Adaptive Capability of Farmer Group in Management of Lowland Rice Variety for Self-Reliance Production for Fai Kaew Community Enterprise in Fai Kaew Sub-District, Phupieng District, Nan Province

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Abstract

RD 6 rice variety is a well-known glutinous jasmine rice and widespread adoption variety in Northern Thailand and Nan province. This variety is threatened by rice blast disease, which is a serious rice disease in the area. Farmers are losing their yields. To solve this problem, a group of farmers in Nan province integrated scientific knowledge and local knowledge in a participatory rice varieties selection approach to achieve new rice varieties. This study applied the mixed methods. It relied on both quantitative and qualitative data encompassing secondary data gathering, field observation, in-depth interviews with farmers, non-government organization staffs, government organizations and related stakeholders involved in the operation of managing lowland rice variety for self-reliant production at Fai Kaew (FK) community enterprise, Nan Province, Thailand. The study revealed that the probability problem solving is the management of rice variety that had been implemented continuously. FK farmers' capability to adapt can occur along the way in the cycle of the learning process. They collaborated with rice researchers and non-government organization to select new rice varieties by integrating their local knowledge with scientific knowledge. Consequently, FK farmers can develop new rice varieties that are resistant to rice blast disease, namely Thayasirin and Nan 59. The main discussion is that the adaptive capacity that farmers as key actors can be ready to adapt and develop new solutions or interventions whenever new problems/constraints affect them in rice production and livelihood. Farmers deal with problems by integrating data and knowledge and collaborating with other stakeholders to select rice varieties that are suitable and respond to the farm ecological system, productivity and profitability. Thus, the management of farmers' rice varieties is a dynamic and continuous process. The adaptive capability is one of components of self-reliance of management of farmers' rice varieties.

Keywords: Adaptive Capability, Self-Reliance Production, Sustainable Agriculture, Rice Varieties

Introduction

Rice has played a crucial role in the nation's social and economic development in Thailand. Thai rice has traditionally been an export commodity and a stable food crop (Isvilanonda & Poapongsakorn, 1995; Baker & Phongpaichit, 2014). The effect of market demand has caused a decrease in local varieties, which have been replaced by modern varieties (MVs). Thai government established a policy to support extensive rice production and market network, leading to the regime of rice production, introducing also commercial varieties. Several aromatic modern rice varieties have been developed and released to farmers under the government plant breeding program. By the end of the 20th century, half of Thailand's wet-season rice area was covered by three genetically close varieties: Khao Dawk Mali 105 (KDML 105), which produces the premium quality and priced aromatic Thai Hom Mali rice, and its sisters by mutation breeding (which subjected KDML 105 to gamma irradiation), RD 6 and RD 15, with a further quarter of the area under a handful of modern high-yielding varieties (Rerkasem, 2016). Among the sets of improved rice varieties, RD 6 is a well-known glutinous jasmine rice and it is the

widespread adoption glutinous rice variety for people in Northern Thailand and in Nan province. This variety is preferred due to its grain shape, aroma, yield and eating quality.

The rice research system has been producing new generations of MV. The production of improved varieties has been continuing and the number of varieties released is about 116 (Rice Department, Ministry of Agriculture and Cooperatives, n.d.). The study of local non-government organizations in Nan province in the 1990s observed that the MV has spread to lowland rice cultivation with most farmers shifting from traditional to high-yielding MV. Although RD 6 has been well accepted by farmers and consumers in Nan province, this variety is not resistant to rice blast disease, which is serious rice disease in the area causing farmers to lose their yields.

In 2007, the rice blast disease caused serious damage to RD 6 variety in paddy fields in Nan province, a major problem for both farmers and rice researchers. Even so, from the interviews, farmers said that they still preferred RD 6 so any new variety must be as good quality as RD 6, but resistant to rice blast disease. Addressing this issue, the new improved varieties must respond to 1) rice blast disease resistance, 2) farmers' variety acceptance, 3) environmental condition, 4) productivity and 5) profitability. Therefore, the high adoption of new varieties requires farmers' participation, not only on rice station evaluation. Hence, the participatory method was used in varieties' development and to strengthen farmers' capacity in rice production in the future.

