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

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Abstract: Although the Myanmar Ministry of Agriculture and Irrigation (MOAI) implemented Good Agricultural Practices (GAPs) in rice production, farmers' application of GAPs is decreasing. This study was conducted to examine farmers' perception of GAPs and the determinants of that perception. Data were collected using a structured questionnaire from a random selection of 315 farmers. By applying principal component analysis (PCA) and cluster analysis, the study found that all component technologies of GAPs have relative advantages and visible benefits. However, these component technologies of GAPs in rice production are perceived as relatively difficult to apply by farmers. According to the result of the binary logit model, determinants of farmers' perception were gender, education, farmland size, access to credit, income from crop production, contact with extension agents, receiving agricultural information, and receiving training in GAPs in rice production. Some agricultural policies and extension activities are needed to enhance farmers' perceptions of the compatibility of GAPs in rice production. 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 accept GAPs in rice production. 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 income, concerning the advantages of using GAPs in rice production.

Keywords: perception; GAPs; adoption; binary logit model; Myanmar

1. Introduction

Myanmar's national average rice yield in 2013 was the second-lowest in Asia [1], despite the introduction of Good Agricultural Practices (GAPs) in rice production in 2008 by the Ministry of Agriculture and Irrigation (MOAI) as a nationwide program to enhance the country's rice yield. According to the results of previous studies [2–4], the implementation of GAPs in rice production by MOAI resulted in an increase in Myanmar's rice yield [5–7]. Results of a field experiment showed that the rice yield under GAPs (4.28 t/ha) was higher than that under the conventional method (3.10 t/ha) [8]. GAPs in rice production comprised a package of technologies, including improved variety, nursery preparation and intensive care, transplanting, weeding and pest management, nutrient management, water management, and timely and proper harvesting [9]. These technologies are understood to be suited for a particular environment and aim at helping farmers to boost the yield of rice [10]. GAPs is a voluntary codified system that is related to the efficient production of crops and aims towards sustainability and equity for small-scale farmers [11–15]. The benefits of using GAPs in rice production are shown in Table 1, which shows the rice yield of rice is directly related to five component technologies (GAP1, GAP4, GAP5, GAP6, and GAP9). If farmers adopt these five component technologies, yield components, such as number of tillers, number of panicles, number of spikelets, and thousand-grain weight, will be increased and rice yield will be enhanced.

Table 1. Good Agricultural Practices (GAPs) components and benefits in rice production.

Components	Benefits
GAP1(Quality seeds)	Seed rate will be reduced, and robust seedlings are produced.
GAP2(Sparse sowing)	Sparse sowing will provide uniform growth of seedlings.
GAP3(Covering)	Covering will conserve moisture and easy for uprooting.
GAP4(Systematic care of nursery)	Healthy and vigorous seedlings will be provided by systematic care of the nursery.
GAP5(Uprooting & transplanting)	The seedlings will be quickly recovered by transplanting with natural soil.
GAP6 (Planting depth)	Shallow transplanting will induce healthy roots and easy tillering.
GAP7(Seedlings per hill)	Transplanting with one to two seedlings per hill will reduce seed rate and the cost of production.
GAP8 (Plant population)	Using the recommended population will provide an optimum population and proper ventilation.
GAP9(Alternate wetting & drying)	Intermitted irrigation will reduce water utilization, methane gas emission and enhance tillering.
GAP10(Pests & disease management)	Safety foods are produced by using integrated pests and disease management.
GAP11 (Balanced inputs)	The balanced application will increase the efficiency of fertilizers and reduce environmental pollution.
GAP12 (Submerging)	Submerging will reduce ineffective tillers.
GAP13 (Drainage)	Timely drainage will induce even ripening and easy harvesting.
GAP14(Combine harvester)	Using combine harvester will minimize post-harvest and quality losses.

Source: [16].

The characteristics of GAPs in rice production are related to not only increasing rice yield but also improving environmental benefits. GAPs in rice production enhance the production of safe and good quality food. These practices are usually environmentally safe and ensure that the final product is appropriately handled, stored, and transported. The adoption of GAPs in rice production helps to promote sustainable agriculture [17]. GAPs in rice production also provide safety products with a safe environment. Higher revenue will be generated by the use of GAPs in rice production [18]. Protection of crops against pests, diseases, and weeds must be achieved using appropriate control measures. If growers adopt GAPs in rice production, pest control actions have no potential impact on workers, food, and environmental and health safety. Although MOAI implemented GAPs in rice production, the adoption rate of farmers in 2016 remained at a low level: 16.57% in terms of area cultivated [19].

In adoption studies, farmers' decisions to adopt a new technology depend on many complex factors. One such factor is farmers' perception of the characteristics of the new agricultural technology [20–22]. Farmers' perception of agricultural technology influences their decision on adopt that technology [22]. Furthermore, farmer behavior is determined by their perception of sustainable agriculture [23]. It is likely that the successful adoption of conservation practices would be more influenced by the farmers' attitude and perception than any other factors [24]. When adopting technologies, farmers must pass the stage of evaluating them as a part of the adoption process. Farmers' prior experience in using technologies is likely to affect their perception of new technology [25,26]. If farmers properly receive information about new technologies, they will adopt those technologies quickly. Therefore, it is thought that one of the reasons for the low adoption of GAPs in rice production in Myanmar may be the low perception of farmers, although farmers' perception of agricultural technologies varies from household to household because of different interactive factors [27].

Technology characteristics are one of the major driving forces of farmers' adoption decisions [28]. Farmers' perceptions and characteristics are influential in the preliminary step of extension programs to promote sustainability of adoption among farmers [29]. A better understanding of farmers' perception of technologies and its impact on technology adoption will provide valuable information to technology providers [30]. Five characteristics (relative advantage, compatibility, complexity, trialability, and observability) of new technologies or products influence the adoption of these technologies or products [31]. Farmers' perception of the compatibility of sustainable practices with their farming systems is the best predictor of the adoption of such practices [32]. Indeed, an individual's perception of these five characteristics predicts the rate of adoption of new technologies [33].

Therefore, the present study aims at (i) clarifying farmers' perception of GAPs in rice production and (ii) examining determinants of farmers' perception of GAPs in rice production.

2. Materials and Methods

2.1. Framework and Variables

Researchers define perception in a variety of ways. Perception is defined as an interpretation of information [34]. Perception is mentioned as a process through which a person receives information or stimuli from the environment and transforms it into psychological awareness [35]. Farmers' perception is the knowledge and behavior of farmers regarding something [36]. Perception is mentioned as a cognitive process where an individual gives meaning to the environment [37]. In this study, perception is defined 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. These five characteristics of technology play a crucial role in farmers' decision making on adopting a given technology [38]. Therefore, since GAPs in rice production consist of 14 component technologies, the perception of GAPs in rice production is measured by 70 variables (5 characteristics $\times$ 14 component technologies).

There is a significant association between perceptions of selected sustainable agricultural technologies and characteristics, such as the age of the farmer, education, farming experience, farmland size, and contact with the information source [21]. Farmers' characteristics, such as age, education, land area, and number of family members, have a positive influence on farmers' perception [36]. Age, sex, education level, and farming experience have been adopted as explanatory variables for analysis of farmers' perception of an agricultural information resource center [39]. Moreover, age and cultivation area significantly were found to influence current perceptions of GAPs in a study of coffee farmers [40]. Farmers' perception of soil and water conservation practices in Ethiopia is influenced by age and education of farmers, farmers' previous experience in soil and water conservation, contact with extension agents, and participation in soil and water conservation training [41]. Explanatory variables such as age, gender, and education of the farmer, farming experience, household size, farm income, extension services, and access to credit were used to analyze farmers' perceptions of and adaptation to the effects of climate change in Kenya [42]. Characteristics such as age of the farmer, gender, education, marital status, member group, family members, family labor, farm size, and farming experience were shown to be determinants of farmers' perceptions towards the economic sustainability of rice farming [43]. Age and education level, number of the household labor force, farm income, and extension visits significantly contribute to farmers' perception of organic vegetable production [44]. Farmers' characteristics, such as age, education level of the farmer, and household size affect coping strategies in the perception of rice farmers in Tanzania [45]. Variables such as education, farming experience, and special training or extension programs have also been found to be determinants of farmers' perception toward production constraints [46].

In the present study, farmers' perception of GAPs in rice production is assumed to be influenced by two main factors: internal factors (personal characteristics, farming characteristics, and economic characteristics) and external factors (institutional characteristics) (Figure 1).

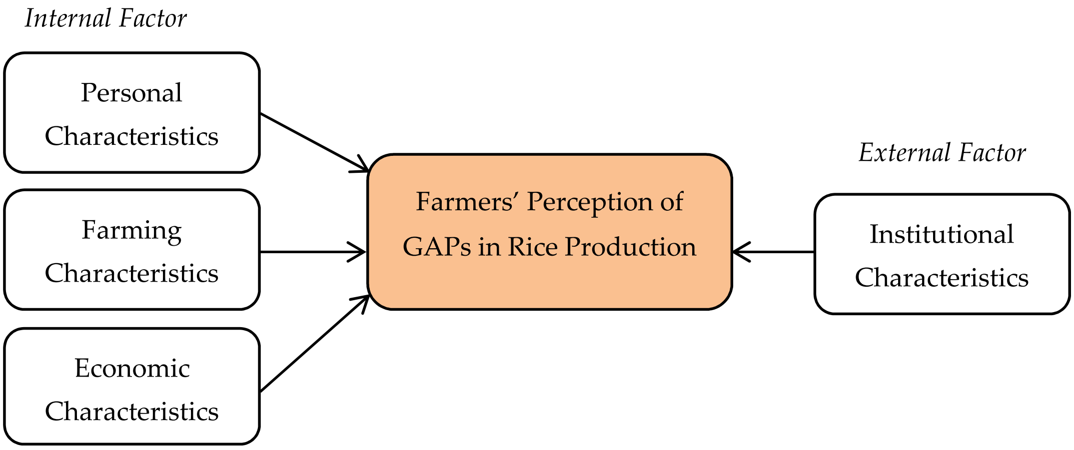

Figure 1. Conceptual framework of the study.

The present study takes the age, gender, marital status, education, and farming experience of the household head, and household size as personal characteristics (Table 2).

Table 2. List of internal and external factors.

Variables	Description	Sign
Personal characteristics		
Age	Age of household head	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 the rice field	FEXP
Household size	Number of household members (persons)	HHSIZE
Farming characteristics		
Farmland size	Size of farmland owned by household (hectares)	FSIZE
Active labor force	Number of household members actively involved in crop production (persons)	LAB
Economic Characteristics		
Access to credit	1 if household head has access to credit; 0 otherwise	CRE
Income from crop production	Level of annual household income from crop production: 1 for low (<6,000,000 kyats) 2 for medium (6,000,000–10,000,000 kyats) 3 for high (>10,000,000 kyats)	INC
Institutional characteristics		
Contact with extension workers	Number of meetings per year in 2017 (times)	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' association	1 for member; 0 otherwise	MLFA
Membership in seed growers' association	1 for member; 0 otherwise	MSGA

Farmland size and active labor force account for farming characteristics. Access to credit and income from crop production are included as economic characteristics. Institutional characteristics comprise contact with extension agents, receiving agricultural information, receiving GAPs in rice production training, membership in local farmers' association, and membership in seed growers' association.

2.2. Study Area and Sampling

Ayeyarwady Region is the most well-known region in Myanmar due to its large rice cultivation area. Myaungmya District, in the Ayeyarwady Region, was selected as the study area. Among the six districts in Ayeyarwady (Myaungmya, Pathein, Hinthada, Maubin, Pyapon, and Labutta), Myaungmya represents the Ayeyarwady Region in terms of two criteria. First, the mean yield of rice in the district was 3.21 t/ha, nearly the same as the 3.46 t/ha of Ayeyarwady Region. Second, the number of GAPs in rice production training in the district was 12, slightly lower than the 14.17 of the Ayeyarwady Region [47]. Since Myaungmya District consists of three townships—Myaungmya, Einme, and Warkhema—all townships were included in the study area (Figure 2). Nine villages (3 villages × 3 townships) were randomly selected, and 35 farmers from each village were chosen by landholding size. Therefore, the total sample for this study was 315 farm households.

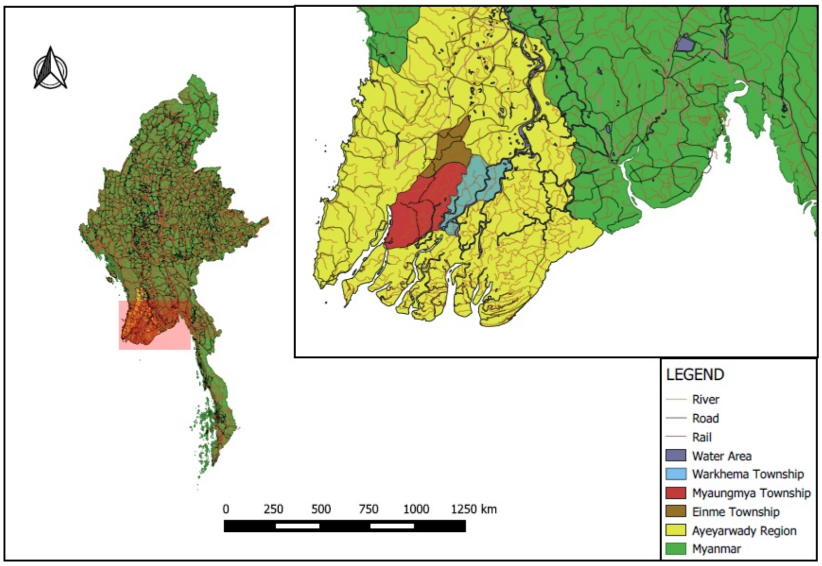

Figure 2. The map of the study area. Source: [48].

2.3. Data Measurement

According to the results of a pilot survey and key informant interviews, structured questionnaires were conducted by face-to-face interviews. The five characteristics of component technologies—relative advantage, compatibility, complexity, trialability, and observability—were used to measure farmers' perception of GAPs in rice production. These five characteristics are essential in studying technology adoption and play a crucial role in farmers' decision making [38]. Therefore, the questionnaire for farmers' perception included seventy statements (5 characteristics × 14 component technologies). For example, all statements for GAP1 are shown in Table 3.

Table 3. Statements to measure the characteristics of GAP1 (Quality seeds).

Characteristics	Statements
Relative advantage	The higher yield can be expected by using quality seeds.
Compatibility	It is compatible to use quality seeds for farmer.
Complexity	It is difficult for farmers to use quality seeds.
Trialability	You can test the characteristics of quality seeds.
Observability	You have a chance to observe the benefit of using quality seeds.

The respondents were requested to indicate the extent of their agreement with each statement using a Likert-scale five-point continuum: strongly disagree, disagree, neither agree nor disagree, agree, and strongly agree with assigned scores of 1, 2, 3, 4, and 5, respectively [23,39,49–53]. Then, based on the score, respondents were categorized into two types: if the score was less than 4, they did "not perceive," while if the score was equal to or greater than 4, they did "perceive" [49,53]. Cronbach's alpha was calculated to examine the reliability of data collected on farmers' perception of GAPs in rice production.

2.4. Data Analysis

A descriptive analysis using average, standard deviation, percentage, variance, and a comparison was carried out to clarify the primary features of farmers' perception of GAPs in rice production. Furthermore, farmers were categorized based on their perception of GAPs in rice production through principal component analysis (PCA) and cluster analysis. The former analysis enabled reducing the number of perception variables to several principal components to describe the features 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 examine the determinants of farmers' perception of GAPs in rice production is as follows [35,54,55]:

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

supposing: P_i = Probability of perceive and and $1 - P_i$ = Probability of not perceive:

$$P_i = \frac{1}{1 + e^{-Zi}} \tag{2}$$

$$1 - P_i = \frac{1}{1 + e^{Zi}} \tag{3}$$

According to [56],

$$\frac{P_i}{1 - P_i} = e^{\beta_i X_i + u_i} \tag{4}$$

$$l_n\left(\frac{P_i}{1 - P_i}\right) = \beta_i X_i + u_i,\ i = 1,\ 2,\ 3, \ldots,\ n \tag{5}$$

where X_i is the set of independent variables, β_i is the coefficient of independent variables, and u_i is an error term. The present study employed the following equation:

$$\begin{aligned} l_n\left(\tfrac{P_i}{1-P_i}\right) = \ & \beta_0 + \beta_1 AGE + \beta_2 GEN + \beta_3 MST + \beta_4 EDU + \beta_5 FEXP + \beta_6 HHSIZE + \\ & \beta_7 FSIZE + \beta_8 LAB + \beta_9 CRE + \beta_{10} INC + \beta_{11} EXT + \beta_{12} INF + \\ & \beta_{13} RGAP + \beta_{14} MLFA + \beta_{15} MSGA + u_i \end{aligned} \tag{6}$$

3. Results and Discussion

3.1. Farmers' Characteristics

The characteristics of respondents (farmers) are summarized in Table 4. Some farmers' characteristics were collected in conjunction with a sample the authors analyzed in a previous study [48]. The mean age of farmers was 50.25 years. Most were male and married. Their mean value of education was 5.57 years. On average, farmers managed 3.92 hectares of farmland, and had 25.56 years of farming experience. The mean household size was 4.51 persons, and the average number of the active labor force was 3.39 persons.

The mean income from total crop production per year was 8,004,010 kyats (USD 5674). They received agricultural information and could access credit for rice production. The average number of contacts with extension agents was 2.87 times in 2017. Around half of the respondents were members of the local farmers' association. Only 7.9 percent of farmers were involved in a seed growers' association.

Table 4. Descriptive summary of farmers' characteristics.

Farmers' Characteristics	Number of Farmers = 315	
	Mean	**Standard Deviation**
Age (years)	50.25	12.576
Gender (% of male)	97.46	15.8
Marital status (% of married)	95.24	21.3
Education (years)	5.57	3.309
Farming experience (years)	25.56	13.706
Household size (persons)	4.51	1.607
Farmland size (hectares)	3.92	5.42
Active labor force (persons)	3.39	1.427
Access to credit (%)	91.74	27.6
Income from crop production (*kyats/year)	8,004,010	11,244,539
Contact with extension workers (times)	2.87	3.658
Receiving agricultural information (%)	87.94	32.6
Receiving GAPs in rice production training (%)	27	44.46
Membership in local farmers' association (%)	45.71	49.9
Membership in seed growers' association (%)	7.9	27.07

Source: Authors and [48]. Note: * = Kyat is the currency of Myanmar; 1 kyat = 0.00071 USD or 1 USD = 1408.25 kyats as of 1 May 2020.

3.2. Farmers' Perception of GAPs in Rice Production

Farmers' perception of GAPs in rice production is shown in Table 5. Since the value of Cronbach's alpha for data on farmers' perception was 0.894 (i.e., greater than 0.7), the data were considered reliable for the analysis. Hereafter, perception is defined as follows: (a) perceive = scores of 4 and 5, (b) not perceive = scores of 1, 2, and 3.

Table 5. Distribution of farmers who perceive and do not perceive the statement of GAPs in rice production.

Components of GAPs in Rice Production	Relative Advantage			Compatibility			Complexity			Trialability			Observability		
	Percentage of Farmers		$\overline{X}$	Percentage of Farmers		$\overline{X}$	Percentage of Farmers		$\overline{X}$	Percentage of Farmers		$\overline{X}$	Percentage of Farmers		$\overline{X}$
	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
GAP2	96	4	4.7	59	41	3.5	80	20	4	94	6	4.5	95	5	4.5
GAP3	97	3	4.7	55	45	3.3	79	21	4	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	76	24	4	75	25	3.9
GAP6	96	4	4.8	35	65	2.8	79	21	4	72	28	3.7	70	30	3.7
GAP7	95	5	4.7	75	25	4	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

Note: (1) a = Percentage of farmers who perceive the characteristic, b = Percentage of farmers who do not perceive the characteristic, and $\overline{X}$ = 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 = Pests & disease management, GAP11 = Balanced inputs, GAP12 = Submerging, GAP13 = Drainage, and GAP14 = Combine harvester.

3.2.1. 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.

3.2.2. Compatibility

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

3.2.3. 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% for GAP9 (Alternative wetting and drying) and GAP10 (Pests and disease management), while the lowest was around 70% for GAP8 (Plant population) and GAP14 (Combine harvester).

3.2.4. Trialability

Because the mean of their scores was more than 3.5, with the exception of 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.

3.2.5. Observability

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

3.2.6. 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 on 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 3) 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 6. Five components, namely, GAP1 (Quality seeds), GAP7 (Seedlings per hill), GAP10 (Pests and disease management), GAP12 (Submerging), and GAP13 (Drainage) were observed in Cluster 1. All five characteristics were perceived by farmers in Cluster 1 because the mean of their scores was more than 3.5. In Cluster 2, four component technologies related to nursery management and combine harvester were involved. Transplanting operations, water, and nutriment management were classified to Cluster 3. Farmers have a low perception of compatibility for Cluster 2 and Cluster 3. All clusters have a high perception of relative advantage.

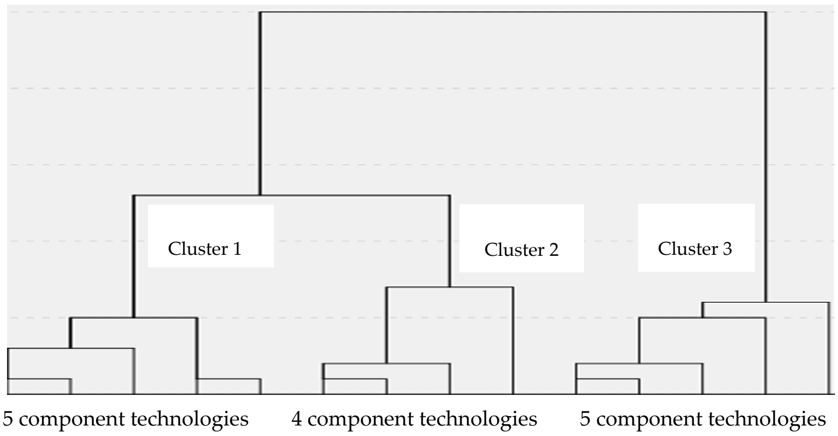

Figure 3. Dendrogram of 14 component technologies of GAPs of rice.

Table 6. The result of cluster analysis of 14 component technologies of GAPs in rice production.

Cluster	Component Technologies of GAPs in Rice Production		Mean Value				
	Number	Name	RA	COM	CPLEX	TR	OBS
1	5	GAP1, GAP7, GAP10, GAP12, and GAP13	4.64	4	4.06	3.82	4.2
2	4	GAP2, GAP3, GAP4, and GAP14	4.6	3.45	3.88	4.23	4.48
3	5	GAP5, GAP6, GAP8, GAP9, and GAP11	4.7	3.18	4.04	3.94	3.74

Note: (1) RA = relative advantage, COM = compatibility, CPLEX = complexity, TR = trialability, and OBS = observability. (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 = Pests & disease management, GAP11 = Balanced inputs, GAP12 = Submerging, GAP13 = Drainage, and GAP14 = Combine harvester.

3.3. Classification of Farmers Based on Their Perception of GAPs in Rice Production

3.3.1. 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 $\times$ 14 component technologies = 70) to several principal components (common factors) to describe the feature of perception of GAPs in rice production. In PCA, the Kaiser–Meyer–Olkin (KMO) test was used to determine that the data was suited for the analysis. Since the value of KMO was 0.828 and Bartlett's Test of Sphericity was significant at the 1% level, the collected data were useable for PCA. The result of varimax-rotated factor analysis (Table 7) shows that there are sixteen common factors of farmers' perception of GAPs in rice production. These common factors explained 71.487% of the variance. These 16 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 was considered as one common factor and explained 14.879 percent of the variance.

CF2: Advantages of GAPs (Except Submerging and Harvester)

The second common factor (CF2) showed 6.5 percent of the variance and was named advantages of GAPs in rice production because variables involved in the perception of relative advantages of GAPs in rice production (with the exception of two components—submerging and using combine harvester) were observed in this factor.

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)—were observed, and it explained 7.916 percent of the variance.

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

Common factor CF4 explained 5.125 percent 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, Nursery, 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)—were reduced to one common factor, which explained 4.552 percent of the variance.

CF6: Complexity of Nursery, Population, and Harvester

CF6 explained 4.543 percent of the variance and contained three variables: systematic care of nursery (0.906), plant population (0.901), and combine harvester (0.905).

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

CF7 described 4.405 percent of the variance and four variables were integrated into this factor: sparse sowing (0.826), planting depth (0.841), pests 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)—were observed in CF8 and explained 4.151 percent of the variance.

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

CF9 described 4.056 percent of the variance and consisted of four variables. These were 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 explained 3.944 percent of the variance, and four variables were found in this factor. These were 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 showed that 3.67 percent of the variance and three variables—soil covering (0.801), seedlings per hill (0.783) and drainage (0.798)—were integrated into this factor.

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

CF12 explained 3.213 percent of the variance and observability of three component technologies occurred in this factor. These were 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

In CF13, two variables—the relative advantage of the combined harvester and benefit of the population—were reduced to a common factor, which explained 1.95 percent of the variance.

CF14: Visible results of Using Planting Depth

The result showed that one variable—planting depth (0.725)—occurred in this common factor, which explained 1.748 percent of the variance.

CF15: Advantages of Submerging

The result showed 1.719 percent of the variance and one variable—submerging (0.609)—was observed in this common factor.

CF16: Compatible with Nursery

The common factor CF16 explained 1.624 percent of the variance and contained only one variable: compatibility of systematic care of nursery (0.702).

Table 7. 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 nursery	0.542		
Trialability of uprooting & transplanting	0.641		
Trialability of planting depth	0.762		
Trialability of seedlings per hill	0.83		
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 combine harvester	0.893		
Advantages of GAPs in rice production (except Submerging & harvester) (CF2)		6.5	4.55
Relative advantages of quality seeds	0.64		
Relative advantages of sparse sowing	0.577		
Relative advantages of covering	0.706		
Relative advantages of systematic care of 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	0.55		

Table 7. *Cont.*

Farmers' Perception	Factors		
	Factor Loading	Variance Explained (%)	Eigenvalues
Visible results of using nursery, pest & water management & harvester (CF3)		5.408	3.786
Observability of sparse sowing	0.864		
Observability of systematic care of 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	0.61		
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	3.18
Complexity of systematic care of 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 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 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)		1.95	1.365
Relative advantages of 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		

Table 7. *Cont.*

Farmers' Perception	Factors		
	Factor Loading	Variance Explained (%)	Eigenvalues
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 nursery	0.702		
Total variance explained		71.487	

Note: (1) Factor loading taken is over 0.3, and eigenvalues is over 1. (2) Kaiser–Meyer–Olkin of sampling adequacy (KMO) = 0.828, (3) CF = common factor, and (4) AWD = alternate wetting and drying.

3.3.2. Results of Cluster Analysis

Based on 16 common factors of farmers' perception of GAPs in rice production, farmers were categorized into groups by cluster analysis. According to the dendrogram (Figure 4) 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 value was assumed to be above 0.000 "high perception" because most of the mean values were less than 1. The accurate perception of GAPs in rice production for each cluster is summarized in Table 8.

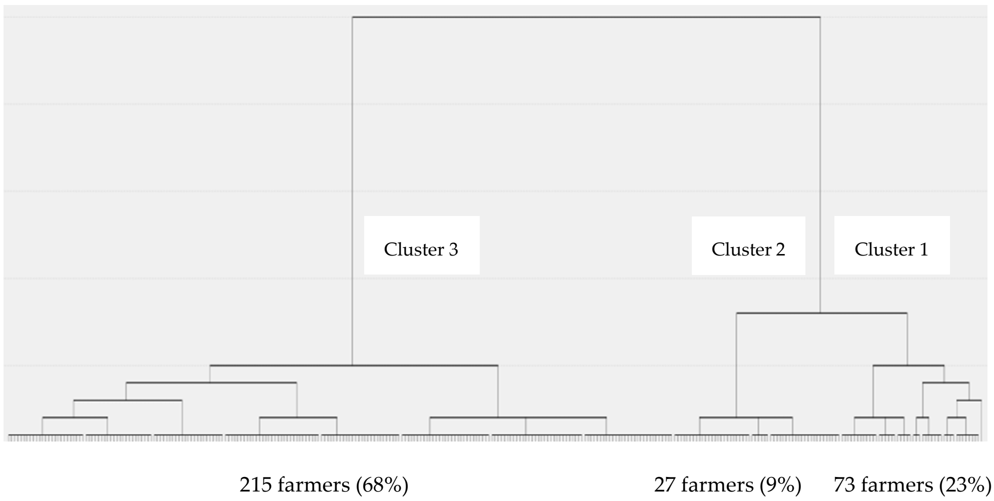

Figure 4. Dendrogram of farmers' perception by cluster analysis.

Cluster 1 (73 farmers: 23%)

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

Cluster 2 (27 farmers: 9%)

Similarly, compared with Cluster 1, a remarkable difference is 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 when the mean is positive and negative.

Cluster 3 (215 farmers: 68%)

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

Table 8. Farmers' perception of GAPs in rice production by group (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)	0.11 (1.718)	0.148 (1.51)	−0.01 (0.957)	−0.002 (2.045)	0.135 (1.995)	−0.084 (1.8)	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 (1.4)	0.677 (1.375)	0.123 (1.084)	−0.119 (1.757)	0.51 (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)	−0.12 (1.381)
3	215 (68%)	−0.088 (2.363)	−0.026 (1.03)	0.011 (0.95)	−0.103 (1.818)	0.015 (1.394)	−0.135 (1.256)	−0.012 (1.035)	0.016 (1.597)	−0.11 (1.467)	0.029 (1.39)	−0.032 (1.24)	1.98 (1.526)	0.194 (1.467)	0.077 (1.502)	−0.011 (1.127)	0.027 (1.051)

Note: (1) * = Cluster analysis by hierarchical clustering method, and CF = common factor. (2) CF1 = Trialability of GAPs, CF2 = Advantages of GAPs (except submerging & harvester), CF3 = Benefit of nursery, pests management, submerging and harvester, CF4 = Compatible with sowing, transplanting, inputs and drainage, CF5 = Benefit of quality seeds, nursery, AWD and inputs, CF6 = Difficulties in nursery, population and harvester, CF7 = Difficulties in sowing, depth, pest management & submerging, CF8 = Difficulties in quality seeds, transplanting, AWD and inputs, CF9 = Compatible with quality seeds, seedling number, pests management, CF10 = Compatible with covering, depth, AWD and harvester, CF11 = Difficulties in covering, seedling number & drainage, CF12 = Benefit of covering, seedling number and drainage, CF13 = Advantage of harvester & Benefit of population, CF14 = Benefit of planting depth, CF15 = Advantage of submerging, and CF16 = Compatible with nursery.

3.4. Determinants of Farmers' Perception of GAPs in Rice Production

As shown in Table 5, relating to five characteristics of GAPs in rice production, measuring significant variance in terms of the percentage of farmers (less than 60%) by Likert scale was limited to the compatibility of nine component technologies of GAPs in rice production: GAP2 (Sparse sowing), GAP3 (Covering), GAP5 (Uprooting and transplanting), GAP6 (Planting depth), GAP8 (Plant population), GAP9 (Alternate wetting and drying), and GAP11 (Balance inputs), GAP13 (Drainage), and GAP14 (Combine harvester). Therefore, the compatibility of nine component technologies of GAPs in rice production was selected as the dependent variable of the binary logit model. Since the 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.

Table 9 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 from the Department of Agriculture (DOA), and receiving GAPs in rice production training. Among these, contact with extension agents and receiving agricultural information from DOA were positively associated with farmers' perception of the compatibility of GAPs in rice production.

As to personal characteristics, gender and education were determinants of farmers' perception of the compatibility of GAP8 (Plant population). Gender showed a negative correlation with farmers' perception on the compatibility of GAP8. This contradicts the finding of [20]. Male farmers show a negative association with their perception of the compatibility of GAP8 (Plant population). This is likely because male farmers perceived that the recommended plant population is inconsistent at transplanting time. 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 [21,57], 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 in is line with the finding of [42]. The result reveals that farmers with access to credit were less likely to perceive the compatibility of GAP3 (Covering). Similarly, income from crop production was negatively correlated with only farmers' perception of the compatibility of GAP13 (Drainage). This contradicted the finding of [57]. The result implies that farmers who had higher income from crop production did not perceive the compatibility of timely drainage before two weeks of harvesting.

Among institutional characteristics, determinants of farmers' perception of the compatibility of GAPs in rice production were found for GAP3 (Covering), GAP6 (Planting depth), GAP8 (Plant population), and GAP14 (Combine harvester). Contact with extension agents was positively correlated with farmers' perception of the compatibility of GAP3 (Covering) and GAP14 (Combine harvester), which is in line with some other findings [27,58]. This implies that the improvement of their agricultural knowledge gained through such contact increases the probability of farmers' perceiving the compatibility of GAP3 and GAP14.

Table 9. The estimated coefficients of the 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	1.15	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	0.01	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	2.7
Gender	−1.682	1.12	−0.552	0.823	−0.663	0.794	0.027	0.795	−2.416 **	1.196	0.564	0.88	−0.408	0.814	−0.451	0.209	−1.034	0.881	1.12
Marital Status	0.002	0.623	0.142	0.604	−0.16	0.585	−0.124	0.614	0.897	0.641	0.581	0.699	−0.159	0.606	0.145	0.643	−0.05	0.598	1.17
Education	−0.01	0.039	0.048	0.039	−0.007	0.038	0.021	0.04	−0.078 *	0.04	−0.01	0.04	−0.071 *	0.039	−0.045	0.04	−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	2.4
Household size	−0.12	0.111	−0.078	0.111	−0.06	0.109	0.046	0.114	−0.135	0.112	0.789	0.112	−0.087	0.11	−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	0.13	0.056	0.136	0.065	0.135	0.001	0.134	0.005	0.132	0.176	0.137	0.05	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	0.45	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	0.17	0.026	0.178	0.14	0.175	0.004	0.179	−1.18	0.172	−0.303 *	0.175	0.084	0.171	1.53
Contact with extension workers	0.03	0.039	0.133**	0.054	0.04	0.038	0.05	0.037	0.019	0.037	0.01	0.039	0.04	0.038	0.04	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	−0.14	0.379	0.602	0.378	0.365	0.383	0.127	0.373	1.1
Receiving GAP training	−0.24	0.289	0.031	0.291	−0.361	0.284	−0.88 ***	0.322	−0.275	0.9	−0.163	0.298	−0.424	0.288	0.019	0.289	−0.17	0.284	1.21
Membership of local farmers' association	0.204	0.253	0.027	0.252	−0.048	0.248	0.231	0.259	0.288	0.254	−0.14	0.257	0.222	0.252	0.193	0.254	−0.131	0.248	1.17
Membership of 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	0.88	0.539	0.16	0.48	1.24
Pseudo R^2	0.214		0.475		0.220		0.377		0.785		0.221		0.412		0.635		0.271		-

Note:(1) Coef. = coefficient, SE = standard error, VIF = variance inflation factor, *** = significant at 1% level, ** = significant at 5% level, and * = significant at 10% level. (2) 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, and (3) Pseudo R^2 shows the fitness of model (higher is better for a given estimator).

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 [47]. It is likely that agricultural information helps farmers to understand the compatibility of GAP8. Meanwhile, there was a negative and significant (at the 1% level) relationship between receiving GAPs in rice production training and farmers' perception of the compatibility of GAP6 (Planting depth), though this contradicts the finding of [55]. The result is likely because farmers are afraid that control of planting depth at transplanting time depends on the skillfulness of transplanting laborer.

4. Conclusions

The present study revealed that almost all farmers perceived that all components of GAPs in rice production have three characteristics, namely, relative advantage, complexity, and observability. In perception of compatibility, among 14 component technologies of GAPs in rice production, farmers perceived that GAP1 (Quality seed), GAP4 (Systematic care of nursery), GAP7 (Seedlings per hill), GAP10 (Pest and disease management), and GAP12 (Submerging) were compatible with their farming practices. Farmers perceived that all component technologies of GAPs in rice production, with the exception of GAP13 (Drainage), could be easily tried on their farms. Based on the structure of farmers' perception of GAPs in rice production, farmers were classified into three groups. The differences (meaningful variance) in perception among farmers were identified in "trialability" (CF1) and part 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 agents, receiving agricultural information from the Department of Agriculture (DOA), 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 accept GAPs in rice production by, for example, 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.

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