seedlings are often transplanted later, depending on the availability of water or labor. Typically, seedlings do not attain the expected size (15-20 cm height) even at 25 to 30 days after seeding because of invariably high seeding rates and poor nursery management. At the time of transplanting, seedlings are uprooted, washed, bundled, and transported to the main field. Quite often, the main fields are far away, so there is a long time gap between uprooting and planting (Thiyagarajan, 2006). Therefore, the seedlings are often injured. Transplanting in puddle soil layers more than 5 cm deep will delay crop establishment and reduce tillering.

As shown in Tables 2-1 and 2-2, in GAPs in rice production, there are 14 component technologies from seed selection to harvesting. The yield of rice is influenced by using quality seeds, proper nursery management, water and nutrient management, and pest and disease management. Shallow planting of a single or two healthy seedlings encourages tillering, enhances yield, and reduces seed requirements. Planting young seedlings ensure the preservation of the tiller production potential of the seedlings.

Table 2-2 Conventional farming practices and GAPs in rice production

Conventional farming practices		**GAPs (Good Agricultural Practices)**	
Practices	**Influence to yield**	**Practices**	**Influence to yield**
Seed selection - Most farmers use their own seeds that produced in last year.	It does not provide the optimum yield of rice.	GAP1 (*Quality seeds*)	The yield of rice can be increased by using quality seeds.
Nursery Management - Farmers do not prepare seedbed and the sprouted seeds are broadcasted with high density. - The field is not covered with farmyard manure or ash. - Farmers give less attention to the nursery.	Poor nursery could not provide the optimum yield of rice.	GAP2 (*Sparse sowing*)	Sparse sowing on seedbed will provide uniform growth of seedlings and enhance yield of rice.
		GAP3 (*Covering*)	Covering will facilitate easy for uprooting. This will reduce transplanting shock and influence the yield of rice.
		GAP4 (*Systematic care of nursery*)	Healthy and vigorous seedlings will be provided by systematic care of the nursery. It influences the yield of rice indirectly.
Uprooting and Transplanting	Thirty to forty five days old seedlings are recommended for transplanting. Farmers pull and hit the seedlings to remove the natural soil at lower parts. This may injury the seedlings and influences the yield of rice.	GAP5 (*Uprooting & transplanting*)	Young seedlings will be quickly recovered by transplanting with natural soil. It influences the yield of rice indirectly.
Planting depth	Deeper transplanting will induce delay recovery and influence to yield.	GAP6 (*Planting depth*)	Shallow transplanting will induce effective tillering and increase yield of rice.
Seedlings per hill	More than 2 seedlings per hill were used to increase the number of panicles per hill.	GAP7 (*Seedlings per hill*)	Transplanting with one to two seedlings per hill will induce effective tillering and increase yield.
Plant population	There is no recommended plant population and transplanted randomly. The plant population is totally relying on rice transplanted labor.	GAP8 (*Plant population*)	Using the recommended population will increase the yield of rice.
Water management	Farmers do not use intermitted irrigation.	GAP9 (*Alternate wetting & drying*)	Intermitted irrigation will enhance tillering and increase the yield of rice.
Pest & disease management	Farmers use pesticides to control pest and disease.	GAP10 (*Pest & disease management*)	The optimum yield of rice will be attained by pests and disease management.
Nutrient management	Farmers do not apply the balanced fertilizer. They normally use urea fertilizer.	GAP11 (*Balanced inputs*)	The yield of rice can be increased by using balanced application of fertilizers.
Submerging	Submerging will increase the yield of rice by reducing ineffective tillers.	GAP12 (*Submerging*)	Submerging will increase the yield of rice by reducing ineffective tillers.
Drainage	Drainage two weeks before harvesting will induce even ripening and easy for harvesting. It does not influence to yield.	GAP13 (*Drainage*)	Timely drainage will induce even ripening and easy harvesting.
Harvesting	Manual harvesting will induce crop losses.	GAP14 (*Combine harvester*)	Using combine harvester will minimize post-harvest losses.

Source: Author's modification from DOA (2011).

2.3 Adoption of New Technologies

2.3.1 Adoption Process of New Technologies

Most farmers adopt new technologies to be more efficient and effective for different work processes. Unfortunately, the full potential of technology-based services and products never are never attained, and some of them are simply dismissed (Burton-Jones & Hubona, 2006). Usually, the problem of low yield of a crop can be tackled either by using improved technologies of production or improving the efficiency of resource use or both (Idiong, 2007).

Most of the studies on adopting agricultural technology focus only on some parts of the adoption process such as (i) awareness and adoption, (ii) perception and adoption, or (iii) attitude and adoption. These analyses furthermore focus on socioeconomic characteristics as determinants of adopting new technology (Abdoulaye & Sanders, 2005; Abdulai & Huffman, 2014; Abdulai, Owusu, & Goetz, 2011; Bagheri et al., 2008; Hasan et al., 2012; Marian, Villano, & Fleming, 2012; Simon et al., 2013). Often, the findings only speak to one part of the adoption process.

Seline et al. (2015) mention that the adoption of technology is mainly influenced by three intrinsic variables: knowledge, perception, and attitude. Awareness, perception, and attitude towards the adoption of new technology are often considered the fundamental stages in the adoption process (Rogers & Shoemakers, 1971). Smathers (1982) concludes that farmers' attitude and perception would be the most influencing factors for successfully adopting conservation practices rather than any other factors. Aminrad, Zakarayia, Hadi, and Sakari (2013) analyze the relationship between awareness, knowledge, and attitudes towards environmental education. Herath and Wijekoon (2013) state that coconut farmers' attitudes and perceptions are crucial factors for adoption of organic farming. However, Igene, Solomon, Orji, Akagbosu, and Osifo (2015) state that awareness and perception most influence the adoption of technology.

Fairuz, Idris, Syahrizan, and Noor (2017) explain that the KAP (knowledge, attitude, and practice) Model is one of the popular methods to measure the level of knowledge, attitude, and practice of participants in a survey. It has been used in many study areas such as health science (Shafie & Azman, 2015; ul Haq, Hassali, Shafie, Saleem, Farooqui, Haseeb, & Aljadhey, 2013), environmental science (Ahmad, Noor, & Ismail, 2015), and agriculture (Lekei, Ngowi, & London, 2014; Mohsen, Salah, Mohamed, & Hafez, 2016; Wongwichit, Siriwong, & Robson, 2012). On the other hand, other dimensions such as awareness (Dhakal, Joshi, Ale, Sharma, Dahal, Shah, & Stephen, 2014; Yang, Wang, Meng, Zhang, Fan, Geissen, & Ritsema, 2014) and perception (Seline et al., 2015; Herath & Wijekoon, 2013; Smathers, 1982) are crucial for the analysis of adoption process. Furthermore, Adageba et al. (2008) and Sichali and Banda (2017) state that adoption of new technology is influenced by awareness, perception, and attitudes of technology. Based on the above lines of research, this dissertation will analyze the adoption process of new technology using awareness, perception and attitude.

2.3.2 Awareness of New Technologies

From the viewpoint of theory, awareness antecedes the adoption of new technology (Rogers, 2003). Since awareness plays the role of a catalyst that provokes people's interest to explore further information on a concept, it is a crucial issue that be taken into account before launching new technology. Simon et al. (2013) mention that a failure or success of the adoption process, which consist of interest, assessment, and trial, relies on ways of managing the awareness stage. Rogers (1995) argues that awareness of innovation and its benefits is a vital preliminary stage that probably influences the decision to adopt or refuse the innovation.

For example, farmers' awareness has a positive and significant effect on the adoption of improved varieties of sweet potato in Ghana (Acheampong, Amengor, Nimo-Wiredu, Adogoba, Frimpong, Haleegoah, & Adu- Appiah, 2018). Creation of awareness and education of the improved potato varieties encouraged adoption.

Rogers (2003) states, furthermore, that when launching a new technology or new varieties, the first stage consists of raising farmers' awareness of them utilizing demonstrations or other methods. Because in the adoption process, awareness is the first step to be taken, it is needed to study before attempting to adopt new technology (Rogers & Shoemakers, 1971). Fairuz et al. (2017) mention that awareness is related to a person's attitude to decide whereas to increase or decrease the level of performance.

Two approaches such as Likert scale and dichotomous choices can be used to measure awareness. The former has already been applied by previous studies like a study of climate change by Kibue, Genxing, Zheng, Zhengdong, and Mao (2014), an adoption study by Rezaei et al. (2017), awareness of technology studies by Azmi, Musal, Abdullah, Othman, and Fam (2017) and Sanga (2016), and an ecosystem services study by (Xun, Yecui, Ling, and Jinhui 2017). The latter method involves applying dichotomous ("yes" or "no") choice (Ghulam, Latif, Bashir, Shamsudin, & Daud, 2018; Simon et al., 2013).

2.3.3 Perception of New Technologies

According to the motivation model, perception is one part of the learning processes that lead to human behaviors such as implementation (Buckley & Caple, 2007). Farmers' perception of GAPs is one of the incentives which could lead to implementation (Bandura, 1982). Alonge and Martin (1995) state that farmers' perception towards the adaptability of sustainable practices with their cropping systems is the best predictor of adopting such practices.

Numerous studies indicate that different factors influence farmers' perceptions. Farmers' perception influences decision making on on-farm management, just like their economic situation (Abdul-Gafar, Xu, & Yu, 2016). Bagheri et al. (2008) describe the relationship between many socioeconomic factors (human resources, utilization of information sources, the participation of extension, and scales of landholding) and the perception of farmers towards some sustainable farming technologies. Meseret (2014) reveals that the age of household leaders, education of household leaders, and farmers' previous experience in soil and water conservation affected farmers' perception towards the practices of soil and water conservation on farmland in Ethiopia. Pinthukas (2015) indicates that education level, age, number of the labor force of the household, agricultural income, and visit of extension considerably influenced farmers' perception towards the production of organic vegetables. Mkuna and Mugula (2016) indicate that farmers' perception of coping strategies was influenced by socioeconomic factors such as education, age, number of household members, and major household activities in Tanzania.

Before deciding to use new technologies, farmers may assess one or more technology (Byerlee & Hesse de Polanco, 1986; Leathers & Smale, 1991). Farmers' practical experience in a particular technology is likely to affect their perception of new agricultural technologies before they decide to adopt the technology. Indeed, farmers' perception have been shown to influence their adoption decisions (Sheikh, Rehman, & Yates, 2003; D'Emden, Llewellyn, & Burton, 2008). However, making decisions by farmers to adopt a new technology depends on various complicated factors. One of them is the farmers' perception of the characteristics of new technology (Rogers, 1995; Negatu & Parikh, 1999). According to Rogers (1995), five characteristics of technology (relative advantages, compatibility, complexity, trialability, and observability) play an important role in farmers' making the decision to adopt the technology.

Complexity and adaptability of new technologies with existing practices and equipment are fundamental considerations in the process of decision-making (Rogers, 1983). Alonge and Martin (1995) state that farmers' perception towards the adaptability of sustainable practices with current agricultural systems is the best predictor for adopting such practices.

2.3.4 Attitude to New Technologies

Attitude is shaped by beliefs that have great value for a person (Herath & Wijekoon, 2013). Attitudes may be theoretically conceptualized as either "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly & Chaiken, 1993), or the strength of the memory between a specified object (to be realized in a broad sense) and a summary assessment (in terms of liking) of that object (Fazio, Sanbonmatsu, Powell, & Kardes, 2008). Many researchers define attitude in different ways. The followings are definitions of attitude proposed in the literature:

- Regarding some aspects of our environment, it is defined as a persistent combination of motivational, emotional, perceptual, and cognitive processes (Krech & Crutchfield, 1984).
- Attitude is a person's evaluation of the psychological object (Alleng & Ng, 2003; Petty & Wegener, 1998).
- Attitude is defined as individual characteristics that describe positive or negative behavior or reflection of knowledge and feeling to certain aspects or subjects (Triandis, 1971).
- Attitude is an inclination to react in a situation (Fairuz et al., 2017). They state that farmers' attitudes have a significant effect on farmers' practices toward enhancing the natural enemies in the rice field.

- It is the negative or positive feelings of an individual about executing a behavior (Fishbein & Ajzen, 1975).

Hassan et al. (2015) identify factors affecting farmers' attitudes toward using agrochemicals in rice production. Utaranakorn and Yasunobu (2016) analyze farmers' attitudes toward farm management by using a t-test to determine the significant differences between efficient farms and insufficient farms. Hobbs (2003) mentions that the rise or stabilization of profit and the decrease in costs provide farmers with significant economic incentives to adopt good agricultural practices. Environmental attitude is crucial because it often determines behavior that either deteriorates or improves the quality of the environment (Gifford & Sussman, 2012).

2.4 Summary

In previous studies on farmers' awareness of new technology, most approaches investigated awareness of technologies (Acheampong et al., 2018; Azmi et al., 2017; Banmeke & Ajayi, 2008; Claudy, Michelsen, O' Driscoll, & Mullen, 2010; Grace, 2015; Moon, 2013; Simon et al., 2013; Simtowe, Elijah, Bernard, & Aliou, 2012). They did not examine awareness of actual problems before the technology is introduced to farmers. Therefore, a study on awareness of actual problems is still needed to fill the gap.

According to reviewing previous studies, there are two approaches to analyze of farmers' perception of technologies. One is the general perception of technologies. The other is the perception of the characteristics of technologies. For example, the first approach would ask "How do you perceive soil conservation practices?" However, the second approach analyzes the characteristics of each of the soil conservation practices. This dissertation applied the second approach because it is more appropriate to investigate farmers' perception of the characteristics of GAPs in rice production.

Two approaches are also used to analyze attitude. The first approach deals with an overall attitude to new technology (Bondoria et al., 2018; Ignacio et al., 2018). The second approach observes the breakdown of attitudes such as economic attitude (Hobbs, 2003; Soper & Walstad, 1983) and environmental attitude (Gifford & Sussman, 2012; Eilam & Trop, 2012; Waliczek & Zajicek, 1999). This dissertation utilizes the second approach because it is more appropriate to observe these two aspects of farmers' attitudes of GAPs in rice production.

In most of the studies on determinants of adopting new technologies, socioeconomic characteristics were selected as explanatory variables. A few studies analyzed the adoption process and focused on the linkage between variables (Herath & Wijekoon, 2013; Igene et al., 2015; Seline et al., 2015; Smathers, 1982). The findings of previous studies just only show that there is a linkage between variables and determinants of adoption without looking at the structure of the adoption process. The dissertation will analyze the linkage and the structure of the adoption process to bridge the gap of previous studies.

Chapter 3: Methodology

3.1 Study Area

3.1.1 Rice Production in Ayeyarwady Region

Though rice can be grown throughout Myanmar, five Regions (Ayeyarwady, Sagaing, Bago, Mandalay, and Yangon) have more suitable land for rice production than the other one Union Territory and nine States and Regions. This dissertation was carried out in Ayeyarwady Region, which is also called the rice bowl of Myanmar (Figure 3-1).

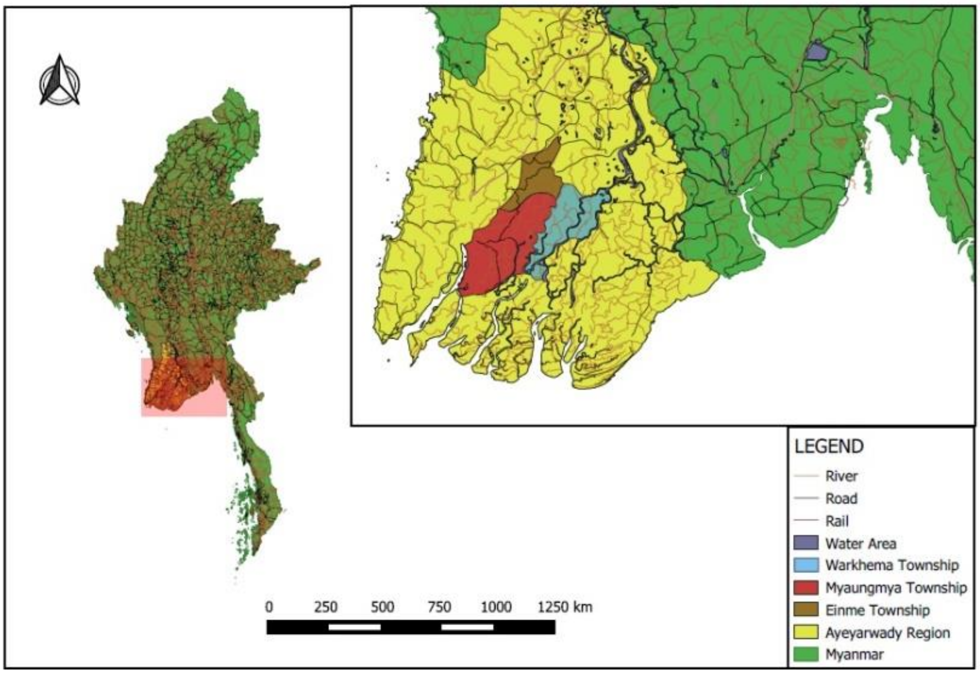

Figure 3-1 Location of the study area

Source: Author's modification from Google map.

Out of Union Territory, States, and Regions in Myanmar, Ayeyarwady Region topped rice production in with 28.29 % of the total sown area in 2017 (DOA, 2017). Rice cultivation area covers around 70 % of the total arable land in the region. GAPs in rice production were introduced to the region by MOAI in 2008. Since then, farmers have been encouraged to adopt GAPs in rice production. The region is suitable for applying GAPs in rice production in both wet and dry seasons due to its favorable soil and water conditions (DOA, 2017).

3.1.2 Adoption Rate of GAPs in Rice Production

Adoption rate of GAPs in rice production is shown in Table 3-1. Among Union Territory, States and Regions, the maximum adoption rates in terms of cultivated area are observed at Union Territory and five regions: Nay Pyi Taw, Sagaing, Bago, Mandalay, Yangon, and Ayeyarwady. Out of these Union Territory and five Regions, the adoption rate was highest in Nay Pyi Taw Union Territory. In general, the adoption rate sharply increased from 2013 to 2016. Then, there was a decreasing trend. This is due to the new government policy after 2015. The union minister of MOALI encouraged farmers to apply the System of Rice Intensification (SRI). SRI was initially developed in Madagascar through participatory on-farm experimentation in the 1980s and 1990s (Dobermann, 2004).

Table 3-1 Adoption rate (%) in terms of cultivated area by Union Territory, States, and Regions

Union Territory, State, and Region	Year					
	2013	2014	2015	2016	2017	2018
Nay Pyi Taw*	12.23	21.67	27.25	29.87	28.69	28.32
Sagaing	8.72	9.28	19.23	20.26	17.31	18.43
Bago	8.21	21.33	24.54	28.84	26.23	23.12
Mandalay	8.71	12.14	19.89	23.89	19.68	22.34
Yangon	7.06	13.23	19.56	16.15	15.35	13.74
Ayeyarwady**	9.34	17.23	20.56	17.34	17.44	18.82
Kachin	0.76	7.88	9.33	9.12	10.19	8.34
Kayah	1.24	3.33	14.56	13.32	9.97	10.43
Kayin	0.86	2.92	11.32	14.43	10.21	12.32
Chin	0.34	1.35	4.65	7.34	6.23	6.71
Tanintharyi	1.92	2.13	14.21	17.36	11.25	13.24
Magway	6.35	12.24	16.13	14.56	16.26	14.45
Mon	3.17	8.13	14.17	11.67	12.11	15.28
Rakhine	1.34	8.21	13.23	12.23	11.32	11.32
Shan	0.42	11.43	18.12	12.21	16.12	14.23

Source: DOA (2018).
Note: * = Union Territory and ** = Study area.

The concept of SRI is similar to that of GAPs in rice production. The significant differences between SRI and GAPs in rice production were younger seedling age and broader spacing at transplanting time. The adoption rate of GAPs in rice production in Ayeyarwady

Region sharply increased from 2013 to 2015. After 2015, there was a decreasing trend. This region represents the 3rd to 4th highest adoption rates of GAPs in rice production in terms of the cultivated area among six Regions while Yangon Region shows the lowest adoption rate.

3.1.3 Training on GAPs in Rice Production

Training on GAPs in rice production conducted by the Department of Agriculture (DOA) for farmers is shown in Figure 3-2. Due to having the largest cultivated area of rice, the maximum number of training occurred in the Ayeyarwady Region, while Mon State represented the minimum number. Out of Union Territory, States and Regions, Bago Region conducted the second-highest number of GAPs in rice production training for farmers in 2016.

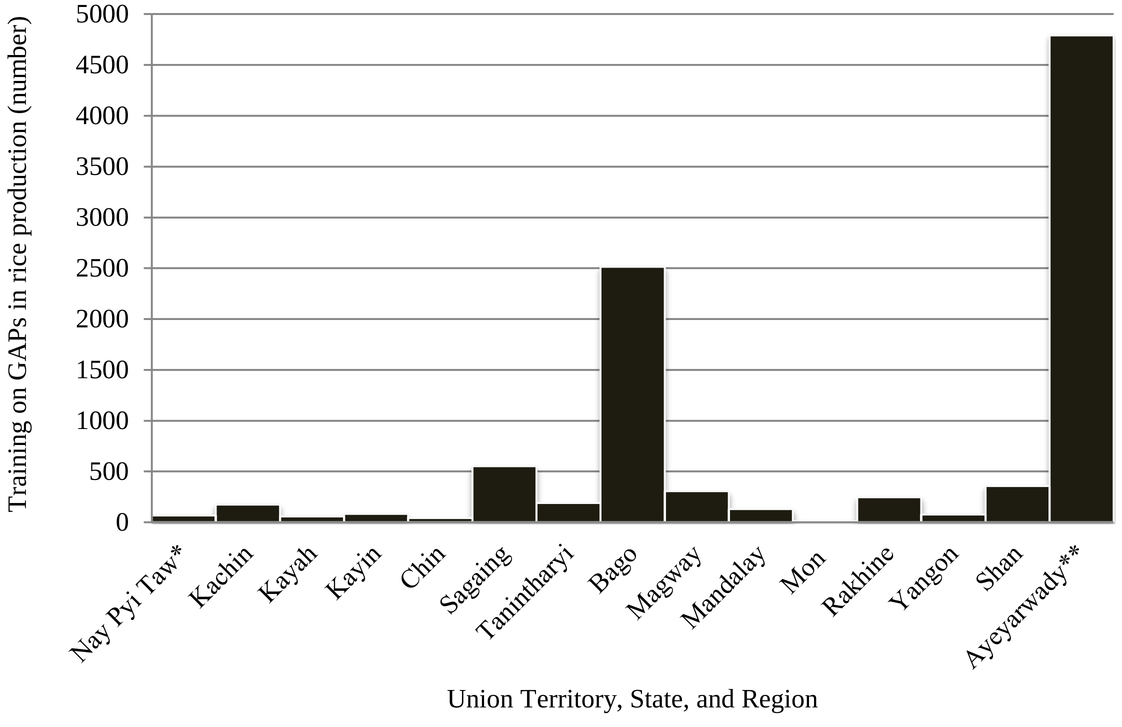

Figure 3-2 Training on GAPs in rice production for farmers by Union Territory, States, and Regions in the wet season, 2016

Source: DOA (2016).
Note: * = Union Territory and ** = Study area.

In Ayeyarwady Region, more than 4,500 trainings on GAPs in rice production were conducted by the DOA. In this region, trainings mostly were seed selection, integrated pest management, and fertilizer application at the agricultural knowledge center (KC) or township office. However, the DOA provided trainings on seedbed preparation and nursery management at the early stage of implementation for GAPs in rice production. The duration of trainings was less than one week.

3.1.4 Cropping Patterns and Cultivated Area

Ayeyarwady Region is called the granary of the country and the central pillar of the national economy. According to the National Census in 2014, around 6.5 million people live in the region, and their source of income largely depends on rice production. As shown in Table 3-2, six cropping patterns are observed in this region. Rice is the main crop and the cropping pattern of "Rice-Fallow" occupies the largest (66.94%) of the total cultivated area while that of "Rice – Rice" is 29.44 %. Even though rice can be grown in both wet and dry seasons, the total area of rice cultivation in wet season was higher than dry season because of limited water resource.

Table 3-2 Cropping patterns and cultivated area in Ayeyarwady Region in 2017

Cropping pattern			Cultivated area	
No.	**Wet season***	**Dry season****	**Hectare**	**Percent**
1	Rice	Rice	117,855	29.44
2	Rice	Pulses	11,385	2.84
3	Rice	Groundnut	411	0.10
4	Rice	Chilli	72	0.02
5	Rice	Vegetables	2,640	0.66
6	Rice	Fallow	268,003	66.94
Total			400,366	100

Source: Ayeyarwady Regional Office [ARO] (2017).
Note: * = Wet season: five months from July to November and main season for rice production.
** = Dry season lasts four months from December to March.

3.2 Sampling and Sample Size

3.2.1 Sampling

Even though there are six districts[6] in Ayeyarwady Region, Myaungmya District was selected as a research area through purposive selection according to two criteria: average rice yield in 2016 (3.21 ton/ha, being nearly the same as 3.46 ton/ha in Ayeyarwady Region) and number of GAPs in rice training for farmers in 2016 (12 times, being just slightly lower than the 14.17 times in Ayeyarwady Region) (ARO, 2017). In Myaungmya District, there are three townships: Myaungmya, Einme, and Warkhema. In the second stage of sampling, three villages were randomly selected from each of the given townships.

3.2.2 Sample Size

Since three villages were randomly selected from each sample township, the total number of sample villages was nine villages (3 townships x 3 villages=9). Then, 35 farmers were selected from the given villages respectively by their landholding sizes. Therefore, the total sample size of this dissertation was 315 farmers (Table 3-3).

3.3 Socioeconomic Conditions, Extension Services, and Adoption Rate of Sample Townships

3.3.1 Socioeconomic Conditions of Farm Households by Sample Townships

The socioeconomic conditions of farm households in three sample townships are shown in Table 3-4. Among the three townships, the highest mean value of landholding (6.63 ha) and annual income from crop production (13,500 thousand kyats per year) were observed at Myaungmya Township. However, farm households in this township indicated the lowest mean values for household head's age (45.31 years), education (5.25 years), household size (4.33 persons), and farming experience (22.86 years). Einme Township indicates the highest mean values for gender of household head (98.41% of male), education of household head

[6] Six districts are Myaungmya, Pathein, Hinthada, Maubin, Pyapon, and Labutta.

Table 3-3 List of sample villages and number of respondents

Township	Number of village tract*	Name of sample village	Number of households who cultivate rice in sample village	Total respondents and its breakdown by landholding size**	
Myaungmya	98	Ma Dawt Pin	163	105	34(S)
		Kyon War	242		29(M)
		Tha Pyay Chaung	215		42(L)
Einme	97	Hpa Yar Gyi Kone	479	105	39(S)
		Ye Thoe	275		41(M)
		Gone Hnyin Tan	242		25(L)
Warkhema	125	Thea Kone	253	105	75(S)
		Kyar Hpyu	382		21(M)
		Au Kyun Taw Gyi	345		9(L)
Total	320	9	2,596	315	

Source: ARO (2018).

Note: * = 5-12 villages organize one village tract.

** = S means small-scale farmers whose landholding size is less than 5 acres of farmland, M= medium-scale farmers whose landholding size is 5- 10 acres of farmland, and L= large-scale farmers whose landholding size is more than 10 acres of farmland.

Table 3-4 Basic socioeconomic conditions of farm households by sample townships in 2017

Socioeconomic condition	Township		
	Myaungmya	Einme	Warkhema
Age of household head (year)	45.31	49.73	50.16
Gender of household head (% of male)	96.53	98.41	95.37
Education of household head (year)	5.25	6.42	5.39
Household size (person)	4.33	4.81	4.36
Landholding (ha)	6.63	3.78	2.48
Farming experience (year)	22.86	26.92	27.41
Income from crop production/household (x,000 kyat* per year)	13,500	8,600	6,300

Source: Myaungmya District Office [MDO] (2018).
Note: * = currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77.44 kyat, as of 1st November, 2020).

(4.81 years), and household size (4.81 persons). Farm households in Warkhema Township showed the lowest landholding (3.78 ha) and income from crop production/ household (6,300 thousand kyats per year). Nevertheless, the highest mean values of age of household (50.16 years) and farming experience (27.41 years) were observed in Warkhema Township.

3.3.2 Extension Services by Sample Townships

Extension services to increase the adoption of GAPs in rice production are shown in Table 3-5. Myaungmya Township shows the highest number of extension workers and organized the highest number of training in general (51 persons), field demonstration for farmers (65 times), distribution of pamphlets (7,300 pieces), and poster presentation (171) for farmers. However, the ratio of extension workers to the total cultivated area is similar among three townships. Furthermore, the number of training on GAPs in rice production and the number of knowledge centers are equal in each township. The lowest values of mean of field demonstration (40), method demonstration (14), and poster presentation (115) were indicated by Einme Township. But, the lowest values of mean of training in general (31), group discussion (47), and pamphlet distribution (5,500) were indicated by Warkhema Township.

Table 3-5 Extension services for GAPs in rice production by sample townships in 2017

Extension Service	Township		
	Myaungmya	Einme	Warkhema
Number of extension workers (person)	30	15	20
Ratio of extension workers to total cultivated area (person: ha)	1:3,520	1:3,860	1:3,997
Number of training in general	51 (3,277)*	35 (3,440)*	31 (2,800)*
Number of GAPs in rice production training	24 (5,033)*	24 (4,590)*	24 (5,030)*
Number of group discussions and farmers who participated in group discussions (person)	50 (3,210)	53 (15,030)	47 (4,800)
Farmers' Knowledge Center (number)	1	1	1
Field demonstration (time)	65	40	43
Method demonstration (time)	20	14	15
Pamphlet distribution (piece)	7,300	6,500	5,500
Poster presentation (number)	171	115	134

Source: MDO (2018).
Note: * = number of farmers who participated in trainings.

3.3.3 Expected Effect of Extension Services on Adoption Process of GAPs in Rice Production

Agricultural extension workers provided many extension services to enhance the adoption process of GAPs in rice production. The detailed extension services and their expected effects are shown in Table 3-6. Most extension services, except for result demonstration and method demonstration, influenced farmers' awareness of the low yield of conventional rice production. Regarding farmers' perception of GAPs in rice production, extension services do not influence compatibility and complexity, while extension activities influence other characteristics of GAPs in rice production. Extension services also influence farmers' attitudes to GAPs in rice production except for method demonstration and poster presentation.

3.3.4 Types of GAPs in Rice Production Trainings by Sample Townships

Training on GAPs in rice production was conducted by the Department of Agriculture (DOA) to enhance understanding and the adoption rate by farmers from 2013 to 2018. As

Table 3-6 Expected effect of extension services on the adoption process of GAPs in rice production by sample townships

Extension Service	Adoption Process							
	Awareness	Perception					Attitude	
		RA	COM	CPLEX	TR	OBS	EC	ENV
Farm and home visits	√	√	×	×	√	√	√	√
Office calls	√	√	×	×	√	√	√	√
Discussion with farmers	√	√	×	×	√	√	√	√
GAPs in rice production training for farmers	√	√	×	×	√	√	√	√
Result demonstration	×	√	×	×	×	×	√	√
Method demonstration	×	×	×	×	√	√	×	×
Agricultural talk	√	√	×	×	√	√	√	√
Pamphlet distribution	√	√	×	×	√	√	√	√
Poster presentation	√	√	×	×	√	√	×	×

Source: Author.

Note: (1) RA= Relative advantage, COM = Compatibility, CPLEX= Complexity, TR= Trialability, OBS= Observability, EC= Economic aspect, and ENV = Environmental aspect.

(2) √ = Extension service affects adoption process and × = Extension service does not affect adoption process.

shown in Table 3-7, the types of training were classified into six types. In the initial year 2013, the DOA conducted a few training sessions, and the total numbers of trainings in each of sample townships is nearly identical. Regional Officers of the DOA decided to conduct two trainings per month for GAPs in rice production, which means 24 trainings per year. There was no training on seedbed preparation after 2015. The DOA conducted mostly training on the selection of quality seeds and integrated pests and disease management.

3.3.5 Adoption Rate by Sample Townships

The adoption rate of GAPs in rice production is shown in Figure 3-3. The trend of adoption rate for three sample townships is nearly identical from 2012 to 2015. The adoption rates are not entirely different in 2012 and 2013. However, adoption rates of Einme Township reached at the maximum rate during 2013 to 2015, while that of Warkhema was at the minimum rate. In 2016, Myaungmya Township represented the maximum adoption rate (19.30 %) and afterward sharply decreased.

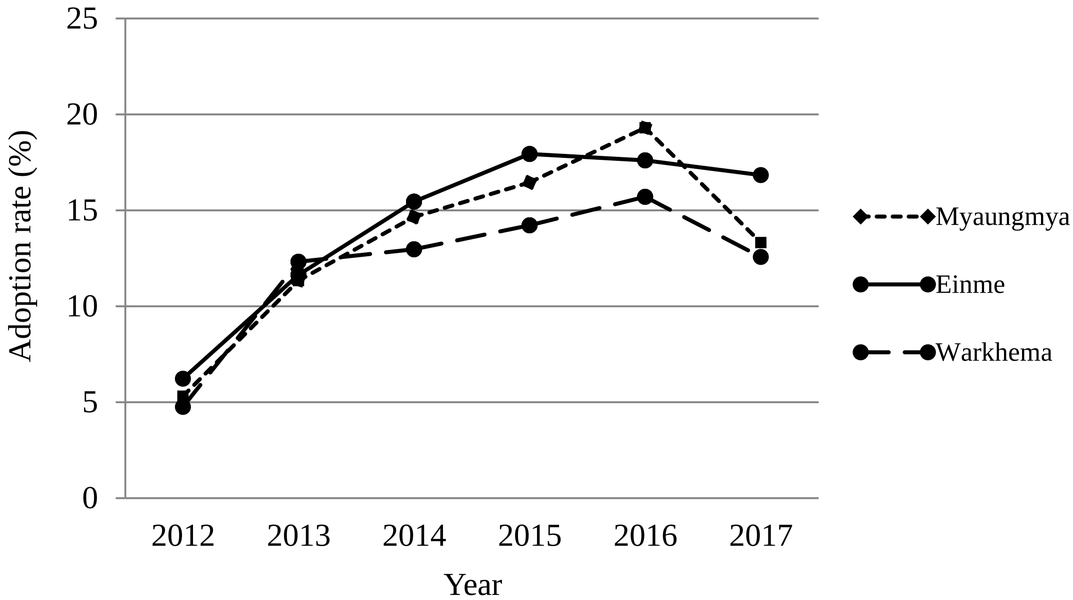

Figure 3-3 Adoption rate (%) in terms of cultivated area by sample townships

Source: DOA (2018).

Table 3-7 Number of GAPs in rice production trainings for farmers by types and sample townships from 2012 to 2017

Type of GAPs in rice production training	Year																	
	2012			2013			2014			2015			2016			2017		
	MT	ET	WT	MT	ET	WT	MT	ET	WT	MT	ET	WT	MT	ET	WT	MT	ET	WT
Selection of quality seeds	2	1	1	5	4	4	6	4	2	8	5	6	9	6	4	4	4	3
Seedbed preparation	1	1	-	4	3	4	1	1	2	0	0	0	0	0	0	0	0	0
Nursery management	-	-	-	2	3	3	2	2	1	2	2	3	4	3	4	2	3	3
Water management	-	-	-	4	2	2	1	2	3	4	3	3	6	5	6	2	1	2
Fertilizer management	1	-	1	3	2	3	4	4	3	6	5	6	4	8	6	4	3	4
Integrated pest and disease management	1	1	1	4	5	4	5	6	6	4	9	6	1	2	4	12	13	12
Total	5	3	3	22	19	20	19	19	17	24	24	24	24	24	24	24	24	24

Source: MDO (2018).

Note: MT = Myaungmya Township, ET = Einme Township, and WT = Warkhema Township.

3.4 Data Collection

Primary data for this dissertation was collected from respondents of Myaungmya District, Ayeyarwady Region, Myanmar. A pilot survey and key informant interviews were conducted in November 2017 to assess the study's feasibility. The primary survey was conducted from July to August 2018 by structured questionnaire interviews. An additional field survey was carried out in September 2019. The questionnaire was pretested in Myaungmya Township, interviewing farmers who were not included in the selected sample. Three extension agents from each selected township were used as enumerators, who were provided with training for three days before conducting the primary survey.

The questionnaire consists of two parts, as shown in Appendix 4. One part contained questions regarding the characteristics of farmers. The other part comprises statements related to awareness of the low yield of conventional rice production, perception of the component technologies of GAPs in rice production, attitude to GAPs in rice production, and adoption of the component technologies of GAPs in rice production. The data measurement is detailed in Chapters 4, 5, and 6.

3.5 Analytical Methods

Descriptive statistics like standard deviation, mean, percent, etc. were used to evaluate the characteristics of farmers' awareness of the low productivity of conventional rice, perception of GAPs in rice production, and attitude to GAPs in rice production based on the data collected. Moreover, analysis of variance was applied to compare the awareness level of the reasons for the low yield of conventional rice production among selected townships. Cluster analysis was conducted to categorize farmers based on their awareness and perception, respectively, as far as the variance was of interest. Meanwhile, to analyze driving factors for farmers' awareness of the reasons for the low yield of conventional rice production and perception of GAPs in rice production Binary Logit Model was applied with the use of the statistical software package of STATA 13, assuming that the dependent variable is "aware/perceive" or "not aware/not perceive" (Acheampong et al., 2018; Ghulam et al., 2018; Maswadi et al., 2018). The details of the model specification are explained in Chapter 4 and Chapter 5.

To clarify the structure of adoption process, Structural Equation Modeling (SEM) was applied to analyze the relationship/linkage among awareness, perception, attitude, and adoption. SEM is a multivariate statistical method that enables researchers to analyze the structural relationships, which are called structural paths, between the latent variables. There are two types of SEM: covariance-based SEM (CB-SEM) and variance-based SEM (VB-SEM) or Partial Least Square SEM (PLS-SEM)[7]. From the viewpoint of properness, Covariance-based SEM was adopted for this dissertation because the sample size is larger than 100. The validity of data was tested with the use of composite reliability, average variance extracted, and Cronbach's alpha. SPSS and Stata 13 software processed the collected data. The details of the model specification are explained in Chapter 6.

[7] PLS-SEM is suitable for small size (n= 30 to 100) of samples.

Chapter 4: Farmers' Awareness of the Low Yield of Conventional Rice Production in Ayeyarwady Region, Myanmar: A Case Study of Myaungmya District[8]

4.1 Introduction

According to Rogers and Shoemakers (1971), the adoption process is essential so that new technology can disseminate properly among people. In the adoption process, there are five steps: awareness, interest, trial, evaluation, and adoption. Among them, awareness is the most important step for the diffusion of environmental knowledge and communication of its fundamental elements (Ghulam et al., 2018). As Rogers and Shoemakers (1971) say, there is a need to study farmers' awareness before reaching the adoption of new technology, and as the first step of the process, farmers must be aware of problems related to farming practices. When farmers become aware of the low yield reasons, they will seek out the better solution for the low yield based on these reasons. Actually, if farmers are properly aware of causality that accounts for the low yield of conventional rice production, they can go through the process of adopting appropriate technologies out of GAPs in rice production.

Most of the previous studies (Acheampong et al., 2018; Azmi et al., 2017; Banmeke, Fakoya, & Ayanda, 2011; Cheteni, 2016; Claudy et al., 2010; Grace, 2015; Hasan et al., 2012; Igene et al., 2015; Roy et al., 2010; Sanga, 2016; Simon et al., 2013; Simtowe et al., 2012) focused on measuring the awareness of issues. However, the study on farmers' awareness of reasons is rare in the literature. The study on the feature of farmers' awareness and determinants of farmers' awareness is needed to formulate appropriate agricultural policies and agricultural extension programs at the grassroots level to cope with the low yield of conventional rice production in Myanmar.

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Therefore, the objectives of this dissertation are (1) to clarify the features of farmers' awareness of the low yield of conventional rice production and (2) to analyze determinants of farmers' awareness of the low yield of conventional rice production. The finding from the study will provide empirical evidence to agricultural policymakers and agricultural extension workers to improve farmers' awareness of the low yield of conventional rice production. The findings from the study will provide empirical evidence to agricultural policy makers and extension service providers on the importance of considering farmers' characteristics.

4.2 Analytical Methods

4.2.1 Framework and Variables

Personal characteristics such as education level of household head, farmland size, and income from crop production were positively associated with awareness of the environment, while the household head's age showed a negative significance (Roy et al., 2010). Xun et al. (2017) mention that age and gender of household head, level of education, and landholding were significant variables for farmers' awareness of ecosystem services. However, the marital status of the household head showed non-significant variable for their awareness of ecosystem services. Hasan et al. (2012) state that household size was a determinant of farmers' awareness of environmental degradation. Age and education level of household head and members of community organizations were determinants of awareness of land, soil, and water conservation practices (Mango, Makate, Tamene, Mponela, & Ndengu, 2017). Nevertheless, family size, active labor force, access to agricultural advice, and access to credit for agriculture were not significant variables (Mango et al., 2017). Oladeji, Okoruwa, Ojehomon, Diagne, and Obasoro (2015) mention that age of household head and membership in local farmers' associations were determinants of farmers' awareness and their adoption of improved rice varieties. Some characteristics such as years of farming experience in pigeon pea and contact with public agricultural extension workers were selected as explanatory variables for the analysis of farmers' awareness and adoption of pigeon pea varieties in Kenya (Simtowe et al., 2012). Ghulam et al. (2018) state that rice yield absolutely fluctuates from one place to another because of unpredicted conditions in rice production. Therefore, farmers' awareness of yield differences in one location will diverge from that of another. Climate change in one location bears no resemblance from that of another, and so does awareness.

In this dissertation, several characteristics will influence farmers' awareness of the low yield of conventional rice production. According to the literature, the selected characteristics are personal characteristics, farming characteristics, economic characteristics, institutional characteristics, and location (Figure 4-1).

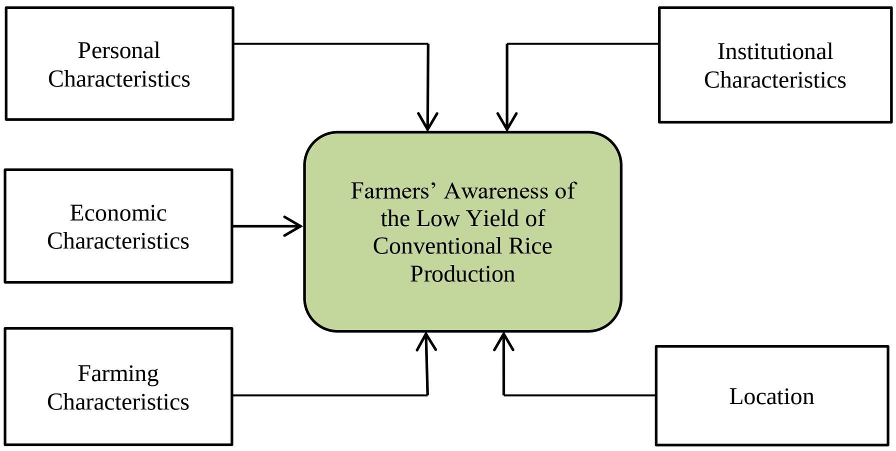

Figure 4-1 Conceptual framework of the study

Source: Author.

In this dissertation, age and gender of household head, marital status, years of education, farming experience in rice production, and household size were chosen as personal characteristics. Two variables, such as access to agricultural credit and annual income from crop production, were selected for economic characteristics. In farming characteristics, two variables such as farmland size and active labor force were applied in the analysis. In institutional characteristics, three variables such as contact with extension workers, receiving agricultural information, and membership in local farmers' associations were involved. Farmers' awareness of reasons for the low yield in one location will vary from that of another. Therefore, three townships, such as Myaungmya, Einme, and Warkhema, were selected explanatory variables for location (Table 4-1).

Table 4-1 Description of independent variables

Independent Variable	Description	Symbol
Personal characteristics		
Age	Age of household head (year)	AGE
Gender	1 for male; 0 otherwise	GEN
Marital status	1 for married; 0 otherwise	MST
Education	Years of formal schooling	EDU
Farming experience	Years of experience in farming	FEXP
Household size	Number of household members	HHSIZE
Economic characteristics		
Access to credit	1 for the household head has access to credit; 0 otherwise	CRE
Income from crop production	Level of annual income from crop production: 1 for low (<6,000,000 kyat*), 2 for medium (6,000,000 to 10,000,000 kyat), 3 for high (>10,000,000 kyat)	INC
Farming characteristics		
Farmland size	Size of farmland owned by household in hectare	FSIZE
Active labor force	Number of household members who are actively involved in rice production (person)	LAB
Institutional characteristics		
Contact with extension workers	Number of meetings per year (2017)	EXT
Receiving agricultural information	1 for received; 0 otherwise	INF
Membership in local farmers' association	1 for member; 0 otherwise	MEM
Location		
Einme Township	1 for the farmer who lives in Einme Township; 0 otherwise	LOCE
Warkhema Township	1 for the farmer who lives in Warkhema Township; 0 otherwise (Myaungmya Township as a base case)	LOCW

Source: Author.
Note: * = currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77 kyat, as of 1st November, 2020).

4.2.2 Data Measurement

Awareness is defined by many researchers in a variety of ways. Behrens and Evans (1984) define it as a state of knowing and being informed of something. Nijafi (2012) states that awareness is mentioned as the state or ability to perceive, feel, or be conscious of events, objects, or sensory patterns. Generally, awareness is the state or quality of being knowledgeable about something. Sudarmadi et al. (2001) defined awareness as the concern for environmental problems. In this dissertation, awareness is mentioned as a state of knowing reasons for the low yield of conventional rice production. When farmers have properly known reasons for the low yield of conventional rice production, the proper solution will be searched by farmers and they can go through the process of adopting appropriate component technologies of GAPs in rice production.

According to the key informant interviews and a pilot survey on reasons for the low yield of rice production, ten statements were prepared to measure farmers' awareness. These statements cover three aspects of reasoning such as general risks, farmer's management, and Ministry's management (Table 4-2). Farmers' awareness of general risks is to observe awareness of risks in rice production. The aspect of general risks is crucial because if farmers are aware of the general risks faced by them, they are likely to change their farming practices as ex-ante coping strategies. The aspect of farmer's management is to investigate farmers' awareness of their farm management practices. If farmers are aware of difficulties in rice production, they will find the appropriate solution to overcome these difficulties in rice production. Ministry's management aspect is essential because if farmers are aware that there are problems with the Ministry's management, the Ministry may be pressured to provide suitable policies, services, and agricultural inputs for farmers.

Table 4-2 Aspects and statements to measure farmers' awareness

Aspect		Statement
General risks (natural condition, price, and human)	AW1	Climate change (heavy rain and flooding) affects the yield of rice.
	AW2	Less attention is paid to rice production due to the small profit.
	AW3	Knowledge of rice production technology is inadequate.
Farmer's management	AW4	It is challenging to hire the required number of laborers when necessary.
	AW5	Farmers cannot plant and harvest rice at the right time.
	AW6	Soil fertility is becoming more inadequate for cropping.
	AW7	Farmers do not use the adequate and correct amount of farmyard manure (FYM) and fertilizers.
Ministry's management	AW8	Agricultural policies of the Ministry of Agriculture and Irrigation are unstable.
	AW9	Agricultural extension services are not helpful for farmers.
	AW10	Quality seed is not sufficiently available for farmers.

Source: Author.
Note: AW = awareness.

According to previous studies, awareness can be measured by two approaches. The first approach is to use Likert scale. This approach has already been used by previous studies such as Kibue et al. (2014) on climate change, Rezaei et al. (2017) on adaptation, Azmi et al. (2017), and Sanga (2016) on technology, and Grace (2015) on ecosystem services. The second approach is to use dichotomous choices ("yes" or "no") like Ghulam et al. (2018) and Simon et al. (2013) who used dichotomous choice in measuring awareness. This dissertation follows the first approach (using the Likert scale) because it is more appropriate for obtaining a detailed answer from the respondent that furthermore, it includes a neutral response option.

In this dissertation, farmers' awareness of the low yield of conventional rice production was measured directly by using the Likert scale (Likert scale is a type of rating scale to measure farmers' awareness). With this scale, respondents are asked to rate the statement according to their level of awareness ranging from 1 to 5 (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree). Though farmers' awareness is measured as five levels by Likert scales, these scales were transformed to two categories: if the Likert score was less than 4, it was categorized as "not aware of the statement, herein, a reason for the low yield of conventional rice production," while if the Likert scale was equal to or greater than 4, it was categorized as "aware of the statement." Cronbach's alpha[9] was used to examine the strength of the interior flexibility and the reliability of awareness statements.

4.2.3 Data Analysis

For the objective (1), that is, the feature of awareness, descriptive analyses such as average, standard deviation, percent, etc. were used for categorizing and describing the variables whenever possible. Analysis of variance (ANOVA) was applied to compare farmers' awareness among three townships. Moreover, the Cluster Analysis was used to define groups of farmers under similar awareness. It was also applied to investigate the proper model used in the analysis.

For the objective (2), Binary Logit Model was used to analyze the determinants of farmers' awareness (Ghulam et al., 2018; Acheampong et al., 2018), assuming that the dependent variable is "aware" or "not aware." A farmer's awareness of the low yield of conventional rice production can be written as follows:

$$Y_i = \begin{cases} 1 \text{ (aware)} \\ 0 \text{ (not aware)} \end{cases} \tag{4.1}$$

Suppose P_i = probability of being aware and $1 - P_i$ = probability of not being aware.

$$P_i = \frac{1}{1 + e^{-Zi}} \tag{4.2}$$

$$1 - P_i = \frac{1}{1 + e^{Zi}} \tag{4.3}$$

[9] Cronbach's alpha is a measure of internal consistency that is how close a set of items is related as a group.

The equation for Binary Logit Model could be used as follows (Gujarati, 2012):

$$\frac{P_i}{1-P_i} = e^{\beta_i X_i + u_i} \tag{4.4}$$

$$l_n\left(\frac{P_i}{1-P_i}\right) = \beta_i X_i + u_i\,, \qquad i = 1, 2, 3, \ldots, n \tag{4.5}$$

where X_i is the set of independent variables, β_i are coefficients of independent variables, and u_i is error term.

The present study employs the following equation to determine the factors affecting farmers' awareness of the low yield of conventional rice production:

$$\begin{aligned} l_n\left(\frac{P_i}{1-P_i}\right) = {} & \beta_0 + \beta_1 AGE + \beta_2\, GEN + \beta_3\, MST + \beta_4\, EDU + \beta_5\, FEXP \\ & + \beta_6 HHSIZE + \beta_7\, CRE + \beta_8\, INC + \beta_9\, FSIZE + \beta_{10}\, LAB \\ & + \beta_{11}\, EXT + \beta_{12}\, INF + \beta_{13}\, MEM + \beta_{14}\, LOCE + \beta_{15}\, LOCW + u_i \end{aligned} \tag{4.6}$$

4.3 Results and Discussion

4.3.1 Characteristics of Farmers

The characteristics of farmers are shown in Table 4-3. The mean age of household heads was 50.25 years. Most of the household heads were male, and they were married. The mean education level of household heads was 5.57 years. The mean of farmland was 3.92 ha, and they have 25.56 years of experienced in farming.

The mean of household size was 4.51 persons, and mean for the active labor force per household was 3.39 persons. The mean annual income from crop production was 8,004,010 kyat[10] (US$ 6,210.58). Farmers easily received agricultural information and could access to credit for rice production. The mean number of contacts with extension workers was 2.87 times per year. Around 50 percent of the farmers were members of local farmers' associations.

[10] Kyat is the currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77 kyat, as of 1st November 2020).

Table 4-3 Descriptive summary of sample farmers' characteristics

Characteristic	Myaungmya (n = 105)		Einme (n = 105)		Warkhema (n = 105)		All Respondents (n =315)	
	Mean	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Age (year)	48.68	13.10	50.96	12.45	51.11	12.17	50.25	12.58
Gender (% of male)	97.10	0.17	98.10	0.14	97.10	0.17	97.46	15.80
Marital status (% of married)	95.20	0.21	93.30	0.25	97.10	0.17	95.24	21.30
Education (year)	5.19	3.26	6.23	3.13	5.29	3.46	5.57	3.31
Farming experience (year)	23.37	13.20	27.29	14.04	26.03	13.70	25.56	13.71
Household size (person)	4.63	1.61	4.77	1.68	4.13	1.47	4.51	1.61
Access to credit (%)	86.70	0.34	99.00	0.10	89.50	0.31	91.74	27.60
Income from crop production (kyat*/year)	11,558,195	14,238,329	7,615,098	7,734,315	4,838,736	9,807,098	8,004,010	11,244,539
Farmland size (ha)	5.76	18.19	3.66	8.77	2.35	9.86	3.92	5.42
Active labor force (person)	3.30	1.45	3.47	1.53	3.42	1.30	3.39	1.43
Contact with extension workers (time)	4.09	5.39	2.40	2.14	2.13	2.13	2.87	3.66
Receiving agricultural information (%)	87.60	0.33	85.7	0.35	90.5	0.29	87.94	32.60
Membership in local farmers' associations (%)	40.00	1.43	50.5	2.71	47.6	1.62	45.71	49.90

Source: Author.

Note: (1) Std. Dev. = Standard deviation.

(2) * = currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77 kyat, as of 1st November, 2020).

4.3.2 Farmers' Awareness of the Low Yield of Conventional Rice Production

The data on farmers' awareness were reliable for the analysis because Cronbach's alpha for the measurement of awareness was 0.75. The level of awareness is defined as follows: (a) aware = scores of 4 and 5, (b) not aware = scores of 1, 2, and 3. Their awareness of reasons for the low yield of farmers' conventional practices is shown in Table 4-4.

General Risks: AW1 through AW3

General risks consist of three reasons for the low yield of conventional rice production. Among them, in terms of percent, farmers' awareness of AW2 (*Less attention is paid to rice production due to the low profit*) was relatively low (76.2 % of farmers), comparing with AW1 (*Climate change*) and AW3 (*Knowledge of rice production technology is inadequate*), since mean value was greater than 3.5.

Farmer's Management: AW4 through AW7

Among four reasons, in terms of percent, farmers' awareness of AW4 (*It is challenging to hire the required number of laborers when necessary*) was relatively low (66.7 % of farmers), while the other awareness (AW5, AW6, and AW7) were relatively high (79.4 %, 81.9 %, and 80 % respectively).

Ministry's Management: AW8 through AW10

In terms of percent, farmers' awareness of AW8 (*Agricultural policies of the Ministry of Agriculture and Irrigation are unstable*) and AW9 (*Agricultural extension services are not helpful for farmers*) was remarkably low (56.5 % and 12.1 % of farmers, respectively). Since the mean value of scores was less than 3.5, farmers had low awareness of AW8 and AW9. However, farmers were highly aware of AW10 (*Quality seed is not sufficiently available for farmers*).

Table 4-4 Comparison of farmers' awareness between "not aware" and "aware" of the low yield of conventional rice production (n=315)

Aspect	**Statement**	**Not Aware (<4)**				**Aware (≥4)**				***t*-value**
		Respondent		**Likert Scale**		**Respondent**		**Likert Scale**		
		Number	**Percent**	**Mean**	**Std. Dev.**	**Number**	**Percent**	**Mean**	**Std. Dev.**	
General risks	AW1	25	7.9	2.24	0.78	290	92.1	4.68	0.52	0.001 ***
	AW2	75	23.8	2.41	0.79	240	76.2	4.51	0.51	0.001 ***
	AW3	27	8.6	2.59	1.05	288	91.4	4.68	0.52	0.001 ***
Farmer's management	AW4	105	33.3	1.95	0.73	210	66.7	4.50	0.63	0.001 ***
	AW5	65	20.6	1.85	0.75	250	79.4	4.55	0.52	0.001 ***
	AW6	57	18.1	1.98	0.88	258	81.9	4.60	0.56	0.001 ***
	AW7	63	20.0	2.14	0.76	252	80.0	4.58	0.50	0.001 ***
Ministry's management	AW8	137	43.5	2.19	0.80	178	56.5	4.47	0.54	0.001 ***
	AW9	277	87.9	2.39	0.86	38	12.1	4.65	0.52	0.001 ***
	AW10	53	16.8	2.55	0.82	262	83.2	4.65	0.51	0.001 ***

Source: Author.

Note: (1) AW = awareness. AW1 = Climate change (heavy rain and flooding) affects yield loss, AW2 = Less attention is paid to rice production due to the small profit, AW3 = knowledge of rice production technology is inadequate, AW4 = It is challenging to hire the required number of laborers when necessary, AW5 = Farmers cannot plant and harvest rice at the right time, AW6 = Soil fertility is becoming more inadequate for cropping, AW7 = Farmers do not use the adequate and correct amount of FYM and fertilizers, AW8 = Agricultural policies of the Ministry of Agriculture and Irrigation are unstable, AW9 = Agricultural extension services are not helpful for farmers, and AW10 = Quality seed is not sufficiently available for farmers.

(2) Std. Dev. = Standard deviation.

(3) *** = significant at 1% level.

In summary, the highest awareness (92.1 % of farmers) was found in the aspect of general risks, while the lowest awareness (12.1 % of farmers) was found in the aspect of Ministry's management, and it was a remarkable lack of awareness. Farmers had a high awareness of climate change and inadequate knowledge of rice production. However, they were not aware that the low yield is attributed to agricultural policies and agricultural extension services for rice production.

4.3.3 Classification of Farmers Based on Their Awareness

Cluster analysis was applied to find out the structural feature of farmers' awareness of GAPs of rice, namely the combination of awareness levels of the ten statements rather than which statements were high or low. According to the result of the K-means method[11], three Clusters are identified based on farmers' awareness scores, as shown in the dendrogram of Figure 4-2.

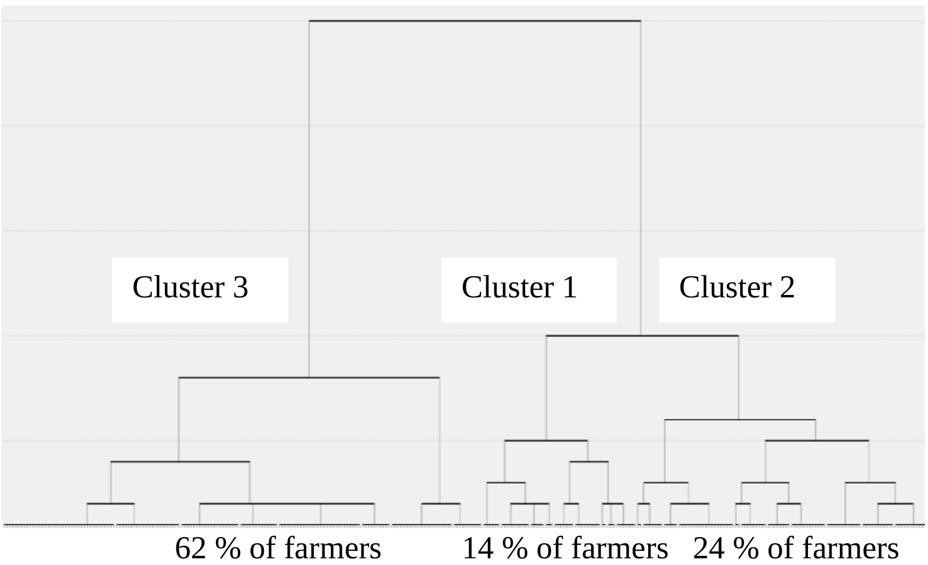

Figure 4-2 Dendrogram of farmers based on awareness of the low yield of conventional rice production

Source: Author.

[11] K-means clustering is a method of vector quantization, originally from signal processing, that aims to partition *n* observations into *k* Clusters in which each observation belongs to the Cluster with the nearest mean (Cluster centers or Cluster centroid), serving as a prototype of the Cluster.

According to Tables 4-5, firstly, the Clusters did not differ statistically in terms of characteristics of farmers, such as age, education, farming experiences, farmland size, active labor force, annual income from crop production, receiving agricultural information, and the number of contacts with extension workers (Table 4-5). The detailed awareness of three Clusters (Table 4-6) could be pointed out as follows.

Cluster 1 (14 %: 43 farmers)

Farmers' awareness was limited to AW1 (*Climate change*) since a Likert scale of four and over means "agree: is aware". Farmers' awareness extended to AW3 (*Knowledge of rice production technology is inadequate*) and AW7 (*Farmers do not use the adequate and correct amount of FYM and fertilizers*) only because the mean value was greater than 3.5. The feature of this Cluster was lowering awareness of AW2, AW6 AW8 AW10 than other Clusters. Therefore, farmers' awareness was narrow but not necessarily high. In this Cluster, the mean income of farmers was relatively higher than that of Cluster 2. Furthermore, the percentage of male farmers and membership in local farmers' associations were relatively lower than that of Cluster 3. Since their awareness of AW7 (*Farmers do not use the adequate and correct amount of FYM and fertilizers*) is different from Cluster 2, it could be mentioned as the feature of farmers in this Cluster even though they had low awareness of the low yield of conventional rice production. This Cluster can be called as "narrow and low awareness group".

Cluster 2 (24 %: 75 farmers)

Since the mean score was greater than 3.5, seventy five farmers were aware of six statements, such as AW1, AW2, AW3, AW6, AW8, and AW10. Meanwhile, their awareness of AW4 (*It is challenging to hire the required number of laborers when necessary*) and AW9 (*Agricultural extension services are not helpful for farmers*) were low, compared with the

Table 4-5 Comparison of sample farmers' characteristics among three Clusters

Characteristic	**Cluster 1**	**Cluster 2**	**Cluster 3**	***p*-value**
Age (year)	47.91	49.17	51.17	0.214
Gender (% of male)	91 ^{b}	96	99 ^{a}	0.002
Marital status (% of married)	95	89 ^{b}	97 ^{a}	0.094
Education (year)	5.07	6.01	5.51	0.304
Farming experience (year)	24.14	26.25	24.27	0.511
Household size (person)	4.23	4.08 ^{b}	4.74 ^{a}	0.005
Access to credit (%)	88	87 ^{b}	94 ^{a}	0.080
Income from crop production (kyat*/year)	7,760,802	9,993,477	7,299,684	0.208
Farmland size (ha)	3.79	5.05	3.52	0.112
Active labor force (person)	3.14	3.19	3.53	0.096
Contact with extension workers (time/year)	2.12	3.33	2.86	0.220
Receiving agricultural information (%)	86	87	89	0.817
Membership in local farmers' association (%)	35 ^{b}	35 ^{b}	52 ^{a}	0.016

Source: Author.

Note: (1) * = currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77 kyat, as of 1st November, 2020).

(2) Mean values of Clusters denoted by different letters (a, b) show significant differences at 5% significant level.

Table 4-6 Result of Cluster Analysis on farmers' awareness of the low yield of conventional rice production

Cluster	Mean Value										Number of farmers (%)
	AW1	AW2	AW3	AW4	AW5	AW6	AW7	AW8	AW9	AW10	
1	4.3	2.7	3.8	2.9	2.9	2.5	3.6	2.2	2.8	3.3	43 (14%)
2	4.2	3.9	4.4	2.0	3.2	3.9	3.4	3.6	1.5	4.1	75 (24%)
3	4.6	4.3	4.7	4.5	4.5	4.5	4.5	3.7	1.4	4.6	197 (62%)

Source: Author.

Note: AW = awareness. AW1 = Climate change (heavy rain and flooding) affects yield loss, AW2 = Less attention is paid to rice production due to the small profit, AW3 = knowledge of rice production technology is inadequate, AW4 = It is challenging to hire the required number of laborers when necessary, AW5 = Farmers cannot plant and harvest rice at the right time, AW6 = Soil fertility is becoming more inadequate for cropping, AW7 = Farmers do not use the adequate and correct amount of FYM and fertilizers, AW8 = Agricultural policies of the Ministry of Agriculture and Irrigation are unstable, AW9 = Agricultural extension services are not helpful for farmers, and AW10 = Quality seed is not sufficiently available for farmers.

other Clusters. Therefore, their awareness was comparatively expanded, but their unawareness was deep, leading to an extreme gap. The maximum mean values of farming experiences, farmland size, annual income from crop production, and the number of contacts with extension workers were significant characteristics of farmers in Cluster 2. By comparing with Cluster 1, the features of this Cluster were awareness of AW2, AW6, AW8, and AW10. This Cluster can be called as "medium and high awareness group".

Cluster 3 (62 %: 197 farmers)

There was no remarkable gap in farmers' awareness because their awareness was broad and high. Their awareness was very low in AW9 (*Agricultural extension services are not helpful for farmers*). In Cluster 3, small landholders and low-income farmers were involved, and they had a high awareness of the low yield of conventional rice production. Gender (% of male) and household size were highly significantly different at 0.01 significance level by the least significant difference test[12]. In this Cluster, nearly all farmers (99 %) were male. Household size, marital status, and access to credit were significantly different from those of Cluster 2 and showed the maximum mean values. More than 50% of farmers are memberships of local farmers' associations, and it was significantly different from that of the other two Clusters. This Cluster can be called as "broad and high awareness group".

Therefore, seven statements of AW2, AW4, AW5, AW6, AW8, AW9, and AW10 were selected as determinants of Clustering. Of interest that among ten statements, AW9 occupied the role of demarcating Cluster 1 from Clusters 2 and 3, though AW 9 (*Agricultural extension services are not helpful for farmers*) showed low awareness in all Clusters.

[12] The least significant difference (LSD) test is used in the context of the analysis of variance when the *F*-value suggests the rejection of the null hypothesis H_0, that is, when the difference between the population means is significant. It is applied to identify the populations whose means are statistically different.

4.3.4 Comparison of Farmers' Awareness among Sample Townships

Farmers' awareness of reasons for the low yield of conventional rice production was compared among sample townships by using analysis of variance (ANOVA) (Table 4-7) and Schiff's test (Table 4-8). According to the ANOVA results, four statements of AW4, AW5, AW6, and AW7 in farmer's management, and one statement of AW9 in Ministry's management were significantly different among sample townships.

AW4 (*It is challenging to hire the required number of laborers when necessary*)

According to the result of Schiff's test, significant low awareness (average Likert scale = 3.40) of AW4 was observed at Myaungmya Township, compared with the other two townships. There was no significant difference between the other two townships even though the average Likert scale was less than 4.0 in each township.

AW5 (*Farmers cannot plant and harvest rice at the right time*)

Among the sample townships, the lowest mean value (3.82) was at Warkhema Township. According to the results of Schiff's test, a significant difference was found only between Einme Township and Warkhema Township. Myaungmya Township did not show a significant difference from the other two townships.

AW6 (*Soil fertility is becoming more inadequate for cropping*)

Regarding AW6, the lowest awareness was observed at Myaungmya Township, and it was significantly different (average value of Likert scale = 4.09) with the other two townships. Though the average Likert scale score was more than 4.0 in each township, there was no significant difference between Einme and Warkhema Townships.

Table 4-7 Comparison of awareness of the low yield of conventional rice production among sample townships

Aspect	Statement	Myaungmya (n = 105)			Einme (n = 105)			Warkhema (n = 105)			*F*-value
		Mean	Std. Dev.	Variance	Mean	Std. Dev.	Variance	Mean	Std. Dev.	Variance	
General risks	AW1	4.45	0.84	0.71	4.51	0.87	0.75	4.49	0.86	0.73	1.76
	AW2	3.93	1.07	1.14	3.95	1.16	1.35	4.15	0.97	0.94	1.35
	AW3	4.29	0.96	0.92	4.60	0.66	0.43	4.61	0.79	0.62	0.14
Farmer's management	AW4	3.40	1.43	2.03	3.76	1.36	1.84	3.78	1.31	1.71	2.60 *
	AW5	3.91	1.22	1.48	4.24	1.07	1.14	3.82	1.38	1.90	3.36 **
	AW6	4.09	1.24	1.54	4.11	1.20	1.43	4.17	1.13	1.28	5.41 ***
	AW7	3.87	1.30	1.69	4.29	0.99	0.98	4.12	1.03	1.07	3.76 **
Ministry's management	AW8	3.30	1.39	1.92	3.51	1.32	1.73	3.63	1.21	1.47	0.16
	AW9	1.87	1.06	1.14	1.53	0.86	0.75	1.41	0.67	0.46	7.52 ***
	AW10	4.29	0.88	0.78	4.24	1.02	1.05	4.35	1.01	1.02	0.36

Source: Author.

Note: (1) AW= awareness. AW1 = Climate change (heavy rain and flooding) affects yield loss, AW2 = Less attention is paid to rice production due to the small profit, AW3 = knowledge of rice production technology is inadequate, AW4 = It is challenging to hire the required number of laborers when necessary, AW5 = Farmers cannot plant and harvest rice at the right time, AW6 = Soil fertility is becoming more inadequate for cropping, AW7 = Farmers do not use the adequate and correct amount of FYM and fertilizers, AW8 = Agricultural policies of the Ministry of Agriculture and Irrigation are unstable, AW9 = Agricultural extension services are not helpful for farmers, and AW10 = Quality seed is not sufficiently available for farmers.

(2) *** = significant at 1% level, ** = significant at 5% level, and * = significant at 10% level.

Table 4-8 Comparison of awareness of the low yield of conventional rice production among sample townships by Schiff's test

Township	**AW4**		**AW5**		**AW6**		**AW7**		**AW9**	
	MT	**ET**	**MT**	**ET**	**MT**	**ET**	**MT**	**ET**	**MT**	**ET**
ET	0.362 *		0.324		0.314 **		0.419 **		−0.333 **	
WT	0.381 *	0.190	−0.095	−0.419 **	0.324 **	0.095	0.257	−0.162	−0.457 ***	−0.124

Source: Author.

Note: (1) AW= awareness. AW4 = It is challenging to hire the required number of laborers when necessary, AW5 = Farmers cannot plant and harvest rice at the right time, AW6 = Soil fertility is becoming more inadequate for cropping, AW7 = Farmers do not use the adequate and correct amount of FYM and fertilizers, and AW9 = Agricultural extension services are not helpful for farmers.

(2) *** = significant at 1% level, ** = significant at 5% level, and * = significant at 10% level.

(3) MT = Myaungmya Township, ET = Einme Township, and WT = Warkhema Township.

AW7 (*Farmers do not use the adequate and correct amount of FYM and fertilizers*)

According to the result of Schiff's test, a significant difference of AW7 was found between Myaungmya Township (average Likert scale score = 3.87) and Einme Township (average Likert scale = 4.29). Though the average Likert scale scores were more than 4.0 in these two townships, there was no significant difference between Einme Township and Warkema Township.

AW9 (*Agricultural extension services are not helpful for farmers*)

Regarding AW9, a significant difference was observed at Myaungmya Township. It showed low awareness (average Likert scale score = 4.10), compared with the other two townships. There was no significant difference between the other sample townships though the average Likert scale scores were more than 4.0 in each township.

Therefore, Myaungmya Township was significantly different from the other sample townships in the awareness of AW4, AW6, and AW9. Regarding awareness of AW7, Myaungmya Township was different from only Einme Township, and it was a minor difference. Finally, a minor difference was found in the awareness of AW5 like Einme Township was more aware than Warkhema Township.

Farmers' awareness was significantly different among sample townships, to some extent, due to the differences in their characteristics (Table 4-9). Among sample townships, Myaungmya Township showed the maximum mean values of farmland size, annual income from crop production, and the number of contacts with extension workers per year. The mean of these characteristics were significantly different and higher than those of the other sample townships: Einme and Warkhema.

Therefore, low awareness of AW4, AW6, and AW9 was found in Myaungmya Township, and it was significantly different from the other two sample townships: Einme and

Table 4-9 Comparison of sample farmers' characteristics among sample townships

Characteristic	Township			*p*-value
	Myaungmya	**Einme**	**Warkhema**	
Age (year)	48.68	50.96	51.11	0.292
Gender (% of male)	97.1	98.1	97.1	0.881
Marital status (% of married)	95.2	93.3	97.1	0.434
Education (year)	5.19 [b]	6.23 [a]	5.29 [b]	0.043
Farming experience (year)	23.37	27.29	26.03	0.117
Household size (person)	4.63 [a]	4.77 [a]	4.13 [b]	0.010
Access to credit (%)	86.7 [b]	99.0 [a]	89.5 [b]	0.003
Income from crop production (*kyat/year)	11,558,195 [a]	7,615,098 [b]	4,838,736 [b]	0.000
Farmland size (ha)	5.76 [a]	3.66 [b]	2.35[b]	0.000
Active labor force (person)	3.30	3.47	3.42	0.669
Contact with extension workers (number)	4.086 [a]	2.40 [b]	2.133 [b]	0.000
Receiving agricultural information (%)	87.6	85.7	90.5	0.569
Membership in local farmers' association (%)	40.0	50.5	47.6	0.292

Source: Author.

Note: (1) * = currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77 kyat, as of 1st November, 2020).

(2) Mean values of farmers' characteristics denoted by different letters (a, b) show a difference at 5% level of significance.

Warkhema. Since farmers in Einme Township showed the maximum mean values of education, access to credit and household size, their awareness of AW7 was different from Myaungmya Township and that of AW5 from Warkhema Township.

4.3.5 Determinants of Farmers' Awareness of the Low Yield of Conventional Rice Production

As shown in Table 4-4, relating to farmers' awareness, in terms of "percent of farmers," the significant difference between "aware" and "not aware," with the former being less than 80%, was found in AW2, AW4, AW5, and AW8. Therefore, the study utilized these five statements for awareness, respectively, as the dependent variable in Binary Logit Model. Since the values of variance inflation factors (VIFs) for independent variables were less than 5 (maximum value = 2.67), there was no multicollinearity among the independent variables. The result of the Binary Logit analysis is shown in Table 4-10 (Appendix 5, Part A3).

Table 4-10 Estimated coefficients of Binary Logit Model

Independent Variable	AW2		AW4		AW5		AW8		VIF
	Coef.	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	**Coef.**	**SE**	
Constant	−2.266	1.345	−2.570	1.196	−2.9512	1.337	−2.932	1.390	-
Age (X_1)	0.069 ***	0.023	0.025	0.017	0.0312	0.022	0.047 ***	0.167	2.67
Gender (X_2)	2.687 ***	0.920	1.338 *	0.809	1.821 **	0.834	2.403 **	1.135	1.12
Marital status (X_3)	−0.475	0.701	0.311	0.608	0.278	0.718	−0.413	0.631	1.19
Education (X_4)	0.021	0.049	−0.002	0.042	0.036	0.050	−0.001	0.040	1.22
Farming experience (X_5)	−0.023	0.020	−0.016	0.015	−0.028	0.019	−0.030 **	0.015	2.43
Household size (X_6)	0.230	0.151	0.273 **	0.127	0.266 *	0.153	0.172	0.118	2.45
Access to credit (X_7)	0.511	0.508	0.160	0.463	0.172	0.492	−0.137	0.450	1.11
Income from crop production (X_8)	−0.369 *	0.208	0.087	0.193	−0.213	0.233	−0.441 **	0.180	1.61
Farmland size (X_9)	0.015	0.014	−0.024 *	0.014	−0.015	0.013	0.013	0.012	1.73
Active labor force (X_{10})	−0.185	0.173	−0.107	0.148	0.094	0.186	−0.117	0.139	2.71
Contact with extension workers (X_{11})	−0.057	0.039	−0.042	0.043	0.031	0.046	0.035	0.039	1.26
Receiving agricultural information (X_{12})	−1.680 **	0.733	−0.451	0.431	−0.093	0.487	−0.331	0.392	1.10
Membership in local farmers' association (X_{13})	−0.211	0.298	0.424	0.263	0.458	0.312	0.164	0.245	1.05
Location: Einme township (X_{14})	−0.380	0.368	0.343	0.326	0.605	0.426	0.314	0.311	1.54
Location: Warkhema township (X_{15})	0.093	0.402	0.381	0.339	−0.552	0.382	0.134	0.323	1.69

Source: Author.

Note: (1) AW = awareness. AW2 = Less attention is paid to rice production due to the small profit, AW4 = It is challenging to hire the required number of laborers when necessary, AW5 = Farmers cannot plant and harvest rice at the right time, and AW8 = Agricultural policies of the Ministry of Agriculture and Irrigation are unstable.

(2) Coef. = Coefficient, SE = Standard error, and VIF = Variance Inflation Factor.

(3) *** = significant at 1% level, ** = significant at 5% level, and * = significant at 10% level.

Table 4-10 shows that only seven independent variables: age, gender, farming experience, household size, income from crop production, farmland size, and receiving agricultural information were found to have a significant association with farmers' awareness. In personal characteristics, age and gender were determinants of AW2 (*Less attention is paid to rice production due to the small profit*) and AW8 (*Agricultural policies of the Ministry of Agriculture and Irrigation are unstable*). It is in line with Dhillon (2001) finding who mentioned that the age and gender of household demonstrate a positive correlation with awareness. And then, gender was positively correlated with AW4 (*It is challenging to hire the required number of laborers when necessary*) and AW5 (*Farmers cannot plant and harvest rice at the right time*). The results are in line with the finding of Oladeji et al. (2015). This is because most of the household heads were male, and they were more actively involved in farming than females. However, the farming experience was negatively correlated with AW8 (*Agricultural policies of the Ministry of Agriculture and Irrigation are unstable).* It is likely that farmers who have higher farming experience are likely less aware of agricultural policies.

Regarding economic characteristics, annual income from crop production was determinant of both AW2 (*Less attention is paid to rice production due to the small profit*) and AW8 (*Agricultural policies of the Ministry of Agriculture and Irrigation are unstable*), and it was a negative correlation with AW2 and AW8. It is likely that most farmers have received higher annual income from crop production because they have a larger farmland size. Thus, farmers who received higher annual income from crop production are less aware of low profit from rice production and agricultural policies. They were not aware that agricultural policies of the Ministry of Agriculture and Irrigation were unstable.

In farming characteristics, farmland size was a determinant of AW4 (*It is challenging to hire the required number of laborers when necessary*). It is in line with the finding of

Dhillon (2001). It explains that farmers, who have a larger farmland size, have a lower awareness of the problem of the hired labor force. This is likely because farmers, who have a larger farmland size, can easily hire labor force when they need labors in rice production since they can pay the wages before the rice-growing season.

On the other hand, AW4 (*It is challenging to hire the required number of laborers when necessary*) was positively associated with household size. This is likely because if they have more household members, all members will involve in rice production, and enabling them to operate farming practices efficiently.

For institutional characteristics, receiving agricultural information was the determinant of AW2 (*Less attention is paid to rice production due to the small profit),* and it was negatively correlated. It is likely that even though farmers have received agricultural information from the Department of Agriculture and agrochemical companies, they are less aware of low profit from rice production. Perhaps this is because they have received basic knowledge and did consider the benefit. It is of interest that location was not a significant determinant of farmers' awareness of the low yield of conventional rice production.

4.4 Conclusion

Among the three aspects of awareness, most farmers were aware of general risks as reasons for the low yield of conventional rice production. However, some farmers have low awareness of the other two aspects such as farmer's management and Ministry's management. In the aspect of farmer's management, only 66.7 % of farmers were aware of challenging labor force problems. In the aspect of Ministry's management, most farmers were not aware of agricultural extension services. Then, 43.5 % of farmers were not aware of agricultural policies. Among sample townships, Myaungmya Township showed the highest mean value of farmland size, annual income from crop production, and the number of contacts with extension workers per year. The mean values of these characteristics were significantly different and higher than those of the other two townships: Einme and Warkhema.

Based on their awareness of the low yield of conventional rice production, farmers were categorized into three Clusters. Among the three Clusters, most of the farmers were involved in Cluster 3 and showed a wider awareness. In this Cluster, farmers had large household size, received credit for crop production, and had membership in local farmers' associations.

According to the results of Binary Logit Model, seven independent variables: age, gender, farming experience, household size, income from crop production, farmland size, and receiving agricultural information were found to have a significant association with farmers' awareness of the low yield for conventional rice production.

Farmers' awareness of the low yield of conventional rice production can be increased through developing extension service programs to distribute useful information on rice production effectively.

Chapter 5: Farmers' Perception of Good Agricultural Practices in Rice Production in Ayeyarwady Region, Myanmar: A Case of Myaungmya District[13]

5.1 Introduction

Technology characteristic is one of the major driving forces to farmers' decisions on the adoption of technology (Jamal et al., 2014). In adoption studies, farmers' decisions to adopt a new technology depend on many complex factors. One factor is farmers' perception of the new agricultural technology (Negatu & Parikh, 1999; Bagheri et al., 2008; Emmanuel, 2014). Tatlidil et al. (2009) state that farmers' perception and farmers' characteristics are influential in the preliminary step of extension programs to promote sustainability of adoption among farmers. Farmers' perception of agricultural technology influences their decision to adopt that technology (Emmanuel, 2014). A better understanding of farmers' perception of technologies and their impacts on technology adoption will provide valuable information to technology providers (Thompson et al., 2018). Rogers and Shoemakers (1971) state that five characteristics (relative advantages, compatibility, complexity, trialability, and observability) of new technologies or products affect the adoption of them. Alonge and Martin (1995) say that farmers' perception of the compatibility of sustainable practices with their farming systems is the best predictor of adopting such practices. An Individual's perception of these five characteristics predicts the adoption of new technologies (Rogers, 2003).

Therefore, this dissertation aims at (1) clarifying the feature of farmers' perception of GAPs in rice production and (2) examining determinants of such farmers' perception of GAPs in rice production.

[13] This Chapter 5 was published in the article:
Paing Oo, S., & Usami, K. (2020) Farmers' Perception of Good Agricultural Practices in Rice Production in Myanmar: A Case Study of Myaungmya District, Ayeyarwady Region. *Agriculture*, 10 (7), 1-20. https://doi:10.3390/ agriculture10070249.

5.2 Analytical Methods

5.2.1 Framework and Variables

Not a few researchers define perception with different views. Rao et al. (1995) define perception as an interpretation of information. van den Ban and Hawkins (1974) define perception as the process, through which a man receives information or stimuli from his environment and transforms it into psychological awareness. Maswadi et al. (2018) say that farmers' perception is farmers' knowledge and behavior on something. Winardi (2004) says that perception is a cognitive process, where an individual gives meaning to the environment. Therefore, this dissertation defines perception as an understanding of the characteristics of GAPs in rice production. Herein, these characteristics of GAPs in rice production are relative advantages, compatibility, complexity, trialability, and observability. According to Rogers (1995), these five characteristics of technology play a crucial role in farmers' decision-making on technology adoption.

In this dissertation, farmers' perception of GAPs in rice production is supposed to be affected by two main factors: internal factors (personal characteristics, farming characteristics, and economic characteristics) and external factors (institutional characteristics) (Figure 5-1).

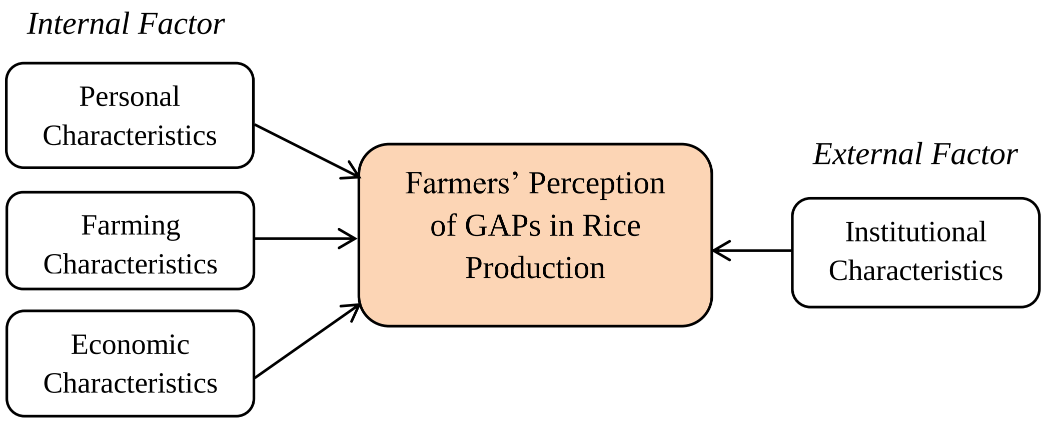

Figure 5-1 Conceptual framework of the study

Source: Author.

As shown in Table 5-1, the present study considers age, gender, marital status, education, farming experience, and household size as personal characteristics. Farming characteristics consist of farmland size and active labor force. Accesses to credit and income from crop production are considered as economic characteristics. Institutional characteristics involve contact with extension workers, receiving agricultural information, receiving GAPs in rice production training, membership in local farmers' association, and seed growers' association.

Table 5-1 List of internal and external factors

Independent Variable	Description	Sign
Personal characteristics		
Age	Age of household head (year)	AGE
Gender	1 for male; 0 otherwise	GEN
Marital status	1 for married; 0 otherwise	MST
Education	Years of formal schooling	EDU
Farming experience	Years of farming experience of household head in rice production	FEXP
Household size	Number of household members (person)	HHSIZE
Farming characteristics		
Farmland size	Size of farmland owned by household (ha)	FSIZE
Active labor force	Number of household members who are actively involved in rice production	LAB
Economic characteristics		
Access to credit	1 for the household head has access to credit; 0 otherwise	CRE
Income from crop production	Level of annual income from crop production: 1 for low (<6,000,000 kyat*), 2 for medium (6,000,000 to 10,000,000 kyat), 3 for high (>10,000,000 kyat)	INC
Institutional characteristics		
Contact with extension workers	Number of meetings per year in 2017 (time)	EXT
Receiving agricultural information	1 for received; 0 otherwise	INF
Receiving GAPs in rice production training	1 for received; 0 otherwise	RGAP
Membership in local farmers' associations	1 for member; 0 otherwise	MLFA
Membership in seed growers' associations	1 for member; 0 otherwise	MSGA

Source: Author.

Note: * = currency of Myanmar and 1 kyat = 0.00078 US$ (1 US$ = 1288.77 kyat, as of 1st November, 2020).

These characteristics are selected based on previous studies as follows. Bagheri et al. (2008) reveal a significant relationship between perceptions of selected sustainable agricultural technologies and characteristics such as age, education, farming experiences, farmland size, and contact with the information source. Maswadi et al. (2018) indicate that farmers' characteristics such as age, education, land area, and the number of family members positively influence farmers' perception of fermented cocoa bean technology. Banmeke and Ajayi (2008) adopt age, sex, education level, and farming experiences as explanatory variables for analysis on farmers' perception of the agricultural information resource center. Moreover, Pongvinyoo, Yamao, and Hosono (2014) say that age and cultivation area significantly influence current perceptions of GAPs, referring to coffee farmers. Meseret (2014) reveals that farmers' perception of soil and water conservation practices on cultivated land in Ethiopia is influenced by age, education, farmers' previous experience in soil and water conservation, contact to extension agents, and participation in soil and water conservation training. Ndambiri, Ritho, and Mbogoh (2013) use explanatory variables such as age, gender, education, farming experience, household size, farm income, extension services, and access to credit to analyze the evaluation of farmers' perceptions of and adaptation to the effects of climate change in Kenya. Sasima, Suneeporn, and Panya (2016) reveal that age, gender, education, marital status, member group, family member, family labor, farm size, and farming experience were determinants of farmers' perceptions of rice farming's economic sustainability. Pinthukas (2015) indicates that age, education level, number of the household labor force, farm income, and extension visit significantly contributed to farmers' perception of organic vegetable production. Mkuna and Mugula (2016) indicate that farmers' characteristics, such as age, education level, and household size, affect coping strategies perception of rice farmers in Tanzania. Abdul-Gafar et al. (2016) found that variables such as education, farming experience, and specialized training or extension programs were determinants of farmers' perception of production constraints.

5.2.2 Data Measurement

According to the key informant interview and pilot survey, the structured questionnaire survey was conducted by face to face interview. Five characteristics, such as relative advantages, compatibility, complexity, trialability, and observability of GAPs in rice production, were used to measure farmers' perception of GAPs in rice production. These five characteristics were essential in technology adoption study and played a crucial role in farmers' decision making (Rogers, 1995). Therefore, seventy statements (5 characteristics x 14 component technologies of GAPs in rice production) were prepared for the questionnaire. For example, all statements for GAP1 are shown in Table 5-2. Respondents were asked to indicate the extent of their agreement with the statement using a Likert-scale five-point continuum like strongly agree, agree, neither agree nor disagree, disagree, and strongly disagree with scores of 5, 4, 3, 2, and 1 being assigned, respectively (Agahi, Ghambarali, & Afsharzade, 2011; Banmeke & Ajayi, 2008; Eric, Lagat, Ithinji, Mutai, Kenneth, & Joseph, 2013; Hayran, Gul, & Saridas, 2018; Hosseini, Mohammadi, & Mirdamadi, 2011; Sasima et al., 2016; Shahpasand, 2014). Then, based on the score, respondents were categorized into two types: if the score is less than 4, they are "not perceive", while if equal to or greater than 4, being "perceive" (Bagheri, 2010; Eric et al., 2013). Cronbach's alpha was calculated to examine the reliability of data collected on farmers' perception of GAPs in rice production.

Table 5-2 Statements to measure farmers' perception of GAP1 (*Quality seeds*)

Characteristic	Statement
Relative advantage	A higher yield can be expected by using quality seeds.
Compatibility	It is compatible to use quality seeds for farmers.
Complexity	It is difficult for farmers to use quality seeds.
Trialability	Farmers can test the characteristics of quality seeds.
Observability	Farmers have a chance to observe the benefit of using quality seeds.

Source: Author.

5.2.3 Data Analysis

Descriptive analysis using average and standard deviation, percentage, variance, and comparison was carried out to observe the feature of farmers' perception of GAPs in rice production. Furthermore, farmers could be categorized based on their perception of GAPs in rice production through Principal Component Analysis (PCA) and then Cluster Analysis (CA). The former analysis enables to reduce the number of perception variables to several principal components to describe the feature of perception of GAPs in rice production for each cluster that could be derived from the later analysis.

Assuming that the dependent variable (Y_i) is "perceive" or "not perceive", the Binary Logit Model to analyze determinants of farmers' perception of GAPs in rice production is as follows (Acheampong et al., 2018; Ghulam et al., 2018; Maswadi et al., 2018):

$$Y_i = \begin{cases} 1 \text{ (perceive)} \\ 0 \text{ (not perceive)} \end{cases} \quad (5.1)$$

Supposing: P_i = probability of perceiving and $1 - P_i$ = probability of not perceive.

$$P_i = \frac{1}{1+e^{-Zi}} \quad (5.2)$$

$$1 - P_i = \frac{1}{1+e^{Zi}} \quad (5.3)$$

The equation for Binary Logit Model could be used as follows (Gujarati, 2012):

$$\frac{P_i}{1- P_i} = e^{\beta_i X_i + u_i} \quad (5.4)$$

$$l_n\left(\frac{P_i}{1- P_i} \right) = \beta_i X_i + u_i \quad , \quad i = 1, 2, 3, \ldots, n \quad (5.5)$$

where, X_i is the set of independent variables, β_i are the coefficients of independent variables, and u_i is an error term. This dissertation employed the following equation.

$$l_n\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 AGE + \beta_2\, GEN + \beta_3\, MST + \beta_4\, EDU + \beta_5\, FEXP + \beta_6 HHSIZE + \beta_7 FSIZE + \beta_8 LAB + \beta_9 CRE + \beta_{10} INC + \beta_{11} EXT + \beta_{12} INF + \beta_{13} RGAP + \beta_{14} MLFA + \beta_{15} MSGA + u_i \quad (5.6)$$

5.3 Results and Discussion

5.3.1 Farmers' Perception of GAPs in Rice Production

The summary of farmers' perception of GAPs in rice production is presented in Table 5-3. The data were reliable for the analysis because the value of Cronbach's alpha for data on farmers' perception of GAPs in rice production was 0.894 greater than 0.7. Hereinafter, the level of perception is defined as follows: (a) perceive = scores of 4 and 5, (b) not perceive = scores of 1, 2, and 3.

Relative advantage

Most farmers perceived that all component technologies of GAPs in rice production have a relative advantage since the mean of the score ($\overline{X}$) was more than 3.5. Among the 14 component technologies of GAPs in rice production, the means of the scores for GAP9 (*Alternative wetting and drying*), GAP12 (*Submerging*), and GAP14 (*Combine harvester*) were comparatively low compared with those of the other component technologies of GAPs in rice production.

Compatibility

Because the mean of the score was more than 3.5, GAP1 (*Quality seeds*), GAP4 (*Systematic care of nursery*), GAP7 (*Seedlings per hill*), GAP10 (*Pest and disease management*), and GAP12 (*Submerging*) were perceived to be compatible with their current farming practices. In contrast, farmers' perception of compatibility was low in six component technologies of GAPs in rice production: GAP3 (*Covering*), GAP5 (*Uprooting and Transplanting),* GAP6 (*Planting*

Table 5-3 Distribution of farmers who perceive and do not perceive GAPs in rice production

Component technology	Relative advantage			Compatibility			Complexity			Trialability			Observability		
	Percent of farmers		$\bar{X}$	Percent of farmers		$\bar{X}$	Percent of farmers		$\bar{X}$	Percent of farmers		$\bar{X}$	Percent of farmers		$\bar{X}$
	a	b		a	b		a	b		a	b		a	b	
GAP1	98	2	4.8	87	13	4.3	80	20	4.1	72	28	3.9	77	23	4.0
GAP2	96	4	4.7	59	41	3.5	80	20	4.0	94	6	4.5	95	5	4.5
GAP3	97	3	4.7	55	45	3.3	79	21	4.0	71	29	3.9	81	9	4.5
GAP4	100	0	4.9	61	39	3.6	74	26	3.8	80	20	4.1	93	7	4.5
GAP5	97	3	4.7	50	50	3.3	79	21	4.0	76	24	4.0	75	25	3.9
GAP6	96	4	4.8	35	65	2.8	79	21	4.0	72	28	3.7	70	30	3.7
GAP7	95	5	4.7	75	25	4.0	76	24	3.9	72	28	3.9	81	19	4.1
GAP8	99	1	4.8	52	48	3.4	70	30	3.7	73	27	3.9	71	29	3.7
GAP9	89	11	4.4	37	63	2.9	90	10	4.3	71	29	3.7	71	29	3.7
GAP10	93	7	4.6	80	20	4.1	91	9	4.3	72	28	3.9	89	11	4.3
GAP11	98	2	4.8	54	46	3.5	86	14	4.2	94	6	4.4	70	30	3.7
GAP12	87	13	4.3	81	19	4.1	85	15	4.1	74	26	3.9	89	11	4.3
GAP13	97	3	4.8	58	42	3.5	77	23	3.9	63	37	3.5	83	17	4.3
GAP14	77	23	4.1	56	44	3.4	72	28	3.7	94	6	4.4	92	8	4.4

Source: Author.

Note: (1) a = Percentage of farmers who perceive the characteristic, b = percentage of farmers who do not perceive the characteristic, and $\bar{X}$ = mean of scores.

(2) GAP1= *Quality seeds*, GAP2= *Sparse sowing*, GAP3= *Covering*, GAP4= *Systematic care of nursery*, GAP5= *Uprooting & transplanting*, GAP6= *Planting depth*, GAP7= *Seedlings per hill*, GAP8= *Plant population*, GAP9= *Alternate wetting & drying*, GAP10= *Pest & disease management*, GAP11= *Balanced inputs*, GAP12= *Submerging*, GAP13= *Drainage*, and GAP14= *Combine harvester*.

depth), GAP8 (*Plant population*), GAP9 (*Alternate wetting and drying*), and GAP14 (*Combine harvester*). It is of interest that there was a difference in the variance among the 14 component technologies.

Complexity

Since the mean of their scores was more than 3.5, most of the farmers perceived that all component technologies of GAPs in rice production have complexity. Among 14 component technologies of GAPs in rice production, relating to the percentage of farmers who perceive complexity, the highest was around 90 percent for GAP9 (*Alternative wetting and drying*) and GAP10 (*Pest and disease management*), while the lowest was around 70 % for GAP8 (*Plant population*) and GAP14 (*Combine harvester*).

Trialability

Because the mean of their scores was more than 3.5, except for GAP13 (*Drainage*), farmers perceived that almost all component technologies of GAPs in rice production could be easily tried on their farm. For GAP13 (*Drainage*), although its score was not low, 63 % of farmers perceived its trialability.

Observability

Most farmers perceived that all component technologies of GAPs in rice production have observability since the mean of the score was more than 3.5. Among 14 component technologies of GAPs in rice production, the highest percent (95 %) of farmers who perceived observability, was seen for GAP2 (*Sparse sowing*). In contrast, a comparatively low percent (70–71 %) of farmers perceived observability for GAP6 (*Planting depth*), GAP8 (*Plant population*), GAP9 (*Alternate wetting and drying*), and GAP11 (*Balanced inputs*).

Perception as a Whole

Farmers perceived that all component technologies of GAPs in rice production have three characteristics: relative advantages, complexity, and observability. Among 14 components of GAPs in rice production, the comparatively higher perception of compatibility was limited to GAP1 (*Quality seeds*), GAP4 (*Systematic care of nursery*), GAP7 (*Seedlings per hill*), GAP10 (*Pests and disease management*), and GAP12 (*Submerging*). Regarding trialability, the comparatively lower perception was limited to only GAP13 (*Drainage*), although 63 % of farmers perceived it.

According to the dendrogram (Figure 5-2) of Cluster Analysis by the hierarchical clustering method, the 14 component technologies of GAPs in rice production could be classified into three groups. Farmers' perception of GAPs in rice production for each Cluster is summarized in Table 5-4. Five component technologies, namely, GAP1 (*Quality seeds*), GAP7 (*Seedlings per hill*), GAP10 (*Pest and disease management*), GAP12 (*Submerging*), and GAP13 (*Drainage*) were found in Cluster 1. Farmers in Cluster 1 perceived all five characteristics because the score was more than 3.5. In Cluster 2, four component technologies that are related to nursery management and combine harvester were involved. Three component technologies, such as transplanting operations, water, and nutrient management, were classified as Cluster 3. Farmers had a low perception of compatibility for Cluster 2 and Cluster 3. All Clusters have a high perception of relative advantage.

Figure 5-2 Dendrogram of 14 component technologies of GAPs in rice production

Source: Author.

Table 5-4 Result of Cluster Analysis on 14 component technologies of GAPs in rice production

Cluster	Component technology		Mean value				
	Number	Kind	RA	COM	CPLEX	TR	OBS
1	5	GAP1, GAP7, GAP10, GAP12, and GAP13	4.64	4.00	4.06	3.82	4.20
2	4	GAP2, GAP3, GAP4, and GAP14	4.60	3.45	3.88	4.23	4.48
3	5	GAP5, GAP6, GAP8, GAP9, and GAP11	4.70	3.18	4.04	3.94	3.74

Source: Author.

Note: (1) RA = relative advantage, COM = compatibility, CPLEX = complexity, TR = trialability, and OBS = observability.

(2) GAP 1= *Quality seeds*, GAP2= *Sparse sowing*, GAP3= *Covering*, GAP4= *Systematic care of nursery*, GAP5= *Uprooting & transplanting*, GAP6= *Planting depth*, GAP7= *Seedlings per hill*, GAP8= *Plant population*, GAP9= *Alternate wetting & drying*, GAP10= *Pest & disease management*, GAP11= *Balanced inputs*, GAP12= *Submerging*, GAP13= *Drainage*, and GAP14= *Combine harvester*.

5.3.2 Classification of Farmers Based on Their Perception of GAPs in Rice Production

1) Common Factors of Perception of GAPs in Rice Production

Firstly, Principal Component Analysis (PCA) was applied to reduce the number of perception variables (5 characteristics x 14 component technologies = 70) to several principal components (common factors) to describe the feature of perception of GAPs in rice production concisely. In PCA, the Kaiser-Meyer-Olkin (KMO)[14] test was used to determine that the data was suited for the analysis. Since the value of KMO was 0.828, and Bartlett's Sphericity test was significant at 1% level, the collected data were useable for PCA. The result of varimax-rotated factor analysis (Table 5-5) shows that there are sixteen common factors of farmers' perception of GAPs in rice production. These common factors explained 71.487 % of the variance (Appendix 5, Part B2). These sixteen common factors can be given a label based on the factor loading of a significant variable. Common factors of farmers' perception of GAPs in rice production are as follows:

CF1: Trialability of GAPs

The result shows that in the first common factor (CF1), 14 out of 70 variables were classified as "trialability of GAPs in rice production". This means that farmers' perception of trialability of all component technologies of GAPs in rice production is considered as one common factor and explain14.879 % of the variance.

CF2: Advantages of GAPs (Except Submerging & Harvester)

The second common factor (CF2) account 6.5 % of the variance and is named advantages of GAPs in rice production because variables involved in the perception of relative advantages of GAPs in rice production (except for two components–submerging and using combine harvester) were observed in this factor.

[14] KMO is used to measure sampling adequacy.

Table 5-5 Rotated factor matrix of farmers' perception

Farmers' perception	Factors		
	Factor loading	**Variance explained (%)**	**Eigenvalues**
Trialability of GAPs (CF1)		14.879	10.415
Trialability of quality seeds	0.915		
Trialability of sparse sowing	0.933		
Trialability of covering	0.883		
Trialability of systematic care of the nursery	0.542		
Trialability of uprooting & transplanting	0.641		
Trialability of planting depth	0.762		
Trialability of seedlings per hill	0.830		
Trialability of plant population	0.836		
Trialability of alternate wetting & drying (AWD)	0.853		
Trialability of pest & disease management	0.837		
Trialability of balanced inputs	0.826		
Trialability of submerging	0.853		
Trialability of drainage	0.896		
Trialability of the combine harvester	0.893		
Advantages of GAPs (except submerging & harvester) (CF2)		6.500	4.550
Relative advantages of quality seeds	0.640		
Relative advantages of sparse sowing	0.577		
Relative advantages of covering	0.706		
Relative advantages of systematic care of the nursery	0.668		
Relative advantages of uprooting & transplanting	0.631		
Relative advantages of planting depth,	0.683		
Relative advantages of seedlings per hill	0.445		
Relative advantages of plant population	0.637		
Relative advantages of alternate wetting & drying	0.531		
Relative advantages of pest & disease management	0.357		
Relative advantages of balanced inputs	0.507		
Relative advantages of drainage	0.550		
Visible results of using nursery, pest management, submerging & harvester (CF3)		5.408	3.786
Observability of sparse sowing	0.864		
Observability of systematic care of the nursery	0.822		
Observability of pest & disease management	0.808		
Observability of submerging	0.783		
Observability of combine harvester	0.774		
Compatible with sowing, transplanting, inputs & drainage (CF4)		5.125	3.587
Compatibility of sparse sowing	0.895		
Compatibility of uprooting & transplanting	0.610		
Compatibility of plant population	0.832		
Compatibility of balanced inputs	0.837		

Compatibility of drainage	0.887		
Visible results of using quality seeds, transplanting, AWD & inputs (CF5)		4.552	3.186
Observability of quality seeds	0.857		
Observability of uprooting & transplanting	0.838		
Observability of alternate wetting & drying	0.829		
Observability of balanced inputs	0.811		
Complexity of nursery, population & harvester (CF6)		4.543	3.180
Complexity of systematic care of the nursery	0.906		
Complexity of plant population	0.901		
Complexity of combine harvester	0.905		
Complexity of sowing, planning depth, pest management & submerging (CF7)		4.405	3.084
Complexity of sparse sowing	0.826		
Complexity of planting depth	0.841		
Complexity of pest & disease management	0.711		
Complexity of submerging	0.783		
Complexity of quality seeds, transplanting, AWD & inputs (CF8)		4.151	2.905
Complexity of quality seeds	0.918		
Complexity of uprooting & transplanting	0.903		
Complexity of alternate wetting & drying	0.584		
Complexity of balanced inputs	0.827		
Compatible with quality seeds, seedling number, pest management & submerging (CF9)		4.056	2.839
Compatibility of quality seeds	0.818		
Compatibility of seedlings per hill	0.787		
Compatibility of pest & disease management	0.787		
Compatibility of submerging	0.791		
Compatible with covering, depth, AWD & harvester (CF10)		3.944	2.761
Compatibility of covering	0.832		
Compatibility of planting depth	0.738		
Compatibility of alternate wetting & drying	0.728		
Compatibility of the combine harvester	0.867		
Complexity of covering, seedling number & drainage (CF11)		3.670	2.569
Complexity of covering	0.801		
Complexity of seedlings per hill	0.783		
Complexity of drainage	0.798		
Visible results of using covering, seedling number & drainage (CF12)		3.213	2.249
Observability of covering	0.833		
Observability of seedlings per hill	0.813		
Observability of drainage	0.791		
Advantage of harvester & benefit of population (CF13)		1.950	1.365

Relative advantages of the combine harvester	0.602		
Observability of plant population	0.335		
Visible results of using planting depth (CF14)		1.748	1.223
Observability of planting depth	0.725		
Advantage of submerging (CF15)		1.719	1.204
Relative advantages of submerging	0.609		
Compatibility of nursery (CF16)		1.624	1.137
Compatibility of systematic care of the nursery	0.702		
Total variance explained		71.487	

Source: Author.

Note: (1) Perception variables were taken in common factor when factor loading is over 0.3 and eigenvalues are over 1.

(2) Kaiser- Meyer- Olkin of sampling adequacy (KMO) = 0.828.

(3) CF = common factor and AWD = alternate wetting and drying.

CF3: Visible Results of Using Nursery, Pest Management, Submerging, and Harvester

In CF3, observability of five component technologies–sparse sowing (0.864), systematic care of nursery (0.822), pest and disease management (0.808), submerging (783), and combine harvester (0.774) –are observed, and it explains 7.916 % of the variance.

CF4: Compatible with Sowing, Transplanting, Inputs, and Drainage

Common factor CF4 explains 5.125 % of the variance with five variables, namely, compatibility of sparse sowing (0.895), compatibility of transplanting (0.61), compatibility of plant population (0.832), compatibility of balanced inputs (0.837), and compatibility of drainage (0.887).

CF5: Visible Results of Using Quality Seeds, Transplanting, AWD, and Inputs

In CF5, observability of four component technologies–quality seeds (0.857), uprooting and transplanting (0.838), alternate wetting and drying (AWD) (0.829), and balanced inputs (0.811) –are observed, and it explains 4.552 % of the variance.

CF6: Complexity of Nursery, Population, and Harvester

CF6 explains 4.543 % of the variance and contains three variables: systematic care of nursery (0.906), plant population (0.901), and combine harvester (0.905).

CF7: Complexity of Sowing, Planting Depth, Pest Management, and Submerging

CF7 describes 4.405 % of the variance, and four variables are integrated into this CF: sparse sowing (0.826), planting depth (0.841), pest and disease management (0.711), and submerging (0.783).

CF8: Complexity of Quality Seeds, Transplanting, AWD, and Inputs

Four variables–quality seeds (0.918), uprooting and transplanting (0.903), alternate wetting and drying (AWD) (0.584), and balanced inputs (0.827) –are contained in CF8 and it explains 4.151 % of the variance.

CF9: Compatible with Quality Seeds, Seedling Number, Pest Management, and Submerging

CF9 explains 4.056 % of the variance and consists of four variables. These are compatibility of quality seeds (0.818), compatibility of seedlings per hill (0.787), compatibility of pest and disease management (0.787), and compatibility of submerging (0.791).

CF10: Compatible with Covering, Planting Depth, AWD, and Harvester

CF10 explains 3.944 % of the variance, and four variables are found in this CF. These are compatibility of covering (0.832), compatibility of planting depth (0.738), compatibility of alternate wetting and drying (AWD) (0.728), and compatibility of a combine harvester (0.867).

CF11: Complexity of Covering, Seedling Number, and Drainage

The result shows that 3.670 % of the variance and three variables–soil covering (0.801), seedlings per hill (0.783) and drainage (0.798) –are integrated into this CF.

CF12: Visible Results of Using Covering, Seedling Number, and Drainage

CF12 explains 3.213 % of the variance and observability of three-component technologies occur in this CF. These are observability of covering (0.833), observability of seedlings per hill (0.813), and observability of drainage (0.791).

CF13: Advantages of Harvester and Benefit of Population

CF13 explains 1.950 % of the variance and two variables–the relative advantage of the combined harvester and benefit of the population–occur in this CF. These variables are relative advantage of combine harvester (0.602), and observability of plant population (0.335).

CF14: Visible Results of Using Planting Depth

The result showed that one variable–planting depth (0.725) – is occurred in this CF, which explains the variance of 1.748 %.

CF15: Advantages of Submerging

The result shows that 1.719 % of the variance and one variable –submerging (0.609) –is occurred in this CF.

CF16: Compatible with Nursery

The common factor CF16 explains 1.624 % of the variance and contains only one variable: compatibility of systematic care of nursery (0.702).

2) Result of Cluster Analysis

Based on sixteen common factors of farmers' perception of GAPs in rice production, farmers were categorized into groups by Cluster Analysis. Data from PCA were utilized in Cluster Analysis. According to the dendrogram (Figure 5-3) of Cluster Analysis by the hierarchical clustering method, farmers could be classified into three groups. This implies that Cluster 3 is different from Clusters 1 and 2, while Cluster 1 and Cluster 2 are similar. The mean of CF was assumed to be above 0.000 "high perception" because most of the mean values are less than 1. The accurate perception of GAPs in rice production for each Cluster is summarized in Table 5-6.

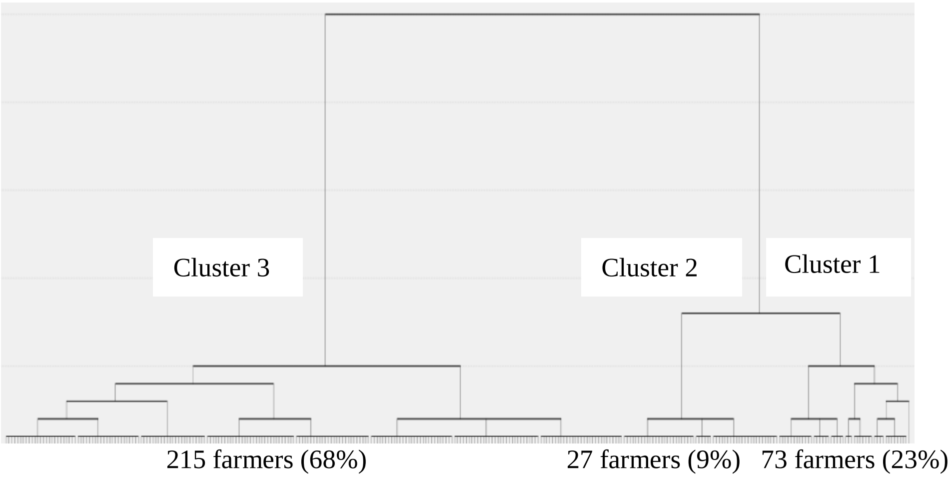

Figure 5-3 Dendrogram of farmers in terms of their perception of GAPs in rice production

Source: Author.

Cluster 1 (73 farmers: 23 %)

Compared with Cluster 2, remarkable differences are found in CF2 (relative advantage), CF4 (compatibility), CF1 (trialability), and CF3 and CF5 (observability). However, "the lowest perception of CF1 but the highest perception of CF3" is featured.

Cluster 2 (27 farmers: 9 %)

Similarly comparing with Cluster 1, remarkable differences are found in CF2 (relative advantage), CF4 and CF9 (compatibility), CF7 (complexity), CF1 (trialability), and CF3 and CF5 (observability). "The lowest perception of CF3 and CF5 and the lower perception of CF1" is featured. In addition, the other CFs show a contrast like the mean is positive and negative.

Cluster 3 (215 farmers: 68 %)

The perception, on the whole, was neither high nor low, but comparing with others (Clusters 1 and 2), it is a feature that only CF1 (trialability) was highly perceived.

Table 5-6 Farmers' perception of GAPs in rice production by Clusters (based on Cluster Analysis*)

Cluster	No. of farmers (%)	Mean values (Standard deviation)															
		Relative advantages (3 CFs)			**Compatibility (4 CFs)**				**Complexity (4 CFs)**				**Trialability (1 CF)**	**Observability (4 CFs)**			
		CF2	**CF13**	**CF15**	**CF4**	**CF9**	**CF10**	**CF16**	**CF6**	**CF7**	**CF8**	**CF11**	**CF1**	**CF3**	**CF5**	**CF12**	**CF14**
1	73 (23%)	0.471 (2.749)	-0.011 (1.273)	-0.011 (0.963)	0.435 (2.315)	0.110 (1.718)	0.148 (1.510)	-0.010 (0.957)	-0.002 (2.045)	0.135 (1.995)	-0.084 (1.800)	0.014 (1.405)	-5.096 (1.773)	1.348 (2.092)	0.327 (2.166)	0.046 (1.139)	-0.036 (0.932)
2	27 (9%)	-0.574 (1.649)	0.237 (1.164)	-0.055 (1.673)	-0.355 (2.073)	-0.419 (1.400)	0.677 (1.375)	0.123 (1.084)	-0.119 (1.757)	0.510 (1.698)	0.000 (1.657)	0.219 (1.724)	-1.985 (2.737)	-5.192 (1.918)	-1.495 (2.396)	-0.039 (1.651)	-0.120 (1.381)
3	215 (68%)	-0.088 (2.363)	-0.026 (1.030)	0.011 (0.950)	-0.103 (1.818)	0.015 (1.394)	-0.135 (1.256)	-0.012 (1.035)	0.016 (1.597)	-0.110 (1.467)	0.029 (1.390)	-0.032 (1.240)	1.980 (1.526)	0.194 (1.467)	0.077 (1.502)	-0.011 (1.127)	0.027 (1.051)

Source: Author.

Note: (1) * = Cluster Analysis by hierarchical clustering method.

(2) CF = common factor.

(3) CF1= Trialability of GAPs, CF2= Advantages of GAPs (except submerging & harvester), CF3= Visible results of using nursery, pest management, submerging and harvester, CF4= Compatible with sowing, transplanting, inputs and drainage, CF5= Visible results of using quality seeds, transplanting, AWD and inputs, CF6= Complexity of nursery, population and harvester, CF7= Complexity of sowing, planting depth, pest management and submerging, CF8= Complexity of quality seeds, transplanting, AWD and inputs, CF9= Compatible with quality seeds, seedling number, pest management and submerging, CF10= Compatible with covering, planting depth, AWD and harvester, CF11= Complexity of covering, seedling number and drainage, CF12= Visible results of using covering, seedling number and drainage, CF13= Advantages of harvester and benefit of population, CF14= Visible results of using planting depth, CF15= Advantages of submerging, and CF16= Compatible with nursery.

5.3.3 Determinants of Farmers' Perception of GAPs in Rice Production

As shown in Table 5-3 above, relating to 5 characteristics of GAPs in rice production, the significant variance in terms of the percentage of farmers (less than 60%)[15] was limited to the compatibility of nine component technologies of GAPs in rice production such as GAP2 (*Sparse sowing*), GAP3 (*Covering*), GAP5 (*Uprooting & transplanting*), GAP6 (*Planting depth*), GAP8 (*Plant population*), GAP9 (*Alternate wetting & drying*), GAP11 (*Balanced inputs*), GAP13 (*Drainage*), and GAP14 (*Combine harvester*). Therefore, the compatibility of these nine component technologies of GAPs in rice production was selected as dependent variables of the Binary Logit Model (Table 5-7). Since values of variance inflation factors (VIFs) for independent variables were less than 5 (maximum value = 2.70), there was no multicollinearity among the independent variables (Appendix 5, Part B4).

Table 5-7 indicates that only eight independent variables were found to have a significant association with farmers' perception of the compatibility of GAPs in rice production, while there was no influencing factor on farmers' perception of the compatibility of GAP2 (*Sparse sowing*), GAP5 (*Uprooting and Transplanting*), and GAP9 (*Alternate wetting and drying*). These variables were gender and education of household head, farmland size, access to credit, income from crop production, contact with extension workers, receiving agricultural information, and receiving GAPs in rice production training. Among these, contact with extension workers and receiving agricultural information were positively associated with farmers' perception of the compatibility of GAPs in rice production.

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[15] The significant variance was observed at 9 component technologies of GAPs in rice production: GAP2, GAP3, GAP5, GAP6 GAP8, GAP9, GAP11 GAP13, and GAP14. The range of variance in terms of the percentage of farmers was 35 through 59 percent. The detailed percentages of farmers' perception of these 9 component technologies are 59, 55, 50, 35, 52, 37, 54, 58, and 56, respectively.

Table 5-7 Estimated coefficients of Binary Logit Model for the compatibility of GAPs in rice production

Independent Variables	GAP2		GAP3		GAP5		GAP6		GAP8		GAP9		GAP11		GAP13		GAP14		VIF
	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	Coef.	SE	
Constant	1.150	1.374	0.109	1.155	0.226	1.109	−2.131	1.157	2.111	1.414	−1.739	1.227	1.208	1.143	0.266	0.979	0.682	1.175	-
Age	0.015	0.016	0.007	0.015	0.010	0.015	0.023	0.016	0.005	0.015	0.006	0.015	−0.002	0.015	0.009	0.015	0.009	0.015	2.70
Gender	−1.682	1.120	−0.552	0.823	−0.663	0.794	0.027	0.795	−2.416**	1.196	0.564	0.880	−0.408	0.814	−0.451	0.209	−1.034	0.881	1.12
Marital Status	0.002	0.623	0.142	0.604	−0.160	0.585	−0.124	0.614	0.897	0.641	0.581	0.699	−0.159	0.606	0.145	0.643	−0.050	0.598	1.17
Education	−0.010	0.039	0.048	0.039	−0.007	0.038	0.021	0.040	−0.078*	0.040	−0.010	0.040	−0.071*	0.039	−0.045	0.040	−0.009	0.038	1.21
Farming experience	−0.013	0.014	0.006	0.013	−0.019	0.013	−0.008	0.013	−0.012	0.013	0.007	0.013	−0.005	0.013	−0.014	0.014	0.004	0.013	2.40
Household size	−0.120	0.111	−0.078	0.111	−0.060	0.109	0.046	0.114	−0.135	0.112	0.789	0.112	−0.087	0.110	−0.103	0.112	0.034	0.109	2.32
Farmland size	−0.005	0.011	−0.025**	0.013	−0.003	0.011	−0.001	0.012	−0.008	0.012	−0.017	0.014	−0.004	0.012	0.001	0.012	−0.014	0.012	1.73
Active labor force	0.147	0.147	0.113	0.132	0.064	0.130	0.056	0.136	0.065	0.135	0.001	0.134	0.005	0.132	0.176	0.137	0.050	0.131	2.61
Access to credit	−0.029	0.443	−0.901*	0.472	0.555	0.442	−0.023	0.473	−0.669	0.461	−0.389	0.450	0.179	0.441	−0.275	0.452	−0.648	0.446	1.09
Income from crop production	−0.036	0.174	0.004	0.174	0.112	0.170	0.026	0.178	0.140	0.175	0.004	0.179	−1.180	0.172	−0.303*	0.175	0.084	0.171	1.53
Contact with extension workers	0.030	0.039	0.133**	0.054	0.040	0.038	0.050	0.037	0.019	0.037	0.010	0.039	0.040	0.038	0.040	0.041	0.081*	0.045	1.28
Receiving agricultural information	0.602	0.376	0.371	0.381	0.056	0.369	0.127	0.389	0.791**	0.395	−0.140	0.379	0.602	0.378	0.365	0.383	0.127	0.373	1.10
Receiving GAP in rice production training	−0.240	0.289	0.031	0.291	−0.361	0.284	−0.88***	0.322	−0.275	0.90	−0.163	0.298	−0.424	0.288	0.019	0.289	−0.170	0.284	1.21
Membership in local farmers' association	0.204	0.253	0.027	0.252	−0.048	0.248	0.231	0.259	0.288	0.254	−0.140	0.257	0.222	0.252	0.193	0.254	−0.131	0.248	1.17
Membership in seed growers' association	0.735	0.532	0.271	0.496	0.483	0.483	−0.093	0.512	0.788	0.517	0.116	0.504	0.632	0.501	0.880	0.539	0.160	0.480	1.24
Pseudo R^2		0.214		0.475		0.220		0.377		0.785		0.221		0.412		0.635		0.271	-

Source: Author.

Note: (1) Coef. = coefficient, SE = standard error, and VIF = variance inflation factor.

(2) *** = significant at 1% level, ** = significant at 5% level, and * = significant at 10% level.

(3) GAP2= *Sparse sowing*, GAP3= *Covering*, GAP5= *Uprooting & transplanting*, GAP6= *Planting depth*, GAP8= *Plant population*, GAP9= *Alternate wetting & drying*, GAP11= *Balanced inputs*, GAP13= Drainage, and GAP14= *Combine harvester*.

(4) Pseudo R^2 shows the fitness of the model.

Regarding personal characteristics, gender and education of household head were determinants of farmers' perception of the compatibility of GAP8 (*Plant population*). Gender showed a negative determinant of farmers' perception of the compatibility of GAP8. The result contradicts the finding of Banmeke and Ajayi (2008). Male farmers show a negative association with their perception of the compatibility of GAP8 (*Plant population*). This is likely because male farmers perceive that the recommended plant population is not compatible for transplanting labor. Education negatively predicted farmers' perception of the compatibility of GAP8 (*Plant population*) and GAP11 (*Balanced inputs*). The result implies that the probability of farmers' perception of the compatibility of GAP8 (*Plant population*) and GAP11 (*Balanced inputs*) is lower for more highly educated farmers compared to less educated farmers.

In farming characteristics, farmland size showed a negative correlation with only farmers' perception of the compatibility of GAP3 (*Covering*). This coincides with previous findings of Bagheri et al. (2008) and Uddin, Bokelmann, and Dunn (2017), and is likely because larger farms require more time, experience, and management capacity to apply farmyard manure on the seedbed.

Regarding economic characteristics, access to credit was a determinant of only farmers' perception of the compatibility of GAP3 (*Covering*), which shows a negative relationship and being in line with the finding of Ndambiri et al. (2013). It means that farmers with access to credit were less likely to perceive the compatibility of GAP3 (*Covering*). Similarly, crop production income was negatively correlated with only farmers' perception of the compatibility of GAP13 (*Drainage*). This contradicted the finding of Uddin et al. (2017). The result implies that farmers who had higher income from crop production do not perceive the compatibility of timely drainage before two weeks of harvesting.

Among institutional characteristics, determinants of farmers' perception of the compatibility of GAPs of rice were found for GAP3 (*Covering*), GAP6 (*Planting depth*), GAP8 (*Plant population*), and GAP14 (*Combine harvester*). Contact with extension workers was positively correlated with farmers' perception of the compatibility of GAP3 (*Covering*) and GAP14 (*Combine harvester*), which is in line with the findings of Allahyari, Chizari, and Homaee (2008) and Moges and Taye (2017). It implies that the improvement of their agricultural knowledge gained through such contact increases the probability of farmers' perceiving compatibility of GAP3 and GAP14. Additionally, receiving agricultural information was positively associated with farmers' perception of the compatibility of GAP8 (*Plant population*), which is in line with the finding of Eric et al. (2013). Agricultural information likely helps farmers to understand the compatibility of GAP8. Meanwhile, there was a negative and significant (at 1% level) relationship between receiving GAPs of rice training and farmers' perception of the compatibility of GAP6 (*Planting depth*), though being contradicted with the finding of Uddin et al. (2017). It is because farmers are afraid that the controlling depth of planting depth at transplanting time highly depends on the skillfulness of transplanting laborer.

5.4 Conclusion

This dissertation revealed that almost all farmers perceived that all components of GAPs in rice production have three characteristics, namely, relative advantage, complexity, and observability. In the perception of compatibility, among 14 component technologies of GAPs in rice production, farmers perceived that GAP1 (*Quality seeds*), GAP4 (Systematic care of nursery), GAP7 (*Seedlings per hill*), GAP10 (*Pest and disease management*), and GAP12 (*Submerging*) were compatible with their current farming practices. Based on the structure of farmers' perception of GAPs in rice production, farmers were classified into three groups. Sixteen common factors were summarized based on farmers' perception of GAPs in rice production. Among five characteristics, farmers' perception of trialability of all component technologies is considered as one common factor while three to four common factors were described by other four characteristics (i.e., relative advantage, compatibility, complexity and observability). The meaningful variances in perception among farmers were identified in "trialability" (CF1) and " two common factors of observability," that is, CF3 and CF5.

According to the result of the Binary Logit Model, farmers' perception was significantly influenced by eight variables: gender, education, farmland size, access to credit, income from crop production, contact with extension workers, receiving agricultural information, and receiving GAPs in rice production training. Some agricultural policies and extension activities are needed to enhance farmers' perception of the compatibility of six components, namely, GAP3 (*Covering*), GAP6 (*Planting depth*), GAP8 (*Plant population*), GAP11 (*Balanced inputs*), GAP13 (*Drainage*), and GAP14 (*Combine harvester*). First, the implementation of GAPs in rice production should focus mainly on low-income farmers who own small amounts of farmland. Second, MOAI should reform the credit plan for farmers, who wish to adopt GAPs in rice production, for example, by increasing the amount of credit for rice production with a low-interest rate. Third, extension workers should have regular contact with farmers to enhance farmers' perception of the compatibility of GAPs in rice production. Finally, more agricultural information should be provided, especially for farmers, who have larger farms and higher incomes, concerning the advantages of using GAPs in rice production.

Chapter 6: Farmers' Adoption Process of Good Agricultural Practices in Rice Production in Ayeyarwady Region, Myanmar: A Case Study of Myaungmya District

6.1 Introduction

Most of the studies on agricultural technology adoption were conducted on awareness and adoption, perception and adoption, or attitude and adoption, focusing on socio-economic determinants of adopting technology (Bagheri et al., 2008; Hasan et al., 2012; Simon et al., 2013). They covered only part of the adoption process, considering that farmers' awareness, perceptions, and attitudes play a crucial role in the adoption of technology (Adageba et al., 2008; Sichali & Banda, 2017). Despite some previous studies aiming at answering the question of the low adoption of technologies, the empirical evidence for the linkage in the adoption process for GAPs in rice production is scant. To ensure the sustainability of technology adopted as well as enhance the adoption of technology, the linkage or sequence of awareness, perception, attitude, and adoption as a process must be a focal point. It makes possible to identify which part of the decision-making process could be in trouble.

Therefore, this dissertation aims at (1) measuring the level of farmers' awareness, perception, attitude, and adoption of GAPs in rice production and (2) clarifying the structure of farmers' decision making behind adopting GAPs in rice production as a process.

6.2 Analytical Methods

6.2.1 Framework and Variables

Seline et al. (2015) purport that the adoption of technology is mainly influenced by three intrinsic variables such as knowledge, perception, and attitude. Rogers and Shoemakers (1971) state that awareness, perception, attitude, and adoption are essential stages in the adoption process. Meanwhile, Igene et al. (2015) take awareness, perception, and adoption as stages of the process, excluding the stage of attitude. Some studies define attitude as a decision of technology (Adageba et al., 2008; Sichali & Banda, 2017). However, some studies (Liu et al., 2009; Tosuntas et al., 2015) state that attitude is proposed as an essential predictor for the adoption of technology. The present study defines adoption as being structured in the order of awareness, perception, attitude, and adoption (Figure 6-1).

Awareness is defined as a state of knowing reasons for the low yield of conventional rice production. If farmers are adequately aware of reasons for the low yield of conventional rice production, they can go through the process of adopting appropriate technologies of GAPs in rice production.

Perception is defined as an understanding of the characteristics of technology. Herein, these characteristics are relative advantage (RA), compatibility (COM), complexity (CPLEX), trialability (TR), and observability (OBS) (Rogers & Shoemakers, 1971).

The definition of attitude has been presented in various ways. Krech and Crutchfield (1984) defines attitude as an enduring combination of motivational, emotional, perceptual, and cognitive processes concerning some aspect of our environment. Alleng and Ng (2003) defines attitude as a person’s evaluation of the psychological object. Attitude is determined as beliefs that are salient or important to a person. Attitude is formed by what an individual perceives to be right about attitude-object. Many beliefs and values may underpin an object (Willock, Deary, McGregor, Sutherland, Edward-Jones, & Morgan, 1999). Attitude is defined as negative or positive feelings of an individual about executing a behavior (Ajzen,1991; Franzoi, 2000; Fishbein & Ajzen, 1975). This dissertation defines attitude as farmer’s negative or positive feelings about GAPs in rice production. Takahiro et al. (2014) state that GAPs are a set of farming practices that address environmental, economic, and social

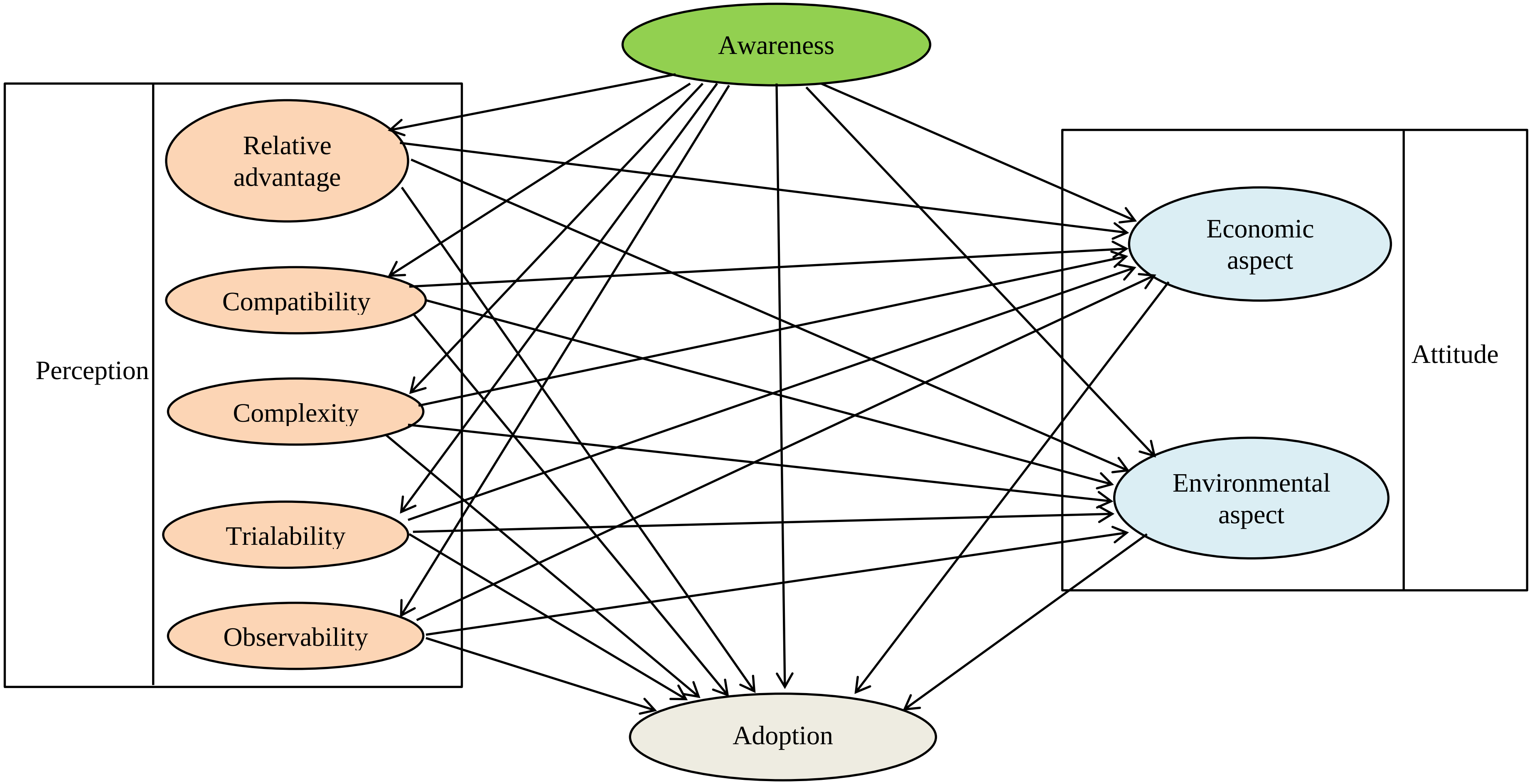


Figure 6-1 Conceptual framework for adoption process

Source: Rogers and Shoemakers (1971).

sustainability for on-farm processes and results in safe and high-quality food and non-food products. However, Hobbs (2003) reveals that economic incentives for individual farmers to adopt GAPs broadly increase or stabilize revenue and reduce costs. Gifford and Sussman (2012) mention that environmental attitude is crucial because it often determines behavior that increases or decreases environmental quality. Therefore, this dissertation takes two aspects of attitude (i.e., economic attitude and environmental attitude) into account.

Lastly, adoption can be defined as a decision on applying innovation since Rogers and Shoemakers (1971) define adoption as accepting or starting to use something new. In the case of this dissertation, this occurs when farmers adopt one or more component technologies of GAPs in rice production.

6.2.2 Data Measurement

The field survey was conducted from July to August 2018. Based on the pilot survey and key informant interviews, the structured questionnaires were prepared to conduct face to face interviews. Awareness, perception, and attitude were measured by the five-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree and strongly disagree) assigning scores of 5, 4, 3, 2, and 1 respectively (Agahi et al., 2011; Banmeke & Ajayi, 2008; Eric et al., 2013; Hayran et al., 2018; Hosseini et al., 2011; Sasima et al., 2016; Shahpasand, 2014). Adoption was measured by answering “Yes or No” to each of component technology of GAPs in rice production. The questionnaire for farmers’ awareness consisted of ten statements (Table 4-2 of Chapter 4) to look into reasons for the low yield of conventional rice production. As mentioned in Chapter 5, seventy statements were prepared to measure farmers’ perception of GAPs in rice production (Table 5-2).

Attitude to new technology is a socio-psychological factor that affects technology adoption behavior (Li et al., 2020). Most people accept that many small-scale farmers could benefit from using GAPs (FAO, 2004). Therefore, farmers' economic attitude to GAPs in rice production influences their adoption of GAPs in rice production. Environmental attitude is a psychological tendency expressed by evaluating responses to the natural environment with some degree of favor or disfavor (Milfont & Duckitt, 2010). Since GAPs in rice production consists of 14 component technologies, farmers' attitude to GAPs in rice production is measured by 28 variables: 2 aspects (economic aspect and environmental aspect) x 14 component technologies, while 14 variables were used to measure the adoption of GAPs in rice production. As an example, all statements used to measure attitude and adoption of GAP1 (*Quality seeds*) are shown in Table 6-1.

Table 6-1 Statements to measure attitude and adoption of GAP1 (*Quality seeds*)

Item	Statement
Economic aspect	Higher profit can be expected by using quality seeds.
Environmental aspect	Using quality seeds can reduce the infestation of pest and disease.
Adoption	Have you applied quality seeds in rice production?

Source: Author.

6.2.3 Data Analysis

Descriptive analysis using average, standard deviation, percent, and variance was used to clarify the features of awareness, perception, attitude, and adoption. Structural Equation Modeling (SEM) was applied to analyze the relationships among awareness, perception, attitude, and adoption as a structure of decision making on adoption (Figure 6-1). In general, SEM enables researchers to test hypotheses of relationships among variables. There are two types of SEM: covariance-based SEM (CB-SEM), and variance-based SEM (VB-SEM), or Partial Least Square SEM (PLS-SEM)[16]. From the viewpoint of properness, covariance-based SEM was adopted for this dissertation because the sample size is larger than 100. The validity

[16] Partial Least Square SEM is suitable for small size (n=30 to 100) of samples.

of data was measured using composite reliability, average variance extracted, and Cronbach's alpha. SPSS and Stata 13 software processed the collected data.

6.3 Results and Discussion

Since the results of farmers' awareness and perception are shown in Table 4-4 (Chapter 4) and Table 5-3 (Chapter 5), respectively, herein, firstly attitude and adoption are referred to.

6.3.1 Farmers' Attitude to GAPs in Rice Production

The values of Cronbach's alpha for data on economic aspect and environmental aspect were 0.818 and 0.934, respectively, meaning the variables are reliable for analysis. Based on scores, farmers are categorized into two groups; (a) the first group = Likert scale of 4 and 5, (b) the second group = Likert scale of 1, 2, and 3. Farmers' attitude to GAPs in rice production is shown in Table 6-2.

Since the mean of scores ($\overline{X}$) more than 3.5 indicates a "positive attitude," more than 70 percent of farmers had a positive economic attitude to GAPs in rice production except for GAP7 (*Seedlings per hill*) and GAP12 (*Submerging*). Farmers are afraid that single seedling per hill (GAP7) could not reduce the cost of seeds because quality seeds are expensive, and it requires them to fill missing hills. As for GAP12 (*Submerging*), farmers explain that they could not manage well the irrigation system. Meanwhile, similarly based on the mean of scores more than 3.5, more than 70 % of farmers had a positive environmental attitude to GAPs in rice production, regardless of kinds of component technologies.

6.3.2 Farmers' Adoption of GAPs in Rice Production

As shown in Table 6-2, the adoption rate of GAPs in rice production was more than 50 % in six component technologies of GAPs in rice production: GAP1 (*Quality seeds*) 66 %, GAP4 (*Systematic care of nursery*) 61 %, GAP10 (*Pest & disease management*) 51%, GAP11

Table 6-2 Distribution of farmers in their attitude and adoption by component technologies of GAPs in rice production

Component technology	Attitude						Adoption
	Economic aspect			Environmental aspect			
	Percent of farmers		$\bar{X}$	Percent of farmers		$\bar{X}$	Percent of farmers
	a	b		a	b		
GAP1	95	5	4.67	89	11	4.39	66
GAP2	96	4	4.67	71	29	3.97	26
GAP3	89	11	4.47	89	11	4.39	20
GAP4	91	9	4.52	71	29	3.97	61
GAP5	92	8	4.59	89	11	4.39	30
GAP6	95	5	4.65	71	29	3.95	29
GAP7	57	43	3.41	72	28	3.96	29
GAP8	90	10	4.46	89	12	4.39	37
GAP9	88	12	4.42	71	29	3.97	42
GAP10	91	9	4.55	95	5	4.62	51
GAP11	94	6	4.61	97	3	4.78	61
GAP12	58	42	3.46	88	12	4.38	36
GAP13	97	3	4.67	70	30	3.96	73
GAP14	77	23	4.07	71	29	3.97	70

Source: Author.

Note: (1) a = Percent of farmers who have a positive attitude, b = percent of farmers who have a negative attitude, and $\bar{X}$ = mean of scores.

(2) GAP1 = *Quality seeds*, GAP2 = *Sparse sowing*, GAP3 = *Covering*, GAP4 = *Systematic care of nursery*, GAP5 = *Uprooting & transplanting*, GAP6 = *Planting depth*, GAP7 = *Seedlings per hill*, GAP8 = *Plant population*, GAP9 = *Alternate wetting & drying*, GAP10 = *Pest & disease management*, GAP11 = *Balanced inputs*, GAP12 = *Submerging*, GAP13 = *Drainage*, and GAP14 = *Combine harvester*.

(*Balanced inputs*) 61 %, GAP13 (*Drainage*) 73 %, and GAP14 (*Combine harvester*) 70 %. In contrast, the other eight component technologies of GAPs in rice production each accounted for less than 50 %. The main reasons why they had not adopted GAPs in rice production are that they are likely to be laborious and time-consuming. Most farmers are willing to continue using conventional methods because the profit is not quite different from that of the transplanting method (Appendix 6).

1) Problems Facing in Rice Production

Problems that farmers are facing in rice production are shown in Table 6-3. Supposing that, farmers are categorized into two groups, such as adopters[17] and non-adopters[18]. Among twelve problems that farmers are facing in rice production, according to *t*-value, significant differences were observed in the first eight problems of adopters and non-adopter. The first and second problems for both adopters and non-adopters were (i) poor irrigation and drainage system and (ii) labor scarcity. The third problem was heavy rain at harvesting time for adopters (40.91 %), while for non-adopters (29.07%) was decreasing rice yield. The problems such as inadequate amount of quality seeds and low price of rice were not faced by adopters because they can produce quality seeds on their farms and also sell rice with higher price (Appendix 7).

Table 6-3 Problems that farmers are facing in rice production

Problem	Adopters (n = 88)		Non-adopters (n = 227)		*t*-value
	Number	Percent	Number	Percent	
Poor irrigation and drainage system	57	64.77	98	43.17	3.5472***
Labor scarcity	53	60.23	82	36.12	3.9234***
Heavy rain at harvesting time	36	40.91	29	12.78	4.9186***
Pest and diseases infestation	27	30.68	43	18.94	2.1003**
Not enough machines in village	23	26.14	34	14.98	2.1153**
Farm road is terrible and too far from main road	23	26.14	10	4.41	4.4309***
Uneven land leveling	15	17.05	6	2.64	3.5435***
Decreasing rice yield	14	15.91	66	29.07	-2.6598***
Not enough investment for rice production	14	15.91	34	14.98	0.0231
Lack of technical knowledge	4	4.55	5	2.20	0.7686
Inadequate amount of quality seeds	0	0	3	1.32	-1.9398
Low price of rice	0	0	2	0.88	-1.4174

Source: Author.
Note: *** = significant at 1% level and ** = significant at 5% level.

[17] Among 14 component technologies, if farmers adopted more than 7, they were identified as GAPs adopters.
[18] If farmers adopted equal or less than 7 component technologies, they were non-adopters.

2) Reasons for Adopting GAPs in Rice Production

Reasons for adopting GAPs in rice production are shown in Table 6-4. Five reasons were identified, and more than 90 % of adopters pointed that higher yield and higher rice price could be obtained by adopting GAPs in rice production. Some farmers mentioned that they had received credit for rice production with adopting 38.64% GAPs in rice production. Around 30 % of adopters understood that pests and disease infestation could be reduced by adopting GAPs in rice production. 17.05 % of adopters mentioned that GAPs in rice production provide easy uprooting and reduce seedling injury. The feature of reasons for adopting GAPs in rice production is higher profit from rice production.

Table 6-4 Reasons for adopting GAPs in rice production

Reason	Number (n =88)	Percent
Higher yield of rice	85	96.59
Receive higher price of rice	83	94.32
Easy access to credit	34	38.64
Reduce pest and disease infestation	24	27.27
Comfortable in uprooting and reduce injury	15	17.05

Source: Author.

3) Reasons for Not Adopting GAPs in Rice Production

As shown in Table 6-5, there were ten reasons for not adopting GAPs in rice production. The first reason is “not enough machines in the village.” Fifty-four farmers (23.79 % of non-adopters) said that there were not enough machines in the village for land preparation and harvesting of rice. Some farmers said that if they need, they hire machines from other villages. Sometime, they were requested to wait for a few weeks or months. Around 16 to 22 % of non-adopters mentioned that they are not willing to adopt GAPs in rice production because of pests and disease infestation, high production costs, and difficulties of irrigation and drainage system. Around 4 to 9 % of non-adopters said they do not like to adopt

Table 6-5 Reasons for not adopting GAPs in rice production

Reason	Number (n=227)	Percent
Not enough machines in village	54	23.79
Infestation of pest and disease	50	22.03
High cost of production	48	21.15
Difficulties of Irrigation and drainage systems	37	16.30
Lack of knowledge	20	8.81
Yield is not different from the conventional method	15	6.61
Labor scarcity	12	5.29
Laborious to use	12	5.29
Prefer conventional farming practices	11	4.85
Poor land leveling	10	4.41
No idea	96	42.29

Source: Author.

GAPs in rice production because of lack of knowledge, no difference in rice yield, labor scarcity, laborious practices, more preferring conventional farming practices and poor land leveling. However, 42.29 % of non-adopters could not answer their reasons for not adopting GAPs in rice production. The feature of reasons for not adopting GAPs in rice production is high investment for rice production.

6.3.3 Measurement Model (Reliability Test)

As shown in Figure 6-1, nine latent variables were adopted to analyze the adoption process. In SEM, it is first necessary to examine the structural validity to determine that selected indicators are accurately measured by the questionnaire (Rezaei et al., 2017). For this dissertation, it means determining whether statements are correctly selected for measuring latent variables or not. This operation, hereinafter, was carried out in three stages as follows:

Checking Factor Loading

Factor loading values of statements (indicators) are shown in Table 6-6. As for the ten statements to measure awareness, factor analysis shows that three statements were precisely connected to the awareness because the value of the loading factor was greater than 0.70. Similarly, 2 out of 14 statements for the perception of relative advantage, 12 out of 14 statements for the perception of compatibility, 13 out of 14 statements for the perception of complexity, 12 out of 14 statements for the perception of trialability, and 3 out of 14 statements for the perception of observability, are retained for the next step of the analysis. Then, 9 out of 14 statements for the economic attitude, and 12 out of 14 statements for the environmental attitude were proven to be effective variables.

Table 6-6 Result of factor loading for statements of awareness, perception, attitude, and adoption of GAPs in rice production

Awareness	Perception					Attitude		Adoption
	RA	**COM**	**CPLEX**	**TR**	**OBS**	**EC**	**ENV**	
0.337[a]	0.626[a]	0.870	0.922	0.944	0.953	0.302[a]	0.951	0.677[a]
0.650[a]	0.506[a]	0.903	0.820	0.951	0.897	0.343[a]	0.987	0.835
0.375[a]	0.722	0.878	0.888	0.897	0.878	0.894	0.953	0.787
0.480[a]	0.785	0.403[a]	0.917	0.559[a]	0.854	0.867	0.986	0.548[a]
0.709	0.514[a]	0.617[a]	0.900	0.644[a]	0.928	0.927	0.947	0.738
0.892	0.661[a]	0.734	0.832	0.759	0.215[a]	0.886	0.987	0.741
0.842	0.371[a]	0.763	0.893	0.833	0.811	0.962	0.986	0.824
0.478[a]	0.528[a]	0.828	0.910	0.837	0.765	0.610[a]	0.952	0.765
0.469[a]	0.434[a]	0.728	0.605[a]	0.865	0.885	0.368[a]	0.987	0.564[a]
0.445[a]	0.626[a]	0.799	0.744	0.846	0.799	0.948	0.316[a]	0.704
-	0.467[a]	0.839	0.835	0.833	0.861	0.898	0.311[a]	0.737
-	0.488[a]	0.811	0.788	0.865	0.778	0.961	0.946	0.576[a]
-	0.451[a]	0.891	0.899	0.907	0.830	0.370[a]	0.984	0.696[a]
-	0.588[a]	0.900	0.924	0.912	0.806	0.989	0.987	0.436[a]

Source: Author.

Note: (1) RA = Relative advantage, COM = Compatibility, CPLEX = Complexity, TR = Trialability, OBS = Observability, EC = Economic aspect, and ENV = Environmental aspect.

(2) a = Since factor loading value is less than 0.70, the statement is discarded in the analysis of SEM.

Reliability and Validity of Latent Variables

In the second stage, composite reliability (CR), average variance extracted (AVE), and Cronbach's alpha were examined to determine the validity and reliability of the Structural Equation Modeling (Table 6-7). The values of Cronbach's alpha and composite reliability (CR) were higher than 0.7, meaning that the measurement tool is reliable. Then, all values of

Table 6-7 Indicators of reliability and validity of latent variables

Latent Variables	Cronbach's Alpha	Composite Reliability (CR)	Average Variance Extracted (AVE)
Awareness	0.750	0.86	0.67
Perception			
- Relative advantage	0.837	0.72	0.57
- Compatibility	0.780	0.96	0.69
- Complexity	0.872	0.98	0.75
- Trialability	0.966	0.97	0.76
- Observability	0.820	0.97	0.72
Attitude			
- Economic aspect	0.818	0.98	0.85
- Environmental aspect	0.934	0.99	0.94
Adoption	0.889	0.86	0.61

Source: Author.

the average variance extracted (AVE) for nine latent variables show that the data were reliable for the Structural Equation Modeling.

Fitness of Structural Equation Modeling

In the last stage of reliability test, Goodness of Fit Index (GFI), Normed Fit Index (NFI), Non-normed Fit Index (NNFI), Incremental Fit Index (IFI), Comparative Fit Index (CFI), Root Mean Residual (RMR), Standardized Root Mean Square Residual (RMSR) and Root Mean Square Error of Approximation (RMSEA) were used to evaluate the Structural Equation Modeling (Rezaei et al., 2017). Values of GFI, NFI, NNFI, IFI, and CFI for the Structural Equation Modeling were above 0.9 (Table 6-8), meaning that the Structural Equation Model is well fitted.

Table 6-8 Indicators of fit for Structural Equation Modeling

Fitness indicator	Calculated value	Suggested value	Reference
Goodness of Fit Index	0.93	> 0.90	Hair, Black, Babin, Anderson, and Tatham (2006)
Normed Fit Index	0.92	≥ 0.90	Hu and Bentler (1999)
Non-normed Fit Index	0.98	≥ 0.90	Rezaei et al. (2017)
Incremental Fit Index	0.92	≥ 0.90	Rezaei et al. (2017)
Comparative fit Index	0.94	> 0.90	Hu and Bentler (1999)
Root Mean Residual	0.06	< 0.08	Hair et al. (2006)
Standardized Root Mean Square Residual	0.07	< 0.08	Rezaei et al. (2017)
Root Mean Square Error of Approximation	0.07	< 0.08	Hair et al. (2006)

Source: Author.

Likewise, as the values of RMR, RMSR, and RMSEA were less than 0.08 (suggested value), the Structural Equation Modeling furthermore demonstrates good fit.

6.3.4 Analysis of Structural Equation Modeling (Path Coefficients)

As a result of SEM analysis, the path coefficients of Structural Equation Modeling are shown in Table 6-9. The output of Structural Equation Modeling is also attached in Appendix 5, Part C. Among structural relationships, awareness was correlated with perception of compatibility, perception of trialability, and perception of observability at 1 % significance level, but the perception of relative advantage was at 5 % significance level.

Table 6-9 Path coefficients of Structural Equation Modeling

Variable		Coefficient	Standard error
Relative advantage	Awareness	0.375**	0.168
Compatibility	Awareness	1.264***	0.420
Complexity	Awareness	0.382	0.278
Trialability	Awareness	2.644***	0.812
Observability	Awareness	2.748***	0.834
Economic aspect	Awareness	2.013**	0.940
Environmental aspect	Awareness	1.950**	0.898
Adoption	Awareness	-1.412	1.080
Economic aspect	Relative advantage	0.086	0.093
Economic aspect	Compatibility	-0.020	0.059
Economic aspect	Complexity	-0.055	0.045
Economic aspect	Trialability	-0.186*	0.092
Economic aspect	Observability	-0.170	0.107
Environmental aspect	Relative advantage	0.340**	0.166
Environmental aspect	Compatibility	-0.174	0.092
Environmental aspect	Complexity	-0.055	0.045
Environmental aspect	Trialability	-0.174*	0.092
Environmental aspect	Observability	-0.176	0.107
Adoption	Relative advantage	0.015	0.050
Adoption	Compatibility	0.111**	0.043
Adoption	Complexity	-0.066**	0.027
Adoption	Trialability	0.200**	0.097
Adoption	Observability	0.154	0.108
Adoption	Economic aspect	0.185	0.122
Adoption	Environmental aspect	0.119	0.084

Source: Author.

Note: *** = significant at 1% level, ** = significant at 5% level, and
* = significant at 10% level.

Farmers' awareness had a positive relationship with two aspects of attitude at 5 % significant level. The result is supported by Aminrad et al. (2013). They found a significant relationship between respondents' awareness and attitude, but there was no relationship between awareness and adoption. It is contradicted the finding of Acheampong et al. (2018), which found that farmers' awareness significantly influenced the adoption of new varieties.

Farmers' perception of trialability was negatively correlated with both economic attitude and environmental attitude at 10 % significance level, while farmers' perception of relative advantage had a positive relationship with environmental attitude. Out of 5 characteristics of GAPs in rice production, perception of compatibility, complexity, and trialability showed a relationship with adoption at 5 % significance level, though only the perception of complexity had a negative relation. Alonge and Martin (1995) mention that farmers' perception of compatibility of sustainable practices with their farming systems is the best predictor of the adoption of such practices. Rogers and Shoemakers (1971) reveal that perception of complexity is negatively correlated with adoption of new technology.

It is of interest that there was no relationship between attitude and adoption in the case of GAPs in rice production. The result coincides with the finding of Wichadee (2015), when they revealed that there was no significant relationship between faculty members' attitudes and the adoption of a learning management system in Thailand. However, there was no previous finding related with the linkage of farmers' attitude and their adoption of technology.

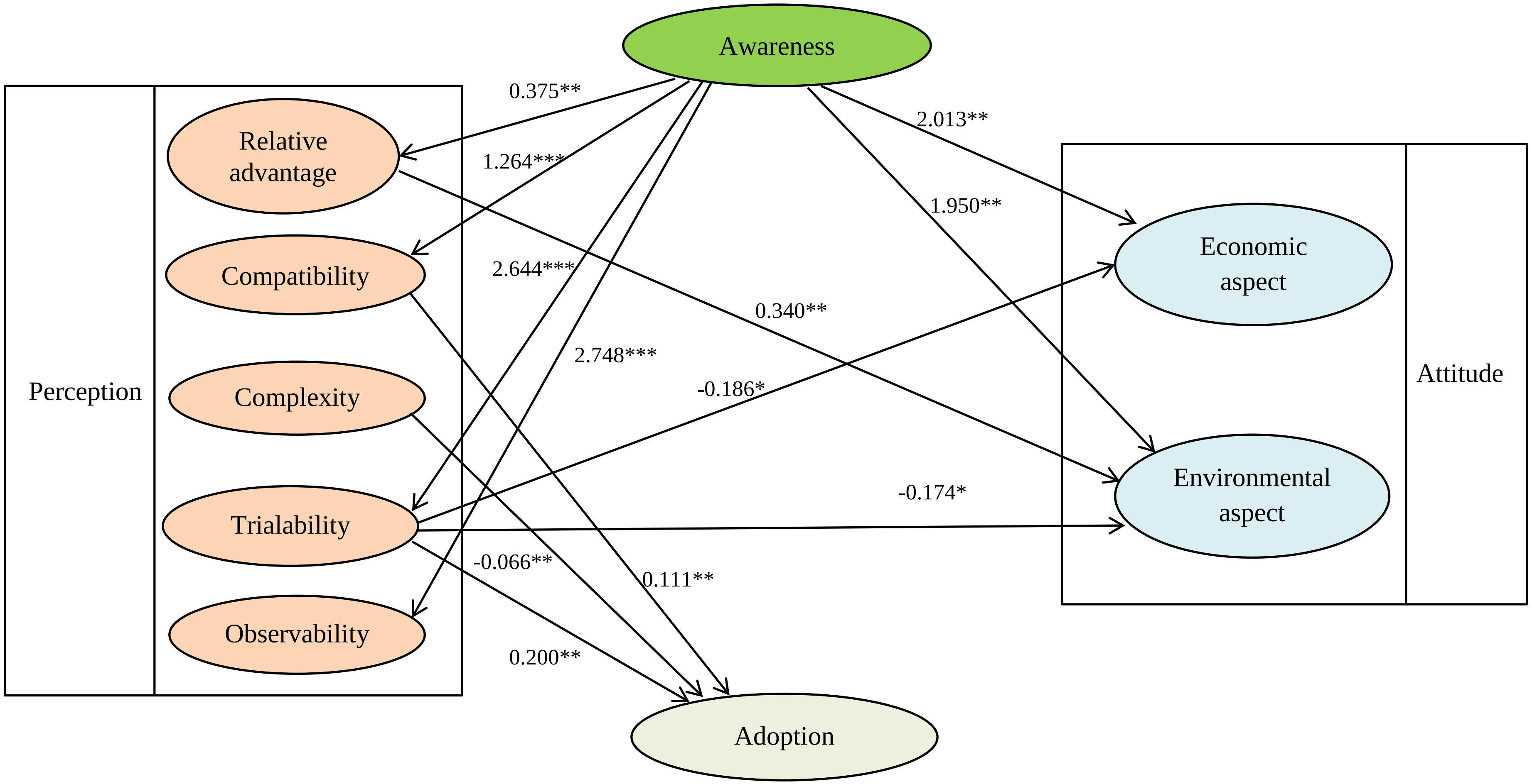


Figure 6-2 Result of Structural Equation Modeling

Note: (1) ⟶ = significant relationship.
(2) *** = significant at 1% level, ** = significant at 5% level, and * = significant at 10% level.

6.4 Conclusion

Almost all farmers had a positive environmental attitude to GAPs in rice production. Forty-two to forty-three percent of farmers have a negative economic attitude to only two components; GAP7 (*Seedlings per hill*) and GAP12 (*Submerging*) while most farmers had a positive economic attitude to the other component technologies. Farmers are afraid that single seedling per hill (GAP7) could not reduce the cost of seeds because quality seeds are expensive and require filling missing hills. As for GAP12 (*Submerging*), farmers explain that they could not easily manage the irrigation system.

Even though GAPs in rice production is a package of technology, farmers can adopt each component technology based on their preference because all component technologies are independent of each other. Therefore, farmers adopt component technologies according to their own decision. Most farmers adopted only six-component technologies (GAP1, GAP4, GAP10, GAP11, GAP13, and GAP14) of GAPs in rice production.

From the viewpoint of decision making on adopting GAPs in rice production, two adoption processes were identified through structural relationships. These processes are:

a) Awareness → perception of compatibility → adoption, and

b) Awareness → perception of trialability → adoption.

It is worth saying as follows: There is no linkage between attitude and adoption, though awareness can proceed to attitude by going through perception. Awareness is directly linked to attitude. Farmers' perception of GAPs in rice production is a crucial stage in the structure of the adoption process. The study provides information for agricultural extension workers to understand how farmers decide the adoption of GAPs in rice production. Even though farmers have a positive attitude to GAPs in rice production, there is no linkage between farmers' attitude and adoption.

Farmers' awareness, perception, attitude, and adoption were essential aspects of adopting component technology of GAPs in rice production. According to the adoption process, there were many possible adoption processes from awareness to adoption. This research pointed out that only two adoption processes and reasons for the low adoption rate of GAPs in rice production were as follows:

(i) Farmers had low awareness of the reasons for the low yield of conventional rice production. There was no linkage between awareness and adoption,

(ii) There were only a few linkages between perception and attitude, and

(iii) Farmers' attitude to component technologies of GAPs in rice production was not involved in the adoption process.

Chapter 7: Conclusions and Policy Recommendations

7.1 Conclusions

When a new technology is introduced, there can be many challenges to adopt it smoothly, particularly in its early stage. Introducing component technologies of GAPs in rice production in Myanmar is no exception.

There are plenty of possible reasons for the low adoption rate of GAPs in rice production. One of them is that farmers are not convinced well to set decision-making on adopting GAPs in rice production in order. Therefore, a good understanding of the characteristics of component technologies and connections among awareness, perception, attitude, and adoption is the key to boosting and sustaining the adoption of GAPs in rice production.

Generally, as reasons for the low yield of rice production by conventional cultivation, most farmers had significant awareness of general risks, whereas some farmers had low awareness of farmer's management and the Ministry's management. In farmer's management, only two-thirds of farmers were aware of challenges to hiring the required number of laborers when necessary. In the Ministry's management, a significantly low level of awareness was observed concerning agricultural policy and extension services. Among sample townships, farmers in Myaungmya Township had relatively lower awareness of challenges to hiring the required number of laborers when necessary, low soil fertility, and impractical extension services for increasing rice yield compared to those in the other townships: Einme and Warkhema. This finding underscores the importance of convincing farmers that it is challenging to tackle such problems with low rice yield awareness. In this respect, the extension service plays an indispensable role in raising farmers' awareness of reasons for the low yield of conventional rice production.

Farmers' characteristics influenced their awareness of reasons for the low yield of conventional rice production. This dissertation found that farmers' awareness was negatively associated with farming experience. Likewise, farmers with higher income levels, larger landholding size, and better access to agricultural information had low awareness. Furthermore, farmers with more farming experience were content with the return from conventional rice production. A larger landholding size provided farmers with enormous total production and hence a higher income. Accordingly, this made them less aware of the low yield of conventional rice production. According to farmers, even though they received agricultural information, this was perceived unhelpful for their rice production.

Almost all farmers perceived that all component technologies of GAPs in rice production had relative advantages. Out of 14 component technologies of GAPs in rice production, farmers perceived that GAP1 (*Quality seeds*), GAP4 (*Systematic care of nursery*), GAP7 (*Seedlings per hill*), GAP10 (*Pest & disease management*), and GAP12 (*Submerging*) are compatible with their current farming practices. Farmers recognized that all component technologies of GAPs in rice production except for GAP13 (*Drainage*) could be easily tried on their farm as a trial. However, they found some complexity with practically applying all component technologies of GAPs in rice production on their farms on a large scale even though they had perceived these component technologies' advantages. Farmers' perceptions of GAPs in rice production were summarized into sixteen common factors, and their perception of trialability of all component technologies is considered as the first common factor (CF1) which could explain 14.879% of the variance of farmers' perception. Based on the structure of farmers' perception of GAPs in rice production, farmers were categorized into three Clusters. Farmers' perception of trialability (CF1) was a significant difference among the three Clusters. Observability of four component technologies such as nursery, pest, water management, and combine harvester (CF3) were different among the three Clusters. Then, observability of quality seeds, transplanting, alternate wetting, and drying and balance inputs (CF5) was a significant difference among the three Clusters. According to the result of the Binary Logit Model, farmers' perception of compatibility of GAPs (but limiting to GAP2, GAP3, GAP5, GAP6, GAP8, GAP9, GAP11, GAP13, and GAP14) in rice production was significantly influenced by eight factors: gender, education, farmland size, access to credit, income from crop production, contact with extension workers, receiving agricultural information, and receiving GAPs in rice production training.

It is an encouraging point that farmers had both positive economic attitude and environmental attitude to GAPs in rice production. Such compatible component technologies of GAPS in rice production as quality seeds, systematic care of nursery, pest and disease management, balanced inputs, drainage, and combine harvester were adopted by more than 50% of farmers.

From the viewpoint of decision making on the adoption of GAPs in rice production, two adoption processes were identified through structural relationships. These processes were

(i) Awareness → perception of compatibility → adoption, and

(ii) Awareness → perception of trialability → adoption.

The feature of adoption process could be pointed out as follows:

(i) No linkage between awareness and adoption,

(ii) No linkage between attitude and adoption, and

(iii) Perception of relative advantage and observability did not link to adoption.

This dissertation highlights the practical farmers' adoption processes for component technologies of GAPs in rice production. According to Rogers and Shoemakers (1971), there are many possible adoption processes. The dissertation found that two adoption processes of farmers for GAPs in rice production coincide with the result of Rogers and Shoemakers (1971). In adopting new agricultural technology, Smathers (1982) and Herath and Wijekoon (2013) founded one adoption process of farmers, such as perception, attitude, and adoption. In this dissertation, farmers' awareness focused on actual problem (i.e. low yield of conventional rice production) while Rogers and Shoemakers (1971) mentioned it as awareness of technology. Among five characteristics of GAPs in rice production, two characteristics (compatibility and trialability) were involved in adoption processes as farmers' perception.

7.2 Policy Recommendations

This dissertation is vitally important for policymakers and agricultural extension workers to thoroughly know farmers' adoption processes for GAPs in rice production. The findings imply that current extension service programs need to be improved to disseminate GAPs in rice production to farmers. Farmers' awareness can be increased by developing extension service programs such as Hybrid Rice Program, Integrated Pest Management Program, etc. to effectively distribute useful information on rice production. Some findings help agricultural extension workers select target groups, especially farmers who have larger farmland size and higher income from crop production, to benefit from extension service programs.

Farmers' perception of the compatibility of five component technologies, such as GAP3 (*Covering*), GAP8 (*Plant population*), GAP11 (*Balanced inputs*), GAP13 (*Drainage*), and GAP14 (*Combine harvester*), is needed to improve. MOALI should encourage farmers who have larger farmland size to improve the perception of the compatibility of GAP3 (*Covering*). To increase the perception of compatibility of GAP8 (*Plant population*), agricultural extension workers should provide information regarding how to attain recommended plant population for one hectare of rice farm. In this case, farmers are suggested to hire skillful transplanting laborers with the help of agricultural extension workers. Farmers' education is essential to enhance the perception of the compatibility of GAP11 (*Balanced inputs*). Educated farmers easily understand that the balanced application of fertilizers would increase the efficiency of applied fertilizers. Therefore, agricultural extension workers should provide training on fertilizer management with farmers. Agricultural extension workers should pay attention to high-income farmers to improve the perception of the compatibility of GAP13 (*Drainage*). MOALI should operate land consolidation for farmers to increase the perception of compatibility of GAP14 (*Combine harvester*).

42-43% of farmers had a negative economic attitude to two component technologies (GAP7: *Seedlings per hill* and GAP12: *Submerging*) of GAPs in rice production, while most farmers had a positive economic attitude to the other component technologies. MOALI should provide information on the advantages of using single seedling per hill and submerging at active tillering stage so that farmers can minimize their negative economic attitude to two components such as GAP7 and GAP12.

Since some component technologies of GAPs in rice production, such as nursery management, crop management, and water management, are labor-intensive technologies, these are more suitable for small-landholder farmers. Therefore, so that large-landholder farmers should be motivated and encouraged to adopt component technologies of GAPs in rice production, agricultural extension workers should help them prepare work schedules and estimate labor requirements for rice production. DOA should provide agricultural extension services such as farm and home visit, field demonstration, etc. with farmers so that their economic attitude and environmental attitude to GAPs in rice production involve in adoption process and increase adoption rate.

7.3 Limitation of the Dissertation

This dissertation is not free from limitations. The first is the number of statements to measure farmers' awareness, perception, attitude, and adoption of GAPs in rice production. In this regard, it might be narrow that only one statement was prepared for one component technology of GAPs in rice production. The second is concerned with the analytical approach. Since GAPs in rice production is a package of technologies, but its component technologies are inter-related and farmers can individually decide to accept or reject component technologies, some technologies' adoption process might be different from others. Therefore, in this dissertation, it is likely that Structural Equation Modeling should have analyzed GAPs in rice production on the basis of grouping component technologies.

References

Abdoulaye, T., & Sanders, J. H. (2005). Stages and Determinants of Fertilizer Use in Semiarid African Agriculture. The Nigeria Experience. *Agricultural Economics, 32*, 167-179.

Abdulai, A., & Huffman, W. E. (2014). The Diffusion of New Agricultural Technologies: The Case of Crossbred-Cow Technologies in Tanzania. *American Journal of Agricultural Economics*, *87*(3), 645-659.

Abdulai, A., Owusu, V., & Goetz, R. (2011). Land Tenure Differences and Investment in Land Improvement Measures: Theoretical and Empirical Analyses. *Journal of Economic Development*, *96*(1), 66-78.

Abdul-Gafar, A., Xu, S., & Yu, W. (2016). Perceptions of Rice Farmers towards Production Constraints: Case Study of Niger State of Nigeria and Hainan of China. *Journal of Agricultural Chemistry and Environment*, *5*, 20-30. https://doi.org/10.4326/jacen.2016.51B004.

Acheampong, P. P., Amengor, N. E., Nimo-Wiredu, A., Adogoba, D., Frimpong, B. N., Haleegoah, J., & Adu- Appiah, A. (2018). Does Awareness Influence the Adoption of Agricultural Technologies? The Case of Improved Sweet Potato Varieties in Ghana. *Ghana Association of Agricultural Economists (GAAE)2nd GAAE Conference 9th - 11th August 2018*.

Adageba, R. K., Danso, K. A., Adusu-Donkor, A., & Ankobea- Kokroe, F. (2008). Awareness and Perceptions of and Attitudes towards Caesarean Delivery among Antenatal. *Ghana Medical Journal*, *42*(4), 137-140.

Agahi, H., Ghambarali, R., & Afsharzade, N. (2011). Wheat Farmers' Perceptions of Sustainable Agriculture: The Case of Kermanshah Province of Iran. *Researches of the*

First International Conference (Babylon and Razi Universities), *2072-3875*, 74-80.

Ahmad, J., Noor, S. M., & Ismail, N. (2015). Investigating Students' Environmental Knowledge, Attitude, Practice and Communication. *Asian Social Science*, *11*(16), 284-293. https://doi.org/10.5539/ass.v11n16p284.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Akkaya, F., Yalcin, R., & Ozkan, B. (2006). Good Agricultural Practices (GAP) and Its Implementation in Turkey. *Acta Horticulture*, *699*, 47-52. https://doi: 10.17660/ActaHortic.2006.699.3.

Allahyari, M. S., Chizari, M., & Homaee, M. (2008). Perceptions of Iranian Agricultural Extension Professionals toward Sustainable Agriculture Concepts. *Journal of Agriculture and Social Science*, *4*(3), 101-106.

Alleng, M. W., & Ng, H. S. (2003). Human Values, Utilitarian Benefits and Identification: The Case of Meat. *Europe Journal of Social Psychology*, *33*(11), 37-56.

Alonge, A. J., & Martin, R. A. (1995). Assessment of the Adoption of Sustainable Agriculture Practices: Implications for Agricultural Education. *Journal of Agricultural Education*, *3*(3), 34-42.

Aminrad, Z., Zakarayia, S. Z. B. S., Hadi, A. S., & Sakari, M. (2013). Relationship between Awareness, Knowledge and Attitudes towards Environmental Education among Secondary School Students in Malaysia. *World Applied Sciences Journal*, *22*(9), 1326-1333.

ARO (Ayeyarwady Regional Office). (2017). *Regional Record of 2016-17*. Ayeyarwady Region, Department of Agriculture, Ministry of Agriculture, Livestock, and Irrigation.

ARO (Ayeyarwady Regional Office). (2018). *Regional Record of 2017-18*. Ayeyarwady

Region, Department of Agriculture, Ministry of Agriculture, Livestock, and Irrigation.

Azmi, F. R., Musal, H., Abdullah, A. R., Othman, N. A., & Fam, S. (2017). Analyzing the Awareness of Green Technology in Malaysia Practices. *Proceedings of Mechanical Engineering Research Day*, 252-254.

Bagheri, A. (2010). Potato Farmers' Perceptions of Sustainable Agriculture: The Case of Ardabil Province of Iran. *Procedia Social and Behavioral Sciences*, *5*, 1977-1981. https://doi.org/10.1016/j.sbspro.2010.07.399.

Bagheri, A., Fami, H. S., Rezvanfar, A., Asadi, A., & Yazdani, S. (2008). Perceptions of Paddy Farmers towards Sustainable Agricultural Technologies: Case of Haraz Catchments Area in Mazandaran Province of Iran. *American Journal of Applied Sciences*, *5*(10), 1384-1391.

Bandura, A. (1982). Self-efficacy Mechanism in Human Agency. *American Psychologist*, *37*, 122-147.

Banmeke, T. O. A., & Ajayi, M. T. (2008). Farmers' Perception of the Agricultural Information Resource Centre at Ago-Are, Oyo State, Nigeria. *International Journal of Agricultural Economics & Rural Development*, *1*(1), 22-29.

Banmeke, T. O. A., Fakoya, E. O., & Ayanda, I. F. (2011). Agricultural Researchers' Awareness of the Causes and Effects of Climate Change in Edo State, Nigeria. *Journal of Agricultural Science*, *4*(1), 233-238.

Banzon, A. T., Mojica, I. E., Angela, A., & Cielo, A. A. (2013). Adoption of Good Agricultural Practices (GAP) in the Philippines: Challenges, Issues, and Policy Imperatives. *Policy Brief Series*, 1-2.

Behrens, J. H., & Evans, J. F. (1984). *Using Mass Media in Extension Teaching in Agricultural Extension* (2nd eds.). FAO.

Bondoria, A., Bagheria, A., Sookhtanliua, M., Allahyarib, M. S., & Damalasc, C. A. (2018). Pesticide Use in Cereal Production in Moghan Plain, Iran: Risk Knowledge and Farmers' Attitudes. *Crop Production*, *110*, 117-124.

Buckley, R., & Caple, J. (2007). *The Theory & Practice of Training* (5th eds.). Kogan Page, United Kingdom.

Burton-Jones, A., & Hubona, G. S. (2006). The Mediation of External Variables in the Technology Acceptance Model. *Information & Management*, *43*(6), 706-717. https://doi.org/doi:10.1016/j.im.2006.03.007.

Byerlee, D., & Hesse de Polanco, E. (1986). Farmers' Stepwise Adoption of Technological Packages: Evidence from the Mexican Altiplano. *American Journal of Agricultural Economics, 68,* 519-527.

Cheteni, P. (2016). Smallholder Farmers' Awareness of Biofuel Crops in the Eastern Cape Province, South Africa. *Environmental Economics*, *7*(3), 75-80.

Claudy, M. C., Michelsen, C., O'Driscoll, A., & Mullen, M. R. (2010). Consumer Awareness in the Adoption of Microgeneration Technologies: An Empirical Investigation in the Republic of Ireland. *Renewable and Sustainable Energy Reviews, 14*, 2154-2160.

D'Emden, F. H., llewellyn, R. S., & Burton, M. P. (2008). Factors Influencing Adoption of Conservation Tillage in Australia Cropping Regions. *Australia Journal of Agricultural Resource Economics*, *52*, 169-182.

Dhakal, S., Joshi, D. D., Ale, A., Sharma, M., Dahal, M., Shah, Y., & Stephen, C. (2014). Regional Variation in Pig Farmers' Awareness and Actions Regarding Japanese Encephalitis in Nepal: Implications for Public Health Education. *PLoS ONE*, *9*(1), 1-7. https://doi.org/10.1371/journal.pone.0085399.

Dhillon, R. P. (2001). *A Study of Farmers' Awareness Regarding Agricultural Pollution in Punjab*. Master's Thesis, Punjab Agricultural University, Ludhiana, India.

DOA (Department of Agriculture). (2011). *Pamphlet for Good Agricultural Practices in Rice Production*. Ministry of Agriculture and Irrigation. Nay Pyi Taw, Myanmar.

DOA (Department of Agriculture). (2013). *Annual Report of Rice Division*. Ministry of Agriculture and Irrigation. Nay Pyi Taw, Myanmar.

DOA (Department of Agriculture). (2016). *Annual Report of Rice Division*. Ministry of Agriculture and Irrigation. Nay Pyi Taw, Myanmar.

DOA (Department of Agriculture). (2017). *Annual Report of Rice Division*. Ministry of Agriculture, Livestock and Irrigation. Nay Pyi Taw, Myanmar.

DOA (Department of Agriculture). (2018). *Annual Report of Rice Division*. Ministry of Agriculture, Livestock and Irrigation. Nay Pyi Taw, Myanmar.

Dobermann, R. P. (2004). A Critical Assessment of the System of Rice Intensification (SRI). *Agricultural Systems*, *79*(3), 261-281.

Eagly, H., & Chaiken, S. (1993). *The Psychology of Attitudes, Harcourt Brace Jovanovich, Fort Worth, TX*.

Eilam, E., & Trop, T. (2012). Environmental Attitudes and Environmental Behavior–Which Is the Horse and Which Is the Cart? *Sustainability, 4*, 2210-2246. https://doi.org/doi: 10.3390/su4092210.

Emmanuel, A. D. (2014). Farmers' Perception on Agricultural Technologies: A Case of Some Improved Crop Varieties in Ghana. *Agriculture, Forestry, and Fisheries*, *3*(1), 13-16. https://doi.org/10.11648/j.aff.20140301.13.

Eric, G. O., Lagat, J. K., Ithinji, G. K., Mutai, B. K., Kenneth, S. W., & Joseph, M. K. (2013). Maize Farmers' Perceptions towards Organic Soil Management Practices in Bungoma

Country, Kenya. *Research Journal of Environmental and Earth Sciences, 5*(2), 41-48.

Fairuz, K., Idris, A. G., Syahrizan, S., & Mohammad Noor, A. H. (2017). Knowledge, Attitude, Awareness, Communication and Practice among Farmers towards Empowerment of Natural Enemies in Rice Field in Melaka, Malaysia. *International Journal of Academic Research in Business and Social Sciences, 7*(11), 1225-1235.

FAO (Food and Agriculture Organization). (2004). Good Agricultural Practices – A Working Concept. *Background Paper for the FAO Internal Workshop on Good Agricultural Practices, Rome, Italy.*, 27-29.

Fazio, R. H., Sanbonmatsu, D. M., & Powell, M. C. & Kardes, F. R., (2008). On the Automatic Activation of Attitudes. *In: R. H. Fazio & R. E. Petty (eds.), Key Readings in Social Psychology. Attitudes: Their Structure, Function, and Consequences, 17-32.* Psychology Press.

Fishbein, M., & Ajzen, I. (1975). *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research. Reading, MA.*

Franzoi, S. L. (2000). *Social Psychology*. McGraw-Hill: Boston.

Ghulam, M., Latif, I. A., Bashir, M. K., Shamsudin, M. N., & Daud, W. M. N. W. (2018). Determinants of Farmers' Awareness of Climate Change. *Applied Environmental Education & Communication*, 18 (3), 219-233. https://doi.org/10.1080/1533015X.2018.1454358.

Gifford, R., & Sussman, R. (2012). Environmental Attitude. *In Chapter 4, In: The Oxford Handbook of Environmental and Conservation Psychology, edited by Clayton, S. D.*

Giller, K. E., Witter, E., Corbeels, M., & Tittonell, P. (2009). Conservation Agriculture and Smallholder Farming in Africa: The Heretics' View. *Field Crop Res., 114*, 23–24. https://doi.org/10.1016/j.fcr.2009.06.017.

Grace, S. N. (2015). *Small Scale Farmers' Awareness of Organic Agriculture in Selected Farm Blocks of Chongwe District*. Master Thesis. The University of Zambia, Lusaka.

Grist, D. H. (1986). *Rice* (6^{th} eds.). Longman. Singapore, 599p.

Gujarati, D. (2012). *Econometrics by Example*; Palgrave McMillan: New York, NY, USA, 2012.

Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. (2006). *Multivariate Data Analysis* (6^{th} eds.).

Hasan, M. B., Ali, M. A., Alam, M. S., & Bhuyian, M. A. S. (2012). Farmers' Awareness of Environmental Degradation Nearby the Brickfield Area. *Journal of Bangladesh Agricultural University*, *10*(2), 229-233.

Hassan, M. R., Ghazi, H. F., Umar, N. S., Masri, N., Jamil, S. M., Zaleha Md. Isa, Z. M., & Safian, N. (2015). Knowledge, Attitude and Practice of Healthy Eating and Associated Factors among University Students in Selangor, Malaysia. *Pakistan Journal of Nutrition*, *14*(12), 892-897.

Hayran, S., Gul, A., & Saridas, M. A. (2018). Farmers' Sustainable Agriculture Perception in Turkey: The Case of Mersin Province. *New Medit*, *3,* 69-78. https://doi.org/10.30682/nm1803f.

Herath, C. S., & Wijekoon, R. (2013). Study on Attitudes and Perceptions of Organic and Non-organic Coconut Growers towards Organic Coconut Farming. *Article in Idesia*, 31(2), 5-14. https://doi.org/doi:10.4067/S0718-34292013000200002.

Hobbs, J. E. (2003). Incentives for the Adoption of Good Agricultural Practices. *Background Paper for the FAO Consultation on Good Agricultural Practices, Rome*.

Hosseini, S. J. F., Mohammadi, F., & Mirdamadi, S. M. (2011). Factors Influencing the Economic Aspects of Sustainable Agriculture in Iran. *Archives of Applied Science*

Research, *3*(2), 503-512.

Hu, L., & Bentler, P. M. (1999). Cutoff Criteria for Fix Indexes in Covariance Structure Analysis: Conventional Criteria Versus New Alternatives. *In: Structural Equation Modeling*, *6*, 1-55.

Idiong, I. C. (2007). Estimation of Farm Level Technical Efficiency in Small-scale Swamp Rice Production in Cross River State of Nigeria: A Stochastic Frontier Approach. *World Journal of Agricultural Sciences*, *3*(5), 653-658.

Igene, L., Solomon, O., Orji, E. G., Akagbosu, B. E., & Osifo, M. (2015). *An Assessment of Processors' Awareness, Perception and Adoption of NIFOR Developed Improved Coconut Processing Technologies in Lagos State, Nigeria*. *2*(8), 10-17.

Ignacio, J. J., Malenab, R. A., Pausta, C. M., Beltran, A., Belo, L., Tanhueco, R. M., Era, M., Eusebio, R. C., Promentilla, M. A., & Orbecido, A. (2018). Perceptions and Attitudes toward Eco-Toilet Systems in Rural Areas: A Case Study in the Philippines. *Sustainability*, *10*(521). https://doi.org/doi:10.3390/su10020521.

IRRI, (International Rice Research Institute). (2009). *GAPs Fill the Gap*. Available at <http://irri.org/irri/annual-reports/annual-report-2010/bridging-the-gap makes farmers - wealthier> [accessed 3 February 2012].

IRRI (International Rice Research Institute). (2010). *Bridging the "GAP" Makes Farmers Wealthier*.

http://irri.org/irri/annual-reports/annual-report-2010/bridging-the-gap makes farmers-wealthier.

Jamal, K., Kamarulzaman, N. H., Abdullah, A. R., & Ismail, M. M. (2014). Adoption of Fragrant Rice Farming: The Case of Paddy Farmers in the East Coast Malaysia. *International Agribusiness Marketing Conference 2013, IAMC 2013, 22-23 October*

2013, Kuala Lumpur, Selangor, Malaysia.
https://doi.org/ 10.1016/ j.umkpro.2004.07.002.

Kibue, G. W., Genxing, P., Zheng, J., Zhengdong, L., & Mao, L. (2014). Assessment of Climate Change Awareness and Agronomic Practices in an Agricultural Region of Henan Province, China. *Environ Dev Sustain (2015)*, *17*, 379-391.
https://doi.org/10.1007/s10668-014-9546-5.

Krech, D., & Crutchfield, R. S. (1984). *Theory and Problems of Social Psychology*. New York: McGraw-Hill.

Leathers, H. D., & Smale, M. (1991). Baysian Approach to Explaining Sequential Adoption of Components of a Technical Package. *American Journal of Agricultural Economics*, *73*, 734-742.

Lekei, E. E., Ngowi, A. V., & London, L. (2014). Farmers' Knowledge, Practices and Injuries Associated with Pesticide Exposure in Rural Farming Villages in Tanzania. *BMC Public Health*, *14*(1), 389. https://doi.org/doi.org/10.1186/1471-2458-14-389.

Li, H., Huang, D., Ma, Q., Qi, W., & Li, H. (2020). Factors Influencing the Technology Adoption Behaviours of Litchi Farmers in China. *Sustaianbility*, *12*(1), 1-13.
https://doi.org/doi:10.3390/su12010271.

Liu, S. H., Liao, H. L., & Pratt, J. A. (2009). Impact of Media Richness and Flow on e-Learning Technology Acceptance. *Computers and Education*, *52*(3), 599-607.

MAC (Ministry of Agriculture and Cooperatives). (2009). *Coffee Strategy 2009-2013 (in Thai)*.

MAFF (Ministry of Agriculture, Forestry and Fisheries. (2017). *For Dissemination and Expansion of Good Agricultural Practices (GAP)*. Power Point Presentation, Agricultural Production Bureau, Japan.

Mango, N., Makate, C., Tamene, L., Mponela, P., & Ndengu, G. (2017). *Awareness and Adoption of Land, Soil, and Water Conservation Practices in the Chinyanja Triangle, Southern Africa*. *5,* 122-129.

Mariano, M. J., Villano, R., & Fleming, E. (2012). Factors Influencing Farmers' Adoption of Modern Rice Technologies and Good Management Practices in the Philippines. *Agricultural Systems*, *110,* 41-53.

Maswadi, Oktoriana, S., & Suharyani, A. (2018). The Effect of Farmer Characteristics on Perceptions of the Fermented Cocoa Beans Technology in Bengkayang Regency, West Kalimantan. *Journal of Agricultural Sciences, AGRITROPICA*, *1*(2), 85-92. https://doi.org/10.31186/J.Agritropica.1.2.85-92.

Mausch, K., Milthofer, D., Asfaw, S., & Waibel, H. (2006). Impact of EurepGAP Standard in Kenya: Comparing Smallholders to Large-scale Vegetable Producers. *International Agricultural Research for Development*.

MDO (Myaungmya District Office). (2018). *District Record of 2017-18*. Myaungmya District, Ayeyarwady Region. Department of Agriculture. Ministry of Agriculture, Livestock, and Irrigation. Nay Pyi Taw, Myanmar.

Meseret, D. (2014). Determinants of Farmers' Perception of Soil and Water Conservation Practices on Cultivated Land in Ankesha District, Ethiopia. *Agricultural Science, Engineering and Technology Research*, *2*(5), 1-9.

Milfont, T. L., & Duckitt, J. (2010). The Environmental Attitudes Inventory: A Valid and Reliable Measure to Assess the Structure of Environmental Attitudes. *Journal of Environmental Psychology*, *30*, 80-94. https://doi.org/doi:10.1016/j.jenvp.2009.09.001.

Mkanthama, J. M. (2013). *An Analysis of Use of Good Agricultural Practices in Rice Production: A Case Study of Bagamoyo and Dakawa Areas, Tanzania*. Master's

Thesis.

MOAI (Ministry of Agriculture and Irrigation) (2013). *Myanmar Agriculture in Brief*. Nay Pyi Taw, Myanmar.

MOAI (Ministry of Agriculture and Irrigation) (2016). *Myanmar Agriculture in Brief*. Nay Pyi Taw, Myanmar.

MOALI (Ministry of Agriculture, Livestock, and Irrigation). (2019). *Myanmar Agriculture in Brief*. Nay Pyi Taw, Myanmar.

Moges, D. M., & Taye, A. A. (2017). Determinants of Farmers' Perception to Invest in Soil and Water Conservation Technologies in the North-Western Highlands of Ethiopia. *International Soil and Water Conservation Research*, *5*, 56-61. https://doi.org/10.1016/j.iswer.2017.02.003.

Mohsen, M. M., Salah, R., Mohamed, E., & Hafez, S. H. (2016). Knowledge, Practice and Self-reported Symptoms among Farmers about Hazards of Pesticide Exposure. *International Journal of Novel Research in Healthcare and Nursing*, *3*(2), 143-154.

Moon, S. J. (2013). *Awareness of the Farmers about Benefit of Using Information and Communication Technology (ICT) Towards Increased Farm Productivity in Bangladesh*. Master's Thesis. Department of International Environment and Development. Norwegian University of Life Science.

Mugula, V. J., & Mkuna, E. (2016). Farmers' Perceptions on Climate Change Impacts in Different Rice Production Systems in Morogoro Tanzania. *International Journal of Scientific and Research Publications*, *6* (2), 334-340.

Ndambiri, H. K., Ritho, C. N., & Mbogoh, S. G. (2013). An Evaluation of Farmers' Perceptions of and Adaptation to the Effect of Climate Change in Kenya. *International Journal of Food and Agricultural Economics*, *1*(1), 75-96.

https://doi.org/10.22004/ag.econ.156144.

Negatu, W., & Parikh, A. (1999). The Impact of Perception and Other Factors on the Adoption of Agricultural Technology in the Moret and JiruWoreda of Ethiopia. *Agric. Econ.*, *21*, 205-216.

Nijafi, I. (2012). The Role of e-Commerce Awareness on Increasing Electronic Trust. *Life Science Journal*, *9*(4), 1487–1494.

Oladeji, O. O., Okoruwa, V. O., Ojehomon, V. E. T., Diagne, A., & Obasoro, O. A. (2015). Determinants of Awareness and Adoption of Improved Rice Varieties in North Central, Nigeria. *Rice Genomics and Genetics, 6*(7), 1-10. https://doi.org/DOI: 10.5376/rgg.2015.06.0007.

Paing Oo, S. (2020). Farmers' Awareness of the Low Yield of Conventional Rice Production in Ayeyarwady Region, Myanmar: A Case Study of Myaungmya District. *Agriculture*, *10*(1), 1-15. https://doi.org/doi: 10.3390/agriculture10010026.

Paing Oo, S., & Usami, K. (2020). Farmers' Perception of Good Agricultural Practices in Rice Production in Myanmar: A Case Study of Myaungmya District, Ayeyarwady Region. *Agriculture*, *10*(7), 1-20. https://doi.org/doi:10.3390/agriculture10070249.

Pandit, U., Nain, M. S., Singh, R., Kumar, S., & Chahal, V. P. (2016). Adoption of Good Agricultural Practices (GAPs) in Basmati (Scented) Rice: A Study of Prospects and Retrospect. *Indian Journal of Agricultural Sciences*, *87*(1), 36-41.

Petty, R. E., & Wegener, D. T. (1998). Attitude Change: Multiple Roles for Persuasion Variables. *In: The Handbook of Social Psychology, Edited by Gilbert, D., Fiske, S., Lindzey, G* (4^{th} eds.), 323-389.

Pinthukas, N. (2015). Farmers' Perception and Adaptation in Organic Vegetable Production for Sustainable Livelihood in Chiang Mai Province. *Agriculture and Agricultural*

Science Procedia, *5*, 46-51.

Pongvinyoo, P., Yamao, M., & Hosono, K. (2014). Factors Affecting the Implementation of Good Agricultural Practices (GAP) amomg Coffee Farmers in Chumphon Proviance, Thailand. *American Journal of Rural Development*, *2*(2), 34-39. https://doi.org/10.12691/ajrd-2-2-3.

Raitzer, D. A., Wong, L. C. Y., & Samson, J. N. G. (2015). *Myanmar's Agriculture Sector: Unlocking the Potential for Inclusive Growth*, *470*. Asia Development Bank.

Rao, S. V. N., Rangnekar, D. V., Dey, R., & Van Den Ban, A. W. (1995). Farmers' Perceptions of Innovation. *In: Handbook for Straw Feeding Systems Kiran Singh and J. B. Schiere* (eds.).

Rezaei, A., Salmani, M., Razaghi, F., & Keshavarz, M. (2017). An Empirical Analysis of Effective Factors on Farmers' Adaptation Behavior in Water Scarcity Conditions in Rural Communities. *International Soil and Water Conservation Research*, *5*, 265-272.

Rogers, E. M. (1983). *Diffusion of Innovations* (3rd eds.). The Free Press: New York, NY, USA.

Rogers, E. M. (1995). *Diffusion of Innovation* (4th eds.). The Free Press: New York, NY, USA.

Rogers, E. M. (2003). *Diffusion of Innovations* (5th eds.). The Free Press: New York, NY, USA.

Rogers, E. M., & Shoemakers, F. F. (1971). *Communication of Innovations: A Cross-Cultural Approach.* (2nd eds.). The Free Press: New York, NY, USA.

Roy, D., Sarkar, M. A. R., Haque, M. E., Rahman, M. S., & Mojumder, M. A. I. (2010). Farmer's Awareness of Environment-Related Farm and Homestead Activities. *J. Agrofor*. *Environ*, *4*(1), 135-138.

Ryan, R. L., Erickson, D. L., & Young, R. D. (2003). Farmers' Motivations for Adopting

Conservation Practices along Riparian Zones in Mid-western Agricultural Watershed. *Journal of Environmental Planning and Management*, *46*(1), 19-37.

Salakpetch, S. (2005). Quality Management System: Good Agricultural Practices (GAP) for on-farm Production in Thailand. *In Proceedings of International Seminar on Technology Development for Good Agriculture Practice in Asia and Oceania*: 44-53.

Sanga, A. (2016). Awareness and Practices of Paddy Farmers towards Sustainable Agricultural Technologies: The Case of Usangu Plains in Mbarali District, Tanzania. *International Journal in Management and Social Science*, *4*(9), 128-139.

Sasima, F., Suneeporn, S., & Panya, M. (2016). Farmers' Perceptions towards Economic Sustainability of Rice Farming in Peri-Urban Area, Bangkok, Thailand. *International Journal of Agricultural Technology*, *12*(7.2), 1759-1772.

Seline, S. M., Catacutan, D., Oluyede, C. A., & Gudeta, W. S. (2015). The Role of Knowledge, Attitudes, and Perceptions in the Uptake of Agricultural and Agroforestry Innovations among Smallholder Farmers in Sub-Saharan Africa. *International Journal of Agricultural Sustainability*, *13*(1), 40-54. https://doi.org/doi:10.1080/14735903. 2014.912493.

Shafie, A. A., & Azman, A. W. (2015). Assessment of Knowledge, Attitude and Practice of Food Allergies among Food Handlers in the State of Penang, Malaysia. *Public Health*, *129*(9), 1278-1284. https://doi.org/doi.org/10.1016/j.puhe.2015.03.016.

Shahpasand, M. R. (2014). Relationship between Awareness of Sustainable Agriculture and Fertilizer Usage by Iranian Farmers in the City of Bajestan in Khorasan Province: A Case Study. *Journal of Agriculture and Sustainability*, *5*(2), 104-124.

Sheikh, A. D., Rehman, T., & Yates, C. M. (2003). Logit Models for Identifying the Factors that Influences the Uptake of New No-Tillage Technologies by Farmers in the Rice-

Wheat and the Cotton-Wheat Farming Systems of Pakistan's Punjab. *Agricultural Systems*, *75*, 79-95.

Sichali, M., & Banda, L. J. (2017). Awareness, Attitudes and Perception of Green Building Practices and Principles in the Zambian Construction Industry. *International Journal of Construction Engineering and Management*, *6*(5), 215-220. https://doi.org/doi:10.5923/ j.ijcem. 20170605.04.

Simon, B. P., Ndaghu, A. A., & Yohanna, I. (2013). Awareness of Sustainable Agricultural Land Management Practices among Crop Farmers in Northern Part of Taraba State, Nigeria. *ARPN Journal of Science and Technology*, *3*(5), 557-560.

Simtowe, F., Elijah, M., Bernard, M., & Aliou. (2012). Technology Awareness and Adoption: The Case of Pigeon pea Varieties in Kenya. *No 126760, 2012 Conference, August 18-24, 2012,* Foz do Iguacu, Brazil, International Association of Agricultural Economists.

Smathers, W. M. Jr. (1982). Farmers Attitudes. *In: L. A. Christensen and L. Miranowski* (eds.). *Perceptions, Attitudes and Risks: Overlooked Variables in Formulating Public Policy on Soil and Water Conservation and Water Quality. Staff Report (AGES 820129).*

Soper, J. C., & Walstad, W. B. (1983). On Measuring Economic Attitudes. *Journal of Economic Education*, *14*(7), 4-17.

Stiftung, B. (2012). *Myanmar Country Report (Online).* www.btiproject.de/uploads/ tx_ itao_ download/BIT_2012_Myanmar.pdf,February 20, 2012.

Sudarmadi, S., Suzuki, S., Kawada, T., Netti, H., Soemantri, S., & Tugaswati, A. T. (2001). A Survey of Perception, Knowledge, Awareness, and Attitude in Regard to Environmental Problems in a Sample of Two Different Social Groups in Jakarta, Indonesia. *Environment, Development, and Sustainability*, *3*(2), 169-183.

Takahiro, S., Sarah, E., & Johnson, B. (2014). *Impact of Introducing Good Agricultural Practices (GAP) into Rice Production in Can Tho, Vietnam.* International Rice Research Institute (IRRI), Metro Manila, the Philippines.

Tatlidil, F. F., Boz, I., & Tatlidil, H. (2009). Farmers' Perception of Sustainable Agriculture and Its Determinants: A Case Study in Kahramanmaras Province of Turkey. *Environ Dev Sustain*, *11*, 1091-1106.

Thiyagarajan, T. M. (2006). Adopting SRI in Tamil Nadu, India. *LEISA Magazine*, 25-26.

Thompson, N. M., Bir, C., Widmar, D. A., & Mintert, J. R. (2018). Farmers' Perceptions of Precision Agriculture Technology Benefits. *Journal of Agricultural and Applied Economics*, 1-22. https://doi.org/10.1017/aae.2018.27.

Tosuntas, S. B., Karadag, B. E., & Orhan, S. (2015). The Factors Affecting Acceptance and Use of Interactive Whiteboard within the Scope of FATIH Project: A Structural Equation Model Based on the Unified Theory of Acceptance and Use of Technology. *Computers and Education*, *81*, 169-178.

Triandis, H. C. (1971). Attitude and Attitude Change. *In: Foundations of Social Psychology*. Hoboken, NJ: John Wileys & Sons Inc.

Uddin, M. N., Bokelmann, W., & Dunn, E. S. (2017). Determinants of Farmers' Perception of Climate Change: A Case Study from the Coastal Region of Bangladesh. *American Journal of Climate Change*, *6*, 151-165. https://doi.org/10.4236/ajcc.2017.61009.

ul Haq, N., Hassali, M. A., Shafie, A. A., Saleem, F., Farooqui, M., Haseeb, A., & Aljadhey, H. (2013). A Cross-Sectional Assessment of Knowledge, Attitude and Practice among Hepatitis-B Patients in Quetta, Pakistan. *BMC Public Health*, *12*(1), 1-9. https://doi.org/doi.org/10.1186/1471-2458-13-448.

Utaranakorn, P., & Yasunobu, K. (2016). Rice Farmers' Attitudes toward Farm Management in Northeater Thailand. *Journal of Agricultural Science*, *8*(8), 21-31. https://doi.org/doi: 10. 5539/jas.v8n8p21.

Van, D. M. (2006). Exclusion of Small-scale Farmers from Coordinated Supply Chain: Market Failure, Policy Failure or Just Economies of Scale?". *In: R. Ruben, M. Slingerland, and H. Nijhoff* (eds.). *Agro-Food Chains and Networks for Development, Netherlands: Springer*, 209-217.

van Den Ban, H. W., & Hawkins, H. S. (1974). Theoretical Background to Farmers' Use of Extension. *Agricultural Extension*, 61-67.

Waliczek, T. M., & Zajicek, J. M. (1999). School Gardening: Improving Environmental Attitudes of Children Through Hands-on learning. *Journal of Environmental Horticulture*, *14*(4), 174-180.

Wannamolee, W. (2018). Development of Good Agricultural Practices (GAP) for Fruit and Vegetables in Thailand. *Paper Present for Training of Trainers in Good Agricultural Practices (GAP) and Benchmarking: Global GAP for Fruit and Vegetable, Sheraton Subang Hotel and Tower, Kuala Lumpur, Malaysia, 14-23 July 2008.*

Wichadee, S. (2015). Factors Related to Faculty Members' Attitude and Adoption of a Learning Management System. *TOJET: The Turkish Online Journal of Educational Technology*, *14*(4), 53-61.

Willock, J., Deary, I., McGregor, M., Sutherland, A., Edward-Jones, G., & Morgan, O. (1999). Farmers' Attitudes, Objectives, Behaviours, and Personality Traits: The Edinburgh Study of Decision Making on Farms. *Journal of Vocational Behaviour, 54*, 5-36.

Winardi, J. (2004). *Motivasi dan Pemotivasian dalam Manajemen. Jakarta: Rajawali Pers.*

Wongwichit, D., Siriwong, W., & Robson, M. G. (2012). Herbicide Exposure to Maize Farmers in Northern Thailand: Knowledge, Attitude, and Practices. *Journal of*

Medicine and Medical Sciences, *3*(1), 34-38.

Xun, F., Yecui, H., Ling, L., & Jinhui, T. (2017). Farmers' Awareness of Ecosystem Services and the Associated Policy Implications. *Journal of Sustainability*, *9* (9), 1-13. http:// creativecommons. org/licenses/by/4.0/.

Yang, X., Wang, F., Meng, L., Zhang, W., Fan, L., Geissen, V., & Ritsema, C. J. (2014). Farmer and Retailer Knowledge and Awareness of the Risks from Pesticide Use: A Case Study in the Wei River Catchment, China. *Science of the Total Environment*, 172-179. https://doi.org/doi.org/10.1016/j.scitotenv.2014.07.118.

Appendices

Appendix 1: Rice Production in Myanmar from 2001 to 2017

Year	Cultivated Area (Million ha)	Average Yield (ton/ha)	Production (Million MT)
2001	6.45	3.42	21.92
2002	6.49	3.42	21.81
2003	6.54	3.54	23.14
2004	6.86	3.64	24.75
2005	7.39	3.75	27.68
2006	8.12	3.83	30.92
2007	8.09	3.93	31.45
2008	8.09	4.03	32.57
2009	8.07	4.06	32.68
2010	8.05	4.07	32.58
2011	7.59	3.83	29.01
2012	7.24	3.84	27.70
2013	7.28	3.90	28.32
2014	7.17	3.94	28.19
2015	7.21	3.97	28.21
2016	7.16	3.92	27.69
2017	7.26	3.92	28.09

Source: MOALI (2018).

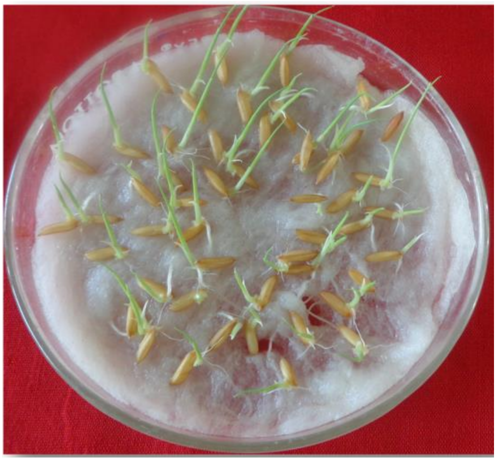
Appendix 2: Average Rice Yield of Farming Methods by Union Territory, States, and Regions in the Wet Season, 2017

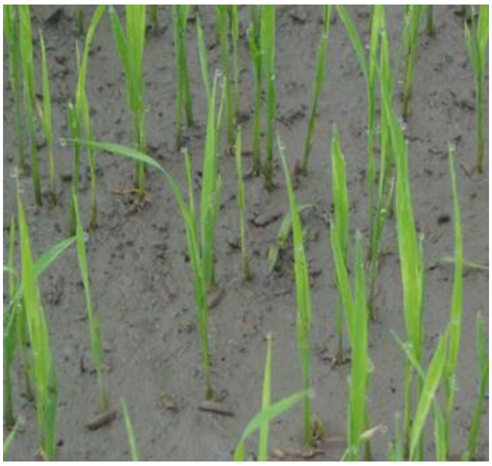
Union Territory, State, and Region	Average Yield (basket/acre)			
	Line sowing (Seeder)	Broadcasting	GAPs in rice production	SRI
Nay Pyi Taw*	89.88	92.50	97.81	98.07
Kachin	98.49	85.09	120.9	105.98
Kayah	119.36	111.43	128.58	114.87
Kayin	67.41	66.55	89.08	87.73
Sagaing	80.74	72.02	95.38	92.86
Tanintharyi	84.80	79.76	103.16	103.37
Bago	85.39	77.96	98.17	98.63
Magway	94.15	85.59	110.6	113.91
Mandalay	76.72	72.37	89.00	83.71
Mon	69.79	69.40	85.71	83.91
Rakhine	91.87	77.96	105.94	105.88
Yangon	88.35	78.00	100.83	109.48
Shan	107.78	95.62	138.02	132.44
Ayeyarwady	87.12	79.84	102.45	101.2
Average	88.70	81.72	104.69	102.29

Source: DOA (2018).

Note: * = Union Territory and SRI = System of Rice Intensification.

Appendix 3: Practices of 14 Component Technologies of GAPs in Rice Production
(taken by Soe Paing Oo, 2016)


GAP1 (*Quality seeds*)


GAP2 (*Sparse sowing*)


GAP3 (*Covering*)


GAP4 (*Systematic care of nursery*)


GAP5 (*Uprooting and transplanting*)


GAP6 (*Planting depth*)

GAP7 (*Seedlings per hill*)

GAP8 (*Plant population*)

GAP9 (*Alternate wetting and drying*)

GAP10 (*Pest and disease management*)

GAP11 (*Balance inputs*)

GAP12 (*Submerging*)

GAP13 (*Drainage*)

GAP14 (*Combine harvester*)

Appendix 4: Interview Questionnaire

Questionnaire No.	Name of Village
Name of Interviewer	Village Tract
Date of Interview	Township

Part (A) Characteristics of Farmer (Demographic profile)

1.

Name of household head	Gender of household head (1 for male and 0 for female)	Marital status of respondent (1 for married and 0 for single)	Farming experience (year)

2.

No.	Name of household member	Relationship with household head	Age	Education (Year)	Jobs		Annual income
					Primary	Secondary	

3.

No.	Name of household member	Name of Association			Started year	Remark
		1	2	3		

4.

Type of Landholding	Lowland (ha)	Upland (ha)	Orchard (ha)
Own (ha)			
Cultivated Land (ha)			
Rent In (acre)			
Rental Value (Kyat or basket)			
Rent Out (ha)			
Rainfed (ha)			
Irrigated (ha)			

5.

Did you receive GAPs in rice training? (1 = yes, 0 = no)		
If yes, when?	What kinds of training did you receive?	How many times of training did you receive?

6.

Contact with extension workers (number of meetings per year)	Availability of agricultural information	
	(yes = 1, no= 0)	If yes, *Code No. 1,2,3,4,5,6,7,8,9,10,11

* Code 1 = DOA, 2 = DAR, 3 = YAU, 4 = Farmers, 5 = Radio, 6 = Newspaper, 7 = TV, 8 = Pamphlet, 9 = Fertilizer shops, 10 = NGO, and 11 = Others.

7.

Year	Did you receive the credit for rice production in the last five years? (If yes, source of credit)	Received amount (kyat)	Interest rate (%)	Remarks
2017				
2016				
2015				
2014				
2013				

8.

Crop	Sown area (ha)	Growing season	Growing time/ harvesting time	Yield (ton/ha)	Total production (tons)	Seed kept (tons)	Home consumption (tons)	Total sale (tons)	Price (kyats)

Part (B) Farmers' Awareness, Perception, Attitude and Adoption of GAPs in Rice Production

Part (B-1) Farmers' Awareness of the Low Yield of Conventional Rice Production

	Statement	5 - point Likert scale				
		1	2	3	4	5
AW1	Climate change (heavy rain and flooding) affects the yield of rice.					
AW2	Less attention is paid to rice production due to the small profit.					
AW3	Knowledge of rice production technology is inadequate.					
AW4	It is challenging to hire the required number of laborers when necessary.					
AW5	Farmers cannot plant and harvest rice at the right time.					
AW6	Soil fertility is becoming more inadequate for cropping.					
AW7	Farmers do not use the adequate and correct amount of farmyard manure (FYM) and fertilizers.					
AW8	Agricultural policies of the Ministry of Agriculture and Irrigation are unstable.					
AW9	Agricultural extension services are not helpful for farmers.					
AW10	Quality seed is not sufficiently available for farmers.					

Note: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Part (B-2) Farmers' Perception of Characteristics of GAPs in Rice Production
(Rogers & Shoemakers, 1971)

Relative advantage

No.	Statement	5 - point Likert scale				
		1	2	3	4	5
1.	A higher yield can be expected by using quality seeds.					
2.	Robust seedlings are produced from sparse sowing on seedbed.					
3.	Soil moisture can be conserved by covering the seedbed with compost or ash or sand.					
4.	Healthy seedlings are provided from a good nursery.					
5.	Transplanting shock could be reduced by transplanting within the same day.					
6.	Healthy roots are provided by using the recommended planting depth.					
7.	The required amount of seed rate is reduced by planting one seedling per hill.					
8.	You can expect good aeration by using the recommended plant population with row skipping.					
9.	Water consumption can be reduced by doing alternate wetting &drying (AWD) method.					
10.	You can manage pest and disease efficiently on your farm.					
11.	The efficiency of fertilizers can be increased by applying a balanced amount and proper time.					
12.	Ineffective tillers can be reduced by submerging at maximum tillering stage.					
13.	You can expect even ripening and easy harvesting by doing timely drainage before two weeks of harvesting.					
14.	Postharvest losses can be minimized by using a combine harvester.					

Note: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Compatibility

No.	Statement	5 - point Likert scale				
		1	**2**	**3**	**4**	**5**
1.	It is compatible to use quality seeds for a farmer.					
2.	It is compatible with preparing seedbeds for a farmer.					
3.	The soil covering on seedbeds is compatible with a farmer.					
4.	Take care of the nursery is compatible with a farmer.					
5.	It is compatible to do uprooting and transplanting within the same day.					
6.	It is compatible with the following recommended planting depth.					
7.	It is compatible to use single seedling per hill.					
8.	Row skipping and the recommended plant population is compatible with a farmer.					
9.	It is compatible to use alternate wetting & drying method.					
10.	It is compatible with managing pest and disease for a farmer.					
11.	It is compatible to apply at the recommended time and amount of fertilizers.					
12.	Continuous Submerging at the maximum tillering stage is compatible with your farm.					
13.	It is compatible with drainage at two weeks before harvesting.					
14.	It is compatible to use combine harvester in your field.					

Note: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Complexity

No.	Statement	5 - point Likert scale				
		1	2	3	4	5
1.	It is difficult for farmers to use quality seeds.					
2.	Seedbed preparation is laborious for a farmer.					
3.	Covering on seedbed may be complex for a farmer.					
4.	Systematic take care of the nursery could be complex for a farmer.					
5.	It is difficult to do uprooting and transplanting within the same day.					
6.	It is difficult to use the recommended planting depth.					
7.	It is difficult to transplant with single seedling per hill.					
8.	It is difficult to use row skipping and the exact amount of plant population.					
9.	It is difficult to use alternate wetting & drying method.					
10.	It is difficult to manage pest and disease for a farmer.					
11.	It is difficult to apply the recommended time and amount of fertilizers.					
12.	Continuous submerging at the maximum tillering stage is complexity for a farmer.					
13.	Timely drainage is difficult to do because of no drain in the field.					
14.	It is difficult to use combine harvester for a farmer.					

Note: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Trialability

No.	Statement	5 - point Likert scale				
		1	2	3	4	5
1.	You can test the characteristics of quality seeds.					
2.	You can explore sparse sowing on seedbed.					
3.	You can explore how to conserve soil moisture by covering the seedbed.					
4.	You can make a trial to see that healthy seedlings are provided from a good nursery.					
5.	You can test the extent of transplanting shock.					
6.	A farmer could easily explore shallow planting.					
7.	You can test single seedling per hill on your farm.					
8.	Row skipping with a recommended plant population could easily explore by a farmer on his/her farm.					
9.	Alternate wetting &drying (AWD) method could easily be explored by a farmer on his/her farm.					
10.	Pest and disease management could easily be explored by a farmer on his/her farm.					
11.	You can make a trial to see the results from the balanced application of fertilizers.					
12.	Submerging at maximum tillering stage could easily be explored by a farmer on his/her farm.					
13.	Drainage before two weeks of harvesting could easily be explored by a farmer on his/her farm.					
14.	Combine harvester could easily be explored by a farmer on his /her farm.					

Note: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Observability

No.	Statement	5 - point Likert scale				
		1	2	3	4	5
1.	You have a chance to observe the benefit of using quality seeds.					
2.	You have a chance to observe the robust seedlings from sparse sowing on seedbed.					
3.	You can see visible results of soil moisture conservation on seedbed.					
4.	You have a chance to observe that healthy seedlings are provided from a good nursery.					
5.	You can visible the result of how to reduce the transplanting shock.					
6.	You can observe the result of the shallow transplanting of rice.					
7.	You can observe the result of using a single seedling per hill.					
8.	You have a chance to observe the advantages of row skipping and using the recommended plant population.					
9.	You can see visible results of the alternate wetting &drying (AWD) method.					
10.	You have a chance to observe the results of pest and disease management.					
11.	You can see the visible results of a balanced application of fertilizers.					
12.	You can observe the results of submerging at maximum tillering stage.					
13.	You can see visible results of timely drainage before two weeks of harvesting.					
14.	You have a chance to observe the results of using a combine harvester.					

Note: 1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Part (B-3) Farmers' Attitude to GAPs in Rice Production

Economic Aspect

No.	Statement	5 - point Likert scale				
		1	2	3	4	5
1.	Higher profit can be expected by using quality seeds.					
2.	Higher profit can be expected by doing sparse sowing on seedbed.					
3.	A higher yield can be expected by conserving soil moisture of the seedbed.					
4.	A higher yield can be expected by taking care of nursery on your farm because of using healthy seedlings.					
5.	Doing the same day for transplanting and uprooting will reduce shock and increase yield.					
6.	A higher yield can be expected by shallow transplanting because of the increasing number of tillers.					
7.	Higher profit can be expected using single seedling in rice production will reduce the cost of seeds.					
8.	Higher profit can be expected by using row skipping and the recommended plant population.					
9.	Higher profit can be expected by using the alternate wetting and drying method because of reducing the cost for irrigation.					
10.	Higher yield can be expected by good management of pest and disease.					
11.	Higher profit can be expected by applying balanced application of fertilizers.					
12.	Higher yield can be expected by submerging at active tillering stage because of reducing ineffective tillers.					
13.	Higher profit can be expected by doing timely drainage in your farm because of even in ripening of rice.					
14.	Higher profit can be expected by using combine harvester because of minimizing the losses.					

Note: 1= strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Environmental Aspect

No.	Statement	5 - point Likert scale				
		1	2	3	4	5
1.	Using quality seeds can reduce infestation of land with pests and diseases.					
2.	Doing sparse sowing on seedbed will provide good ventilation.					
3.	Covering on seedbed will conserve soil moisture and reduce evaporation.					
4.	Systematic care for nursery will reduce air and water pollution in the environment.					
5.	Doing transplanting and uprooting within one day will reduce the shock and the environmental pollution.					
6.	Applying shallow planting will reduce the environmental pollution.					
7.	Using single seedling will provide good aeration in the environment.					
8.	Using the recommended plant population with row skip will provide good ventilation.					
9.	Methane emission will be reduced by using AWD method.					
10.	Systematic management of pest and disease will reduce the environmental pollution.					
11.	Application of the recommended fertilizers will reduce the environmental pollution.					
12.	Weed infestation will be reduced by submerging.					
13.	Timely drainage will provide good quality of rice and reduce the environmental pollution.					
14.	Using combine harvester will minimize storage pests and diseases in your farm.					

Note: 1= strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, and 5 = strongly agree.

Part (B-4) Adoption of Component Technologies of GAPs in Rice Production

Have you applied the following component technologies of GAPs in rice production?

No.	Component technologies of GAPs in rice production	If yes, when did you start it?	Are you using in these seasons?	
			Wet Season (2017 Jul to 2017 Oct)	Dry Season (2017 Dec to 2018 April)
1.	Quality seeds			
2.	Sparse sowing on seedbed			
3.	Covering the seed bed with compost or ash or sand			
4.	Systematic care of nursery			
5.	Uprooting and transplanting			
6.	Planting depth (1.5 inches)			
7.	One to two seedlings per hill			
8.	Optimum plant population& row skipping (8” x 6” or 6” x 6”)			
9.	Alternate Wetting & Drying			
10.	Pest and disease management			
11.	Balanced inputs (Fertilizers and manure)			
12.	Submerging at maximum tillering stage			
13.	Timely drainage before two weeks of harvesting			
14.	Combine harvester			

For Adopter of GAPs in rice production

1. Why did you adopt GAPs in rice production?
   (a)……………………………………………………………………………………….
   (b)……………………………………………………………………………………….
   (c)……………………………………………………………………………………….

2. What problems are you facing or suffering from in rice production?
   (a)……………………………………………………………………………………….
   (b)……………………………………………………………………………………….
   (c)……………………………………………………………………………………….

For Non- Adopter of GAPs in rice production

1. Why didn't you adopt GAPs in rice production?
   (a)……………………………………………………………………………………….
   (b)……………………………………………………………………………………….
   (c)……………………………………………………………………………………….

2. What problems are you facing or suffering from in rice production?
   (a)……………………………………………………………………………………….
   (b)……………………………………………………………………………………….
   (c)……………………………………………………………………………………….

Thank you very much for answering and sharing your valuable time!

Appendix 5: Results of Econometric Analyses

Part (A-1) Cluster Analysis on Farmers' Awareness

```
QUICK CLUSTER AW1 AW2 AW3 AW4 AW5 AW6 AW7 AW8 AW9 AW10
/MISSING=LISTWISE
/CRITERIA=CLUSTER (3) MXITER (10) CONVERGE (0)
/METHOD=KMEANS(NOUPDATE)
/SAVE CLUSTER DISTANCE
/PRINT INITIAL ANOVA CLUSTER DISTAN.
```

Final Cluster Centers

	Cluster		
	1	**2**	**3**
Aw1	4.3	4.6	4.2
Aw2	2.7	4.3	3.9
Aw3	3.8	4.7	4.4
Aw4	2.8	1.4	1.5
Aw5	2.9	4.5	3.2
Aw6	2.2	3.7	3.6
Aw7	2.9	4.5	2.0
Aw8	3.6	4.5	3.4
Aw9	2.5	4.5	3.9
Aw10	3.3	4.6	4.1

Number of Cases in each Cluster

Cluster	1	43.000
	2	197.000
	3	75.000
Valid		315.000
Missing		.000

Part (A-2) ANOVA: Single Factor for Comparison of Farmers' Awareness among Sample Townships

AW1

Source of variation	**SS**	**df**	**MS**	***F***	***p-value***	***F crit***
Between Groups	6.025397	2	3.012698	1.764887	0.172911	3.024681
Within Groups	532.5905	312	1.707021			
Total	538.6159	314				

AW2

Source of variation	**SS**	**df**	**MS**	***F***	***p-value***	***F crit***
Between Groups	3.092063	2	1.546032	1.351695	0.260313	3.024681
Within Groups	356.8571	312	1.143773			
Total	359.9492	314				

AW3

Source of variation	**SS**	**df**	**MS**	***F***	***p-value***	***F crit***
Between Groups	0.399999	2	0.2	0.14125	0.868328	3.024681
Within Groups	441.7714286	312	1.415934			
Total	442.1714	314				

AW4

Source of variation	**SS**	**df**	**MS**	***F***	***p-value***	***F crit***
Between Groups	9.67619	2	4.838095	2.601622	0.075761	3.024681
Within Groups	580.2095	312	1.859646			
Total	589.8857	314				

AW5

Source of variation	**SS**	**df**	**MS**	***F***	***p-value***	***F crit***
Between Groups	10.13333	2	5.066667	3.357417	0.036088	3.024681
Within Groups	470.8381	312	1.509096			
Total	480.9714	314				

AW6

Source of variation	SS	df	MS	*F*	*p-value*	*F crit*
Between Groups	7.130159	2	3.56508	5.409541	0.00490	3.02468
Within Groups	205.6190	312	0.659035			
Total	212.7492	314				

AW7

Source of variation	SS	df	MS	*F*	*p-value*	*F crit*
Between Groups	9.377778	2	4.688889	3.761214	0.024317	3.024681
Within Groups	388.9524	312	1.246642			
Total	398.3302	314				

AW8

Source of variation	SS	df	MS	*F*	*p-value*	*F crit*
Between Groups	0.234921	2	0.11746	0.16044	0.851839	3.024681
Within Groups	228.4190	312	0.732112			
Total	228.6540	314				

AW9

Source of variation	SS	df	MS	*F*	*p-value*	*F crit*
Between Groups	12.97778	2	6.488889	7.822196	0.000484	3.02468
Within Groups	258.819	312	0.829548			
Total	271.7968	314				

AW10

Source of variation	SS	df	MS	*F*	*p-value*	*F crit*
Between Groups	0.692063	2	0.346032	0.364197	0.695049	3.024681
Within Groups	296.4381	312	0.950122			
Total	297.1302	314				

Part (A-3) Binary Logit Model for Farmers' Awareness

Binary Logit for AW2	Number of obs	=	315
	LR chi^2 (15)	=	42.44
	Prob > chi^2	=	0.0002
Log likelihood = -148.10724	Pseudo R^2	=	0.1253

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	-2.266449	1.345380	-1.68	0.092	-4.903345	0.370447
Age (X_1)	0.068506	0.023197	2.95	0.003	0.023041	0.113971
Gender (X_2)	2.687209	0.919994	2.92	0.003	0.884053	4.490365
Marital status (X_3)	-0.474624	0.701331	-0.68	0.499	-1.849208	0.899960
Education (X_4)	0.021454	0.048661	0.44	0.659	-0.073919	0.116827
Farming experience (X_5)	-0.023147	0.019976	-1.16	0.247	-0.062299	0.016005
Household size (X_6)	0.230154	0.150880	1.53	0.127	-0.065566	0.525874
Access to credit (X_7)	0.511293	0.508172	1.01	0.314	-0.484706	1.507291
Income from crop production (X_8)	-0.368964	0.207973	-1.77	0.076	-0.776585	0.038656
Farmland size (X_9)	0.014714	0.014077	1.05	0.296	-0.012876	0.042305
Active labor force (X_{10})	-0.185058	0.173246	-1.07	0.285	-0.524613	0.154498
Contact with extension workers (X_{11})	-0.057122	0.038862	-1.47	0.142	-0.133290	0.019047
Receiving agricultural information (X_{12})	-1.679664	0.732784	-2.29	0.022	-3.115894	-0.243435
Membership in local farmers' association (X_{13})	-9.211419	0.297838	-0.71	0.478	-0.795170	0.372332
Location: Einme Township (X_{14})	-0.380388	0.367953	-1.03	0.301	-1.101563	0.340787
Location: Warkhema Township (X_{15})	0.092639	0.401853	0.23	0.818	-0.694978	0.880255

Binary Logit for AW4

Log likelihood = -187.05905

Number of obs	=	315
LR chi^2 (15)	=	26.89
Prob > chi^2	=	0.0297
Pseudo R^2	=	0.2670

Independent variable	**Coefficient**	**Standard error**	**z**	**P > z**	**95% Confident Interval**	
Constant	-2.569615	1.195541	-2.15	0.032	-4.912833	-0.226397
Age (X_1)	0.025472	0.017173	1.48	0.138	-0.008186	0.059130
Gender (X_2)	1.338022	0.808790	1.65	0.098	-0.247177	2.923221
Marital status (X_3)	0.311317	0.608011	0.51	0.609	-0.880362	1.502996
Education (X_4)	-0.002165	0.041765	-0.05	0.959	-0.084023	0.079692
Farming experience (X_5)	-0.015772	0.015106	-1.04	0.296	-0.045379	0.013835
Household size (X_6)	0.272847	0.126913	2.15	0.032	0.024102	0.521592
Access to credit (X_7)	0.160155	0.462910	0.35	0.729	-0.747131	1.067442
Income from crop production (X_8)	0.086521	0.193619	0.45	0.655	-0.292967	0.466008
Farmland size (X_9)	-0.023711	0.013992	-1.69	0.090	-0.051134	0.003712
Active labor force (X_{10})	-0.106894	0.147869	-0.72	0.470	-0.396711	0.182923
Contact with extension workers (X_{11})	-0.042341	0.043083	-0.98	0.326	-0.126782	0.042100
Receiving agricultural information (X_{12})	-0.451172	0.430919	-1.05	0.295	-1.295759	0.393414
Membership in local farmers' association (X_{13})	0.423677	0.262541	1.61	0.107	-0.090895	0.938249
Location: Einme Township (X_{14})	0.342882	0.325762	1.05	0.293	-0.295599	0.981363
Location: Warkhema Township (X_{15})	0.381460	0.338825	1.13	0.260	-0.282623	1.045544

Binary Logit for AW5

Log likelihood = -143.25288

Number of obs = 315
LR chi^2 (15) = 34.21
Prob > chi^2 = 0.0032
Pseudo R^2 = 0.1067

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	-2.951200	1.337047	-2.21	0.027	-5.571763	-0.330637
Age (X_1)	0.031200	0.021766	1.43	0.152	-0.011460	0.073859
Gender (X_2)	1.820991	0.833670	2.18	0.029	0.187028	3.454954
Marital status (X_3)	0.278425	0.718234	0.39	0.698	-1.129287	1.686137
Education (X_4)	0.035909	0.050435	0.71	0.476	-0.062942	0.134761
Farming experience (X_5)	-0.028264	0.019248	-1.47	0.142	-0.065989	0.009461
Household size (X_6)	0.265520	0.153323	1.73	0.083	-0.034988	0.566027
Access to credit (X_7)	0.171750	0.492291	0.35	0.727	-0.793121	1.136622
Income from crop production (X_8)	-0.213432	0.232510	-0.92	0.359	-0.669143	0.242279
Farmland size (X_9)	-0.014514	0.013145	-1.10	0.270	-0.040277	0.011250
Active labor force (X_{10})	0.093516	0.186356	0.50	0.616	-0.271735	0.458767
Contact with extension workers (X_{11})	0.031340	0.045758	0.68	0.493	-0.058344	0.121024
Receiving agricultural information (X_{12})	-0.092600	0.487195	-0.19	0.849	-1.047490	0.862284
Membership in local farmers' association (X_{13})	0.457990	0.311577	1.47	0.142	-0.152690	1.068670
Location: Einme Township (X_{14})	0.604737	0.425939	1.42	0.156	-0.230089	1.439562
Location: Warkhema Township (X_{15})	-0.552386	0.381738	-1.45	0.148	-1.300579	0.195808

Binary Logit for AW8

Log likelihood = -202.87246

Number of obs = 315

LR chi^2 (15) = 25.59

Prob > chi^2 = 0.0426

Pseudo R^2 = 0.2593

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	-2.931851	1.390182	-2.11	0.035	-5.656557	-0.207145
Age (X_1)	0.046583	0.016886	2.76	0.006	0.013487	0.079678
Gender (X_2)	2.403063	1.134671	2.12	0.034	0.179149	4.626976
Marital status (X_3)	-0.413206	0.631137	-0.65	0.513	-1.650211	0.823799
Education (X_4)	-0.000697	0.040200	-0.02	0.986	-0.079488	0.078094
Farming experience (X_5)	-0.030112	0.014796	-2.04	0.042	-0.059112	-0.001112
Household size (X_6)	0.171684	0.118219	1.45	0.146	-0.060022	0.403389
Access to credit (X_7)	-0.137491	0.449924	-0.31	0.760	-1.019326	0.744345
Income from crop production (X_8)	-0.441289	0.180303	-2.45	0.014	-0.794678	-0.087901
Farmland size (X_9)	0.013118	0.011994	1.09	0.274	-0.010389	0.036625
Active labor force (X_{10})	-0.116612	0.139180	-0.84	0.402	-0.389400	0.156176
Contact with extension workers (X_{11})	0.034915	0.038977	0.90	0.370	-0.041478	0.111309
Receiving agricultural information (X_{12})	-0.330986	0.392615	-0.84	0.399	-1.100498	0.438525
Membership in local farmers' association (X_{13})	0.163884	0.245402	0.67	0.504	-0.317094	0.644863
Location: Einme Township (X_{14})	0.314096	0.311120	1.01	0.313	-0.295689	0.923880
Location: Warkhema Township (X_{15})	0.134169	0.322958	0.42	0.678	-0.498817	0.767156

Part (A-4) Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
Active labor force	2.71	0.369416
Age	2.67	0.374664
Household size	2.45	0.408762
Farming experience	2.43	0.411470
Farmland size	1.73	0.579150
Location: Warkhema Township	1.69	0.593239
Income from crop production	1.61	0.621640
Location: Einme Township	1.54	0.649244
Contact with extension workers	1.26	0.793505
Education	1.22	0.820473
Marital status	1.19	0.842630
Gender	1.12	0.894544
Access to credit	1.11	0.899865
Receiving agricultural information	1.10	0.911666
Membership in local farmers' association	1.05	0.949039
Mean VIF	1.66	

Part (B-1) Cluster Analysis on 14 Component Technologies of GAPs in Rice Production

```
QUICK CLUSTER RA COM CPLEX TR OBS
/MISSING = LISTWISE
/CRITERIA = CLUSTER (3) MXITER (10) CONVERGE (0)
/METHOD = KMEANS (NOUPDATE)
/SAVE CLUSTER DISTANCE
/PRINT INITIAL ANOVA CLUSTER DISTAN.
```

Final Cluster Centers

	Cluster		
	1	**2**	**3**
RA	4.64	4.60	4.70
COM	4.00	3.45	3.18
CPLEX	4.06	3.88	4.04
TR	3.82	4.23	3.94
OBS	4.20	4.48	3.74

Number of Cases in each Cluster

Cluster	1	5.000
	2	4.000
	3	5.000
Valid		14.000
Missing		.000

Part (B-2) PCA on Farmers' Perception of Component Technologies of GAPs in Rice Production

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.828
Bartlett's Test of Sphericity	Approx. Chi-Square	17440.618
	df	2415
	Sig.	.000

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.988	17.126	17.126	11.988	17.126	17.126	10.415	14.879	14.879
2	5.849	8.355	25.481	5.849	8.355	25.481	4.550	6.500	21.379
3	5.541	7.916	33.398	5.541	7.916	33.398	3.786	5.408	26.788
4	3.899	5.570	38.968	3.899	5.570	38.968	3.587	5.125	31.912
5	3.310	4.728	43.696	3.310	4.728	43.696	3.186	4.552	36.464
6	2.953	4.219	47.915	2.953	4.219	47.915	3.180	4.543	41.008
7	2.654	3.791	51.707	2.654	3.791	51.707	3.084	4.405	45.413
8	2.290	3.271	54.978	2.290	3.271	54.978	2.905	4.151	49.564
9	2.182	3.117	58.095	2.182	3.117	58.095	2.839	4.056	53.619
10	1.811	2.587	60.682	1.811	2.587	60.682	2.761	3.944	57.563
11	1.751	2.501	63.183	1.751	2.501	63.183	2.569	3.670	61.233
12	1.389	1.985	65.168	1.389	1.985	65.168	2.249	3.213	64.446
13	1.212	1.731	66.899	1.212	1.731	66.899	1.365	1.950	66.395
14	1.113	1.589	68.488	1.113	1.589	68.488	1.223	1.748	68.143
15	1.060	1.515	70.003	1.060	1.515	70.003	1.204	1.719	69.863
16	1.039	1.484	71.487	1.039	1.484	71.487	1.137	1.624	71.487
17	.978	1.396	72.884						
18	.912	1.303	74.187						
19	.891	1.273	75.459						

20	.856	1.223	76.683
21	.825	1.178	77.861
22	.788	1.126	78.987
23	.769	1.098	80.085
24	.711	1.015	81.101
25	.686	.981	82.081
26	.674	.962	83.043
27	.640	.914	83.957
28	.622	.889	84.846
29	.601	.859	85.705
30	.599	.856	86.561
31	.550	.786	87.346
32	.546	.779	88.126
33	.503	.719	88.845
34	.485	.692	89.537
35	.474	.677	90.214
36	.435	.621	90.835
37	.414	.591	91.426
38	.392	.560	91.986
39	.389	.556	92.541
40	.375	.536	93.077
41	.362	.517	93.594
42	.337	.482	94.076
43	.325	.465	94.540
44	.316	.452	94.992
45	.277	.396	95.388
46	.259	.369	95.758
47	.254	.364	96.121
48	.241	.344	96.465
49	.231	.331	96.796
50	.212	.303	97.099

51	.201	.287	97.385
52	.189	.269	97.655
53	.182	.260	97.915
54	.169	.242	98.156
55	.159	.228	98.384
56	.142	.203	98.587
57	.135	.192	98.779
58	.117	.168	98.947
59	.109	.156	99.103
60	.099	.141	99.245
61	.088	.126	99.370
62	.077	.110	99.480
63	.071	.101	99.581
64	.058	.083	99.664
65	.053	.076	99.740
66	.047	.067	99.807
67	.044	.063	99.870
68	.037	.052	99.922
69	.029	.041	99.964
70	.026	.036	100.000

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

Variable	Component															
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
RA1	.006	.640	.066	.016	-.044	-.038	.181	.057	.099	.009	-.073	.109	-.070	-.307	-.019	-.005
RA2	.035	.577	.135	-.061	.102	.123	-.097	-.067	-.022	-.051	-.061	.159	.082	-.171	.063	.148
RA3	.090	.706	.056	-.013	.066	.016	.014	-.031	.018	.032	.045	-.020	-.189	-.132	.117	.094
RA4	-.052	.668	.197	.028	-.060	.102	-.073	.025	.112	-.030	-.069	-.134	-.081	-.071	-.170	-.070
RA5	.076	.631	.085	-.035	.075	-.116	.033	-.031	.047	-.049	.085	.119	.209	.131	-.072	-.251
RA6	.010	.683	.063	.025	-.013	-.052	.022	.010	-.037	-.074	-.057	.076	-.104	.133	.077	.123
RA7	.026	.445	.127	.024	.084	.035	-.096	.132	-.094	-.099	-.045	.133	.185	.075	.315	.031
RA8	.026	.637	.039	-.095	.004	-.062	-.065	.046	.007	-.032	.039	.137	.323	.196	-.010	-.185
RA9	.016	.531	-.142	-.027	.129	.101	.147	.014	.064	-.019	-.098	.028	.305	.048	.058	.111
RA10	.127	.357	.005	.006	.132	.003	.006	.015	.104	.010	.018	.164	.507	-.069	.265	.170
RA11	.015	.507	-.049	-.034	-.001	-.077	-.094	.013	.095	.056	.190	.023	.167	.400	-.184	-.104
RA12	.128	.315	-.054	.009	.020	-.078	.015	.039	.076	.035	.097	.032	.047	-.101	.609	-.213
RA13	.121	.550	.068	-.032	-.055	-.113	-.038	-.036	.038	-.092	.087	.062	.057	.282	.332	-.044
RA14	.079	.090	-.082	.004	-.147	-.070	-.015	-.040	.108	.055	.105	.069	.602	-.077	-.057	-.053
COM1	.226	.133	.039	.115	.064	-.005	-.061	-.005	.818	.129	-.018	.031	.155	.058	-.011	.040
COM2	.165	.011	-.023	.895	.042	-.007	-.001	.000	.029	.159	-.030	-.027	.080	-.001	-.045	-.034
COM3	.216	-.021	.023	.188	.090	.026	-.021	.027	.021	.832	-.103	-.036	.166	.047	-.132	-.020
COM4	.102	.044	-.028	.061	-.042	-.087	-.064	-.032	.269	.108	.051	.002	.039	.108	-.155	.702
COM5	.040	.009	.078	.610	.079	-.024	-.110	.081	-.096	.050	-.107	-.004	-.100	-.068	-.037	.193
COM6	.103	-.079	.105	.073	.037	-.064	.025	-.020	.047	.738	.014	.092	-.119	-.085	.143	-.067
COM7	.002	.020	.070	-.084	.018	-.019	-.076	.038	.787	-.072	.021	.050	-.064	.072	.043	-.083
COM8	.016	-.044	.000	.832	-.006	-.021	-.040	.012	-.028	.066	.023	.024	.001	.066	.075	-.065
COM9	.004	-.114	.042	.049	.015	-.035	-.002	-.003	-.024	.728	.062	-.039	-.073	.075	.050	.194
COM10	.099	.050	.063	-.010	.033	-.071	.026	.036	.787	.035	.017	.031	.008	-.075	.011	.106
COM11	.016	-.046	-.068	.837	.013	-.034	.077	-.037	.060	.089	-.008	-.005	-.038	-.024	-.014	.017
COM12	.082	.011	.009	-.007	.038	.006	-.019	-.067	.791	-.071	-.016	.002	.096	.069	-.001	.117
COM13	.044	-.025	-.004	.887	-.009	.043	.016	-.003	.017	.053	.018	-.030	.039	.017	-.007	-.013
COM14	.168	.002	.004	.158	.050	.016	-.035	.033	-.049	.867	-.097	-.036	.114	.062	-.076	-.012

CPLEX1	.000	-.005	.034	.084	.039	.078	.138	.918	.021	-.003	.127	.085	-.060	-.009	-.001	-.014
CPLEX2	.062	-.028	.067	.031	.014	.241	.826	.214	-.046	-.006	.240	.052	.023	.006	.037	-.044
CPLEX3	.044	-.030	.113	-.033	.071	.392	.303	.105	.002	-.067	.801	.009	.056	-.025	.032	.023
CPLEX4	.090	.001	.001	.001	-.028	.906	.176	.047	-.028	-.043	.247	.015	-.001	-.047	-.024	-.038
CPLEX5	-.032	-.023	-.012	.039	-.009	.064	.107	.903	-.018	-.014	.128	.062	-.047	-.028	.025	.011
CPLEX6	.042	-.029	.035	-.019	-.032	.209	.841	.192	-.037	.008	.206	-.010	.070	-.006	.032	-.005
CPLEX7	.053	-.036	.085	-.059	.008	.343	.269	.049	.002	-.040	.783	-.058	.112	-.033	.076	.040
CPLEX8	.027	-.006	-.044	-.031	-.072	.901	.115	-.019	-.055	.017	.171	-.035	-.032	-.026	.019	-.027
CPLEX9	-.128	.062	.043	-.141	.134	-.064	.136	.584	.025	.033	-.153	-.065	.017	.178	-.022	-.019
CPLEX10	-.004	.070	-.057	-.090	.047	-.055	.711	.030	-.071	-.022	.026	.001	-.037	.007	-.183	.030
CPLEX11	.055	.018	.051	.035	.082	-.014	.055	.827	-.017	.017	.007	.000	.055	-.021	.022	-.003
CPLEX12	.019	-.022	.016	.047	-.040	.142	.783	.062	.011	.000	.110	.039	-.030	.055	.109	-.064
CPLEX13	.015	-.067	.081	-.068	.059	.341	.267	.052	.011	-.065	.798	-.010	.042	-.002	.046	.040
CPLEX14	.096	.003	.016	-.002	-.042	.905	.147	.034	-.024	-.034	.210	.022	-.036	-.058	-.045	-.018
TR1	.915	.077	.093	.067	.173	.066	-.005	.007	.072	.059	.035	.047	.034	.016	-.026	-.011
TR2	.933	.109	.061	.040	.124	.054	.005	-.019	.019	.043	.017	.040	.031	-.011	-.003	-.021
TR3	.883	.077	.030	.044	.116	.027	.019	.005	.000	.088	.035	-.048	.032	-.047	-.006	.002
TR4	.542	.069	.027	.113	.146	-.122	.059	.067	-.006	-.102	.017	.041	.133	-.191	-.404	-.009
TR5	.641	-.031	.055	-.053	.034	.040	.104	-.055	.097	.003	-.143	.063	.089	.071	.007	-.319
TR6	.762	.008	-.097	.058	.044	.006	.038	.005	.031	.046	.005	.003	.092	.029	.032	-.039
TR7	.830	-.001	-.003	.022	.115	.059	-.083	-.042	-.011	-.007	-.023	.031	-.006	.121	.094	.035
TR8	.836	.016	.021	.064	.041	.023	.003	-.010	.023	.023	.081	-.016	-.013	-.003	.091	.034
TR9	.853	.023	.076	-.041	.103	-.047	-.031	-.050	.121	.047	.010	-.005	.028	.061	.007	.029
TR10	.837	-.035	.050	-.036	.104	.047	.022	.011	.034	.072	.008	.023	.035	-.031	.017	.023
TR11	.826	-.009	.109	.067	.032	-.024	-.008	.011	.026	.081	.015	.031	.007	-.103	.000	.113
TR12	.853	.013	.111	-.016	.082	.020	.060	-.010	.041	.034	.031	.038	-.031	.035	.042	.122
TR13	.896	.028	.041	.025	.100	.023	.066	-.011	.028	.086	.010	.045	-.075	-.039	-.040	.020
TR14	.893	.054	.070	.069	.141	.020	-.051	.029	.075	.027	.000	.005	-.019	.058	-.033	-.033
OBS1	.367	.116	.069	.060	.857	-.055	.029	.072	.099	.039	.015	.026	-.055	.013	-.082	-.060
OBS2	.143	.193	.864	.045	.140	-.010	.047	.041	.095	.000	.082	.079	-.045	.030	-.060	-.086
OBS3	.099	.220	.168	.026	.100	-.005	.026	.085	.102	.037	.015	.833	.100	.044	-.037	-.048

OBS4	.161	.195	.822	.047	.109	.068	.021	.087	.089	.026	.043	.067	-.008	-.004	-.101	-.063
OBS5	.339	.125	.020	.029	.838	.000	.047	.075	.107	.032	.052	.027	-.049	-.027	-.073	-.060
OBS6	.048	.038	.137	.022	-.001	-.101	.106	.083	.112	.088	-.082	.099	-.143	.725	.008	.115
OBS7	.004	.091	.068	-.067	.000	-.017	-.024	.007	.050	-.100	-.017	.813	-.014	.013	.093	-.117
OBS8	-.009	-.165	.322	-.071	.172	.158	.130	.023	-.007	-.096	-.417	-.060	.335	-.037	.183	.102
OBS9	.291	-.026	.054	.029	.829	-.022	-.042	.102	-.014	.059	-.028	.008	.009	.054	.034	.034
OBS10	-.010	.003	.808	-.040	.053	-.047	-.077	.029	-.023	.079	.019	.070	-.039	.013	.143	-.030
OBS11	.286	.017	.144	.022	.811	-.077	-.030	.031	.007	.077	.030	-.009	.013	-.047	.110	.026
OBS12	.099	.035	.783	.000	-.033	-.047	.015	-.025	-.042	.027	-.026	.102	.071	-.018	.082	.174
OBS13	.073	.107	.194	.012	-.055	.019	.083	.007	-.026	.065	-.020	.791	.087	.045	-.017	.172
OBS14	.110	.106	.774	-.058	.004	.029	.044	.006	.110	.051	.053	.118	-.078	.116	-.118	-.043

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.[a]

a. Rotation converged in 23 iterations.

Part (B-3) Cluster Analysis on Farmers' Perception of Component Technologies of GAPs in Rice Production

```
Dataset Close D0.37735557597779956.
QUICK CLUSTER PC1 PC2 PC3 PC4 PC5 PC6 PC7 PC8 PC9 PC10
PC11 PC12 PC13 PC14 PC16
/MISSING=LISTWISE
/CRITERIA=CLUSTER (3) MXITER (10) CONVERGE (0)
/METHOD=KMEANS (NOUPDATE)
/SAVE CLUSTER DISTANCE
/PRINT INITIAL.
```

Final Cluster Centers

	Cluster		
	1	**2**	**3**
PC1	-5.0964416	-1.9848961	1.9796858
PC2	.4706639	-.5736961	-.0877618
PC3	1.3478780	-5.1923126	.1944061
PC4	.4349558	-.3545585	-.1031568
PC5	.3273849	-1.4945555	.0765296
PC6	-.0015603	-.1194382	.0155285
PC7	.1346166	.5100456	-.1097594
PC8	-.0843602	.0004092	.0285917
PC9	.1101772	-.4189670	.0152052
PC10	.1480790	.6774621	-.1353546
PC11	.0141290	.2187372	-.0322668
PC12	.0463189	-.0388971	-.0108423
PC13	-.0107824	.2374426	-.0261575
PC14	-.0355912	-.1200742	.0271634
PC16	-.0096605	.1226904	-.0121277

Number of Cases in each Cluster

Cluster	1	73.000
	2	27.000
	3	215.000
Valid		315.000
Missing		.000

Part (B-4) Binary Logit Model for Farmers' Perception of the Compatibility of GAPs in Rice Production

Binary Logit for GAP2	Number of obs	=	315
	LR chi^2 (15)	=	14.50
	Prob > chi^2	=	0.0487
Log likelihood = -205.53148	Pseudo R^2	=	0.214

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	1.149585	1.373542	0.84	0.403	-1.542507	3.841677
Age (X_1)	0.014785	0.015547	0.95	0.342	-0.015687	0.045257
Gender (X_2)	-1.681867	1.120255	-1.50	0.133	-3.877526	0.513792
Marital status (X_3)	0.001519	0.623362	0.00	0.998	-1.220248	1.223287
Education (X_4)	-0.009557	0.039043	-0.24	0.807	-0.086079	0.066965
Farming experience (X_5)	-0.012563	0.013602	-0.92	0.356	-0.039223	0.014098
Household size (X_6)	-0.119963	0.111256	-1.08	0.281	-0.338021	0.098095
Farmland size (X_7)	-0.005427	0.011341	-0.48	0.632	-0.027654	0.016800
Active labor force (X_8)	0.146963	0.134794	1.09	0.276	-0.117228	0.411154
Access to credit (X_9)	-0.029136	0.443055	-0.07	0.948	-0.897509	0.839236
Income from crop production (X_{10})	-0.033591	0.173670	-0.19	0.847	-0.373977	0.306796
Contact with extension agents (X_{11})	0.029564	0.038678	0.76	0.445	-0.046245	0.105372
Receiving agricultural information (X_{12})	0.602294	0.375819	1.60	0.109	-0.134299	1.338887
Receiving GAPs in rice production training (X_{13})	-0.240277	0.289296	-0.83	0.406	-0.807286	0.326732
Membership in local farmers' association (X_{14})	0.204327	0.252984	0.81	0.419	-0.291514	0.700167
Membership in seed growers' association (X_{15})	0.734585	0.532320	1.38	0.168	-0.308744	1.777914

Binary Logit for GAP3

Number of obs = 315

LR chi^2 (15) = 19.70

Prob > chi^2 = 0.0183

Log likelihood = -206.96306

Pseudo R^2 = 0.4754

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	0.109334	1.155508	0.09	0.925	-2.155420	2.374088
Age (X_1)	0.007083	0.015143	0.47	0.640	-0.022597	0.036763
Gender (X_2)	-0.522376	0.823318	-0.63	0.526	-2.136049	1.091298
Marital status (X_3)	0.142470	0.604166	0.24	0.814	-1.041674	1.326614
Education (X_4)	0.047785	0.039020	1.22	0.221	-0.028693	0.124262
Farming experience (X_5)	0.005828	0.013108	0.44	0.657	-0.019863	0.031518
Household size (X_6)	-0.078356	0.110987	-0.71	0.480	-0.295886	0.139175
Farmland size (X_7)	-0.025129	0.012568	-2.00	0.046	-0.049761	-0.000497
Active labor force (X_8)	0.112674	0.132439	0.85	0.395	-0.146901	0.372249
Access to credit (X_9)	-0.901165	0.471917	-1.91	0.056	-1.826104	0.023775
Income from crop production (X_{10})	0.003508	0.174466	0.02	0.984	-0.338437	0.345453
Contact with extension agents (X_{11})	0.133333	0.053817	2.48	0.013	0.027853	0.238812
Receiving agricultural information (X_{12})	0.370786	0.380916	0.97	0.330	-0.375795	1.117368
Receiving GAPs in rice production training (X_{13})	0.030767	0.290568	0.11	0.916	-0.538736	0.600270
Membership in local farmers' association (X_{14})	0.027241	0.252096	0.11	0.914	-0.466857	0.521340
Membership in seed growers' association (X_{15})	0.270596	0.496001	0.55	0.585	-0.701548	1.242740

Binary Logit for GAP5

	Number of obs	=	315
	LR chi^2 (15)	=	9.44
	Prob > chi^2	=	0.8534
Log likelihood = -213.61956	Pseudo R^2	=	0.220

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	0.226336	1.109475	0.20	0.838	-1.948196	2.400868
Age (X_1)	0.009824	0.015125	0.65	0.516	-0.019821	0.039469
Gender (X_2)	-0.663150	0.793783	-0.84	0.403	-2.218936	0.892636
Marital status (X_3)	-0.159909	0.584680	-0.27	0.784	-1.305860	0.986043
Education (X_4)	-0.006528	0.037902	-0.17	0.863	-0.080813	0.067758
Farming experience (X_5)	-0.019183	0.013110	-1.46	0.143	-0.044879	0.006512
Household size (X_6)	-0.060331	0.108924	-0.55	0.580	-0.273818	0.153157
Farmland size (X_7)	-0.002936	0.011288	-0.26	0.795	-0.025061	0.019189
Active labor force (X_8)	0.063574	0.130240	0.49	0.625	-0.191691	0.318840
Access to credit (X_9)	0.554762	0.441680	1.26	0.209	-0.310915	1.420439
Income from crop production (X_{10})	0.111663	0.169734	0.66	0.511	-0.221009	0.444335
Contact with extension agents (X_{11})	0.040196	0.038331	1.05	0.294	-0.034932	0.115323
Receiving agricultural information (X_{12})	0.056470	0.368816	0.15	0.878	-0.666396	0.779336
Receiving GAPs in rice production training (X_{13})	-0.361343	0.284367	-1.27	0.204	-0.918692	0.196006
Membership in local farmers' association (X_{14})	-0.048344	0.247503	-0.20	0.845	-0.533442	0.436754
Membership in seed growers' association (X_{15})	-0.523429	0.482531	-1.08	0.278	-1.469172	0.422314

Binary Logit for GAP6	Number of obs	=	315
	LR chi^2 (15)	=	15.21
	Prob > chi^2	=	0.0436
Log likelihood = -197.99258	Pseudo R^2	=	0.3770

Independent variable	**Coefficient**	**Standard error**	**z**	**P > z**	**95% Confident Interval**	
Constant	-2.131115	1.157194	-1.84	0.066	-4.399173	0.136943
Age (X_1)	0.023329	0.015599	1.50	0.135	-0.007244	0.053902
Gender (X_2)	0.026963	0.794519	0.03	0.973	-1.530267	1.584192
Marital status (X_3)	-0.124075	0.613726	-0.20	0.840	-1.326957	1.078806
Education (X_4)	0.020576	0.040101	0.51	0.608	-0.058022	0.099173
Farming experience (X_5)	-0.007979	0.013334	-0.60	0.550	-0.034113	0.018155
Household size (X_6)	0.045819	0.114318	0.40	0.689	-0.178240	0.269877
Farmland size (X_7)	-0.000651	0.011749	-0.06	0.956	-0.023677	0.022376
Active labor force (X_8)	0.055507	0.135729	0.41	0.683	-0.210517	0.321531
Access to credit (X_9)	-0.022534	0.472742	-0.05	0.962	-0.949092	0.904024
Income from crop production (X_{10})	0.026189	0.178151	0.15	0.883	-0.322981	0.375358
Contact with extension agents (X_{11})	0.049747	0.036766	1.35	0.176	-0.022313	0.121807
Receiving agricultural information (X_{12})	0.127369	0.388342	0.33	0.743	-0.633768	0.888506
Receiving GAPs in rice production training (X_{13})	-0.888145	0.321786	-2.76	0.006	-1.518834	-0.257455
Membership in local farmers' association (X_{14})	0.231394	0.259075	0.89	0.372	-0.276383	0.739171
Membership in seed growers' association (X_{15})	-0.093058	0.511520	-0.18	0.856	-1.095618	0.909503

Binary Logit for GAP8

Number of obs = 315
LR chi^2 (15) = 26.61
Prob > chi^2 = 0.0321
Log likelihood = -204.67856
Pseudo R^2 = 0.7851

Independent variable	**Coefficient**	**Standard error**	**z**	**P > z**	**95% Confident Interval**	
Constant	2.111065	1.414521	1.49	0.136	-0.661345	4.883475
Age (X_1)	0.004607	0.015439	0.30	0.765	-0.025653	0.034867
Gender (X_2)	-2.415709	1.195700	-2.02	0.043	-4.759238	-0.072180
Marital status (X_3)	0.896852	0.641149	1.40	0.162	-0.359776	2.153480
Education (X_4)	-0.077865	0.039936	-1.95	0.051	-0.156138	0.000409
Farming experience (X_5)	-0.012342	0.013429	-0.92	0.358	-0.038662	0.013979
Household size (X_6)	-0.135354	0.112142	-1.21	0.227	-0.355147	0.084440
Farmland size (X_7)	-0.007747	0.011896	-0.65	0.515	-0.031063	0.015570
Active labor force (X_8)	0.064792	0.134889	0.48	0.631	-0.199586	0.329170
Access to credit (X_9)	-0.668645	0.461489	-1.45	0.147	-1.573148	0.235857
Income from crop production (X_{10})	0.140283	0.174975	0.80	0.423	-0.202662	0.483228
Contact with extension agents (X_{11})	0.019074	0.037025	0.52	0.606	-0.053493	0.091641
Receiving agricultural information (X_{12})	0.791082	0.395202	2.00	0.045	0.016500	1.565663
Receiving GAPs in rice production training (X_{13})	-0.274580	0.289811	-0.95	0.343	-0.842599	0.293440
Membership in local farmers' association (X_{14})	0.287823	0.254048	1.13	0.257	-0.210103	0.785749
Membership in seed growers' association (X_{15})	0.787959	0.516543	1.53	0.127	-0.224446	1.800363

Binary Logit for GAP9

Log likelihood = -202.40531

Number of obs	=	315
LR chi^2 (15)	=	8.65
Prob > chi^2	=	0.0052
Pseudo R^2	=	0.2214

Independent variable	**Coefficient**	**Standard error**	**z**	**P > z**	**95% Confident Interval**	
Constant	-1.738645	1.227184	-1.42	0.157	-4.143881	0.666591
Age (X_1)	0.006153	0.015423	0.40	0.690	-0.024075	0.036380
Gender (X_2)	0.563607	0.878948	0.64	0.521	-1.159098	2.286313
Marital status (X_3)	0.581375	0.699337	0.83	0.406	-0.789301	1.952050
Education (X_4)	-0.009510	0.039926	-0.24	0.812	-0.087763	0.068744
Farming experience (X_5)	0.006599	0.013324	0.50	0.620	-0.019515	0.032713
Household size (X_6)	0.076839	0.111858	0.69	0.492	-0.142399	0.296077
Farmland size (X_7)	-0.017406	0.014082	-1.24	0.216	-0.045005	0.010194
Active labor force (X_8)	0.000749	0.133532	0.01	0.996	-0.260968	0.262467
Access to credit (X_9)	-0.388732	0.449536	-0.86	0.387	-1.269806	0.492342
Income from crop production (X_{10})	0.003500	0.179061	0.02	0.984	-0.347452	0.354453
Contact with extension agents (X_{11})	0.009613	0.038792	0.25	0.804	-0.066419	0.085644
Receiving agricultural information (X_{12})	-0.139634	0.378207	-0.37	0.712	-0.880906	0.601638
Receiving GAPs in rice production training (X_{13})	-0.162785	0.298083	-0.55	0.585	-0.747017	0.421447
Membership in local farmers' association (X_{14})	-0.139803	0.256834	-0.54	0.586	-0.643189	0.363584
Membership in seed growers' association (X_{15})	0.116088	0.504138	0.23	0.818	-0.872005	1.104180

Binary Logit for GAP11

Number of obs	=	315
LR chi^2 (15)	=	17.92
Prob > chi^2	=	0.0267
Pseudo R^2	=	0.4120

Log likelihood = -208.38976

Independent variable	**Coefficient**	**Standard error**	**z**	**P > z**	**95% Confident Interval**	
Constant	1.207749	1.142791	1.06	0.291	-1.032079	3.447578
Age (X_1)	-0.002040	0.015244	-0.13	0.894	-0.031918	0.027838
Gender (X_2)	-0.408402	0.814496	-0.50	0.616	-2.004785	1.187980
Marital status (X_3)	-0.158775	0.605595	-0.26	0.793	-1.345720	1.028169
Education (X_4)	-0.070983	0.039254	-1.81	0.071	-0.147920	0.005953
Farming experience (X_5)	-0.005143	0.013202	-0.39	0.697	-0.031018	0.020734
Household size (X_6)	-0.086924	0.110441	-0.79	0.431	-0.303383	0.129536
Farmland size (X_7)	-0.004142	0.011567	-0.36	0.720	-0.026813	0.018530
Active labor force (X_8)	0.005342	0.131560	0.04	0.968	-0.252511	0.263194
Access to credit (X_9)	0.179311	0.440972	0.41	0.684	-0.684978	1.043600
Income from crop production (X_{10})	-0.179776	0.172013	-1.05	0.296	-0.516914	0.157363
Contact with extension agents (X_{11})	0.040349	0.038429	1.05	0.294	-0.034971	0.115668
Receiving agricultural information (X_{12})	0.601997	0.377629	1.59	0.111	-0.138143	1.342136
Receiving GAPs in rice production training (X_{13})	-0.423909	0.287866	-1.47	0.141	-0.988116	0.140297
Membership in local farmers' association (X_{14})	0.221854	0.251790	0.88	0.378	-0.271645	0.715353
Membership in seed growers' association (X_{15})	0.632303	0.500863	1.26	0.207	-0.349369	1.613976

Binary Logit for GAP13

Number of obs	=	315
LR chi^2 (14)	=	14.94
Prob > chi^2	=	0.0382
Pseudo R^2	=	0.2710

Log likelihood = -203.32908

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	0.266218	0.978601	0.27	0.786	-1.651805	2.184242
Age (X_1)	0.008945	0.015436	0.58	0.562	-0.021309	0.039197
Gender (X_2)	-1.034045	0.881585	0.10	0.827	-0.051637	0.083547
Marital status (X_3)	0.144546	0.643153	0.22	0.822	-1.116011	1.405103
Education (X_4)	-0.045293	0.039649	-1.14	0.253	-0.123004	0.032418
Farming experience (X_5)	-0.013849	0.013607	-1.02	0.309	-0.040519	0.012821
Household size (X_6)	-0.102748	0.112130	-0.92	0.359	-0.322517	0.117021
Farmland size (X_7)	0.001044	0.011583	0.09	0.928	-0.021657	0.023746
Active labor force (X_8)	0.176391	0.136865	1.29	0.197	-0.091859	0.444640
Access to credit (X_9)	-0.275495	0.451739	-0.61	0.542	-1.160888	0.609898
Income from crop production (X_{10})	-0.302690	0.175385	-1.73	0.084	-0.646438	0.041057
Contact with extension agents (X_{11})	0.039871	0.040727	0.98	0.328	-0.039953	0.119695
Receiving agricultural information (X_{12})	0.365192	0.383091	0.95	0.340	-0.385653	1.116038
Receiving GAPs in rice production training (X_{13})	0.019130	0.289366	0.07	0.947	-0.548016	0.586277
Membership in local farmers' association (X_{14})	0.193455	0.253552	0.76	0.445	-0.303498	0.690408
Membership in seed growers' association (X_{15})	0.880229	0.536625	1.64	0.101	-0.171536	1.931994

Binary Logit for GAP14

Number of obs	=	315
LR chi^2 (15)	=	11.71
Prob > chi^2	=	0.0057
Pseudo R^2	=	0.2713

Log likelihood = -212.21588

Independent variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
Constant	0.681855	1.175497	0.58	0.562	-1.622077	2.985787
Age (X_1)	0.008642	0.015008	0.58	0.565	-0.020774	0.038058
Gender (X_2)	-1.033597	0.880778	-1.17	0.241	-2.759890	0.692700
Marital status (X_3)	-0.049546	0.598130	-0.08	0.934	-1.221859	1.122766
Education (X_4)	-0.007870	0.038234	-0.21	0.837	-0.082806	0.067067
Farming experience (X_5)	0.003612	0.013005	0.28	0.781	-0.021877	0.029102
Household size (X_6)	0.034178	0.109306	0.31	0.755	-0.180059	0.248414
Farmland size (X_7)	-0.014192	0.011762	-1.21	0.228	-0.037245	0.008862
Active labor force (X_8)	0.049942	0.130849	0.38	0.703	-0.206519	0.306402
Access to credit (X_9)	-0.647704	0.445500	-1.45	0.146	-1.520868	0.225461
Income from crop production (X_{10})	0.083776	0.171167	0.49	0.625	-0.251704	0.419257
Contact with extension agents (X_{11})	0.081440	0.044698	1.82	0.068	-0.006166	0.169045
Receiving agricultural information (X_{12})	0.127321	0.373182	0.34	0.733	-0.604102	0.858745
Receiving GAPs in rice production training (X_{13})	-0.170179	0.283964	-0.60	0.549	-0.726739	0.386380
Membership in local farmers' association (X_{14})	-0.131459	0.248119	-0.53	0.596	-0.617763	0.354845
Membership in seed growers' association (X_{15})	0.159744	0.480330	0.33	0.739	-0.781686	1.101174

Part (B-6) Variance Inflation Factor (VIF)

Variable	VIF	1/VIF
Age	2.70	0.370334
Active labor force	2.61	0.383046
Farming experience	2.40	0.416143
Household size	2.32	0.430223
Farmland size	1.73	0.579507
Income from crop production	1.53	0.651902
Contact with extension agents	1.28	0.778534
Membership in seed growers' association	1.24	0.803667
Receiving GAPs in rice production training	1.21	0.823514
Education	1.21	0.829295
Marital status	1.17	0.854885
Membership in local farmers' association	1.17	0.856983
Gender	1.12	0.888936
Receiving agricultural information	1.10	0.906003
Access to credit	1.09	0.916970
Mean VIF	1.59	

Part (C) SEM for GAPs in Rice Production

Structural Equation Modeling Number of obs = 315

Estimation method = ml

Log likelihood= -28356.439

Variable	Coefficient	Standard error	z	P > z	95% Confident Interval	
PRA <- AW	0.375157	0.168119	2.23	0.026	0.045649	0.704664
PCOM <- AW	1.263827	0.420072	3.01	0.003	0.440500	2.087153
PCPLEX <- AW	0.382450	0.277820	1.38	0.169	-0.162068	0.926967
PTR <- AW	2.644360	0.812348	3.26	0.001	1.052186	4.236533
POBS <- AW	2.748400	0.833626	3.30	0.001	1.114523	4.382276
ATTEC <- PRA	0.086388	0.092878	0.93	0.352	-0.095649	0.268426
<- PCOM	-0.020239	0.058644	-0.35	0.730	-0.135179	0.094702
<- PCPLEX	-0.033861	0.040627	-0.83	0.405	-0.113489	0.045767
<- PTR	-0.186452	0.091595	-2.04	0.042	-0.365976	-0.006928
<- POBS	-0.169728	0.107287	-1.58	0.114	-0.380006	0.040551
<- AW	2.013401	0.940352	2.14	0.032	0.170345	3.856456
ATTENV <- PRA	0.340303	0.166194	2.05	0.041	0.014568	0.666038
<- PCOM	-0.048761	0.062837	-0.78	0.438	-0.171919	0.074397
<- PCPLEX	-0.055399	0.044816	-1.24	0.216	-0.143237	0.032439
<- PTR	-0.174278	0.092477	-1.88	0.059	-0.355529	0.006973
<- POBS	-0.176427	0.107489	-1.64	0.101	-0.387102	0.034247
<- AW	1.949909	0.897870	2.17	0.030	0.190117	3.709701
ADOPT <- PRA	0.014827	0.050386	0.29	0.769	-0.083927	0.113582
<- PCOM	0.110941	0.042947	2.58	0.010	0.026766	0.195116
<- PCPLEX	-0.066480	0.027123	-2.45	0.014	-0.119640	-0.013320
<- PTR	0.200095	0.096570	2.07	0.038	0.010821	0.389369
<- POBS	0.153785	0.108239	1.42	0.155	-0.058360	0.365928
<- ATTEC	0.185110	0.121658	1.52	0.128	-0.053337	0.423556
<- ATTENV	0.118708	0.083893	1.41	0.157	-0.045720	0.283135
<- AW	-1.411741	1.080080	-1.31	0.191	-3.528659	0.705177

Appendix 6: Production Costs (kyat) Per Acre for Rice Production in 2017

Item	Production method		
	Broadcasting	Direct sowing	Transplanting
Land preparation	36,000	50,000	64,000
Planting	40,000	-	40,000
Crop management	60,000	16,000	40,000
Inputs	40,000	45,000	45,000
Harvesting	53,500	64,000	51,200
Total costs	271,500	175,000	280,200
Revenue	467,500	308,000	528,000
Profit	196,000	133,000	247,800
Cost/Benefit Ratio	1:1.7	1:1.8	1:1.9

Source: MOALI (2018).

Appendix 7: Seed Production by Departments, Farmers, and Private Sector

Year	Sown area (ha)				Production (ton)
	Departments	Farmers (Adopters)	Private	Total	
2012	202	-	213	415	662
2013	288	-	255	743	1,311
2014	308	-	223	531	978
2015	149	28	690	867	1,753
2016	28	460	16	504	980
2017	11	8	888	907	40,581

Source: MOALI (2018).