To solve this problem, Fai Kaew Community enterprise on rice seed production (FK group) is an example of farmer groups in Nan province that attempts to develop new rice varieties by collaborating with rice researchers and non-government organizations through Participatory Varieties Selection (PVS). They implemented a Farmer Field School (FFS) as a learning space among farmers' members, rice researchers and farmer networks. They conducted a number of participatory trials in farmers' fields and rice researchers distributed the segregating lines to farmers with knowledge of rice varietal improvement and seed production. The outcome is that FK farmers can develop new rice varieties that are resistant to rice blast disease, namely Thayasirin and Nan 59. Both varieties were developed to solve the rice blast disease in RD 6 variety, productivity and profitability for farmers.

Therefore, the operation of FK farmers in Nan province shows a potential operation of social mobilization of local community to adapt under the constraints by integrated knowledge and created collaborations in rice production.

Objectives

1. To study the operations and results of farmer groups in managing of rice varieties for self-reliance production
2. To understand and synthesize the significant of the adaptive capacity of farmers as one of the crucial mobilizing forces in management of rice varieties for self-reliance production

Methodology

This research applied the mixed methods. It replied on both qualitative and quantitative data. It focused on the process, operations, and results of a farmer group in the management of rice varieties for self-reliance production at Fai Kaew rice production community enterprise, Fai Kaew Sub-district, Phupieng district, Nan Province, Thailand. The FK group was chosen by purposive sampling method from 12 farmer groups organized by Joko Leaning Center. The data collection and fieldwork were conducted during 2017-2018. The method of data collection was based on fieldwork situations, especially the qualitative method.

To understand the process and operation of farmer groups in management of rice varieties, secondary data was collected from previous research papers, project progress reports, farmer's group meeting notebooks, news on websites and leaflets and reviewed. A timeline tool was used to collect and organize the events from the beginning until present of the movement of rice varieties management of farmers group. The actors and acting analysis were also used in timeline to reveal the interactions between key actors and how those interactions lead to the operation.

Information from the timeline helped the researcher to choose key informants who involved in the process of lowland rice variety management of FK group consisting of eight farmer members of FK group, a farmer breeder, six governmental organizations (Sub-district Administrative Organization, Agricultural Office, Provincial Agricultural Land Reform Office, National Science and Technology Development Agency (NSTDA), Rajamangala University of Technology Lanna, and Rice Research Center), a rice researcher, and NGOs. Structured interviews with key informants, on-farm participation, group meetings, farmer workshops and, social and cultural activities participation were employed to further understand the critical problems and condition of rice production, the process of problem analysis of key actors and how they found solutions. Quantitative method was also used to understand and synthesize the adaptive capacity of farmers in management of rice variety for self-reliance production. In addition, the researcher gathered yields, costs of production and incomes of seed production to combine with qualitative data analysis. The data were rechecked and analyzed by using Triangulation analysis and Content Analysis.

Results

A few decades ago, many groups of farmers and non-government organizations in Thailand recognized the impacts of modern or commercial agriculture. Farmers faced an insufficient domestic rice seed supply and the transition of farming from subsistence to commercial rice farming led to high-inputs dependency (Bhatt & Bujarbaruah, 2007). Farmers at present face many problems, such as high costs of production, ageing, pests and diseases and low quality of rice varieties. There are many farmers seeking new technologies and methods to solve these problems. One of the solutions is 'rice varieties' (Community Biodiversity Development and Conservation Programme Nan Province, Thailand: Annual Report (January-December 2003), 2003). Forging sustainable rice production is not easy, as demonstrated by many farmers in all regions. However, in the case of Nan Province, there are many efforts by government, academics, and non-government organizations to implement programs on rice varieties management. Joko Learning Center (Joko) is the local civil society network of Hug Muang Nan Foundation that focuses on the *in situ* conservation and development of plant genetic resources, and on rice in particular. In addition, Joko implemented a participatory rice varieties selection and plant breeding, conducting on-farm trials with local varieties through farmers' field schools (Santos Doctor, 2013). They are a good example of how farmers adapt in the dynamic and complex process of rice production, maintain good quality rice production, ensure that their rice varieties will be suitable or well adapted to ecological conditions, as well as good for both home consumption and the market.

This study revealed that the probability problem solving is the management of rice variety that has been implemented continuously. Fai Kaew group, one of 12 farmer groups under Joko network, who in collaboration with local non-government organizations and rice researchers, were dedicated in searching for new good quality of rice variety which is resistant to rice blast disease to replace RD 6 variety. By so doing, they achieved suitable rice varieties for household consumption and selling seeds for incomes.

1. Geographical and Socio-Economic Features and Rice Cultivation of Fai Kaew Sub-District

Fai Kaew sub-district is located in the central region of Phupieng District, Nan Province, in the northern region of Thailand with a total area of 20,829.92 hectares. Most of the area in the east of the sub-district is comprised of mountains and forest, the lowland area is near the west side of Nan River. Fai Kaew (FK) consists of 17 villages; five villages are located in a mountainous area, with most of the remainder located along the Nan River. The forest area is 49.05% or 10,217.92 hectares. Paddy rice area is 3.02% or 629.6 hectares. Farm crops area is 35.44% or 7,382.72 hectares. Standing timbers for economic value is about 8.8% or 1,840.48 hectares. The residential area is 3.02% or 628.8 ha and water source area is 0.63% or 130.4 hectares. Total population is 11,400 people. Some residents work off-farm, in small businesses or in the government sector. The average income of communities is about US$ 1,744.87 per person per year. Rice farming system is dominant in this area with both irrigation and rainfed ecosystems. Lowland rice growing areas occupies 401 hectares (628 farmers). Most farmers plant the improved rice varieties such as RD 6, KDML 105, Thanyasirin, and RD 6 resistant to rice blast. Agriculture is the main income of people in this area (Fai-Kaew Sub-District Administration Organization, Nan Province, 2017).

2. Historical Timeline of Fai Kaew Rice Seed Production Community Enterprise

The Fai Kaew rice seed production community enterprise (in this study 'FK group') is an empirical example of a farmer group that is dynamic and complex in terms of self-reliance on seeds, knowledge, rice varieties, and group organization. The timeline of FK group can be divided into four major periods; 1) Initiation period (1997-2000), 2) Stagnation period (2001-2005), Rehabilitation period (2007-2009) and Post-rehabilitation period (2010 to present) (See Figure 1 below).

Initiation Period (1997-2000)	Stagnation Period (2001-2005)	Rehabilitation Period (2007-2009)	Post-rehabilitation Period (2010-Present)
Y1997-1999 Farmers in Fai Kaw area produced RD 6 rice seeds for Phrae Rice Research Center (RRC). **Y2000** Setting up 'community rice center' with 50 members supported by RRC.	Number of members decreased to 23 farmers. Some farmers performed as free-rider and shirked responsibility while they got same amount of money after selling seeds. **Y2005** The group stopped the operation.	**Y2007** - Farmers asked Sub-district Agricultural Extension Officer to contact Joko for buying Neo Wan rice variety. - Joko brought rice researchers to meet with farmer leaders. They discussed about disease of RD 6 that affected to yield. **Y2008** 5 farmers set up field trials to select Neo Wan variety and RD 6 Resistant to rice blast. **Y2009** Farmers sold rice seeds again.	**Y2010** Farmers set up new group and registered as a community enterprise. - Setting up group fund. - Sell RD 6 resistant to rice blast at 25 baht per kg. -The group partnered with farmer network, NGOs, Government and Research sectors.

Figure 1 The Historical Timeline of FK Group

In the first period of the group, the farmer members produced rice seeds for Phrae Rice Research Center (Phrae RRC). In 1999, the 'Community Rice Center' group was established with 50 members supported by Phrae RRC. In terms of knowledge of farmers, it was found that farmers mostly used their own knowledge or local knowledge that had been accumulated from their farm work in rice seeds production.

In-depth interviews revealed that this group of farmers therefore had produced good seeds both for household consumption and for sale, but the group had failed in group organization because some members could not participate in all farm activities. Some performed as free-riders of other farmer's duty, especially when they had to clean and package seeds. It is difficult to get individuals to pursue common interests. This circumstance caused a conflict among members; member numbers decreased, only a few farmers produced rice seeds to RRC with low quality of seeds leading to the group becoming stagnant, closing in 2005.

In 2007, the RD 6 in this area had been destroyed by rice blast disease. One farmer said, "Our rice in the field fell down ('Yub' in Northern dialect means died)' at the seedling stage". RD 6 variety has high cooking and eating qualities and rich aroma and widely grown through the north and northeastern regions of Thailand. However, this variety is usually susceptible to rice blast disease, one of the diseases of rice that is widespread in Asia and Africa (Suwannual et al., 2017, p. 1). The severity of rice blast is dependent on many factors, including cultural practices, cultivars, climate, and nitrogen fertilizer (Ou, 1985). The disease can reduce grain yield by up to 90% (Khush & Jena, 2009). Therefore, FK farmers were looking for new varieties that had some of the same characteristics as RD 6 such as aroma, high production, slim grain, and good for market, or other varieties that might be better than RD 6. At that time, the Sub-district Agricultural Extension Agent coordinated with Joko for rice varieties. Joko introduced Neo Wan rice variety (A glutinous rice variety developed by farmer breeder, Mr. Wan Ruangtue) and RD 6 resistant to rice blast variety (Developed by rice researchers from Rajamangala Institute of Technology Lampang Campus and National Center for Genetic Engineering and Biotechnology (BIOTEC)) to FK farmers. In the year 2008, farmers implemented a field experiment for Neo Wan variety and RD 6 resistant to rice blast varieties. As they preferred RD 6 resistant to rice blast, the researchers released two tons of seeds for farmers in the following season.

In 2009, farmers informally sold RD 6 resistant to rice blast seeds. Then in the year 2010, farmers formed a group and registered as 'Community Enterprise for rice seeds production' aimed to produce and sell rice seeds. In the same year, H.R.H Maha Chakri Sirindhorn named the RD 6 resistant to rice blast 'Thanyasirin'.

In 2016, BIOTEC distributed a set of RD 6 resistant to rice blast with short height to FK group. They selected and named the selected line 'Nan 59' and promoted this variety as the success of the group. This group then distributed Nan 59's seeds to 11 farmers groups for agro-ecological adaptation test in 2017.

Following the rehabilitation period until 2018, numbers of the group have remained constant, neither increasing nor decreasing. There are still eight members who maintain the group's activities. From the interview, farmers' members would like to have new members, but they were afraid that new member could not follow their group's rules and might not have enough time to attend group's activities. The chairman of FK group said that one of the major rules was honesty; all members must commit to honestly produce good quality seeds for themselves and for consumers. On the one hand, small number of members are easy for management, but on the other hand, small number of members limit their access to the support from other sectors, especially, organizations that target on large numbers of participants. Notwithstanding, this group has developed for more than two decades. Their historical timeline show how they formed a group from contracted rice seed producers to form their own community

enterprise. Because of their rules and group management, these made them become a strong group in good quality of rice seeds and benefit sharing. The collaboration with non-government organization and academic sectors supported them in terms of knowledge and capacity building on rice varieties improvement and seed business.

3. Rice Varieties Development, Process of Learning and Collaboration of Key Actors in FK Group

3.1 Rice Varieties Development

Because the quality of rice varieties was a concern to FK members, they searched for good rice varieties for their business. However, each variety selected by the group had to be tested in their farms in small amounts before increasing it to a large amount. Each member observed the adaptation of rice varieties and discussed it with each other, then they selected good varieties to increase the next season. The criteria for selection normally were disease and insect resistance, size of grain, yield and eating quality. Table 1 shows the list of rice varieties that were selected and developed by FK group.

Table 1 Lists of Rice Varieties Selected and Developed by FK Group

Year	Distributors	Name of Varieties / Lines	Main Characteristics
1997-1999	RRC	RD 6	Glutinous rice, aroma, slim grain.
2000	Agricultural Extension Office	KDML 105	Non-glutinous rice, aroma, slim grain.
2007	Joko Rice Researcher and BIOTEC	- Neo Wan 2 - RD 6 resistance to rice blast	-Glutinous rice, aroma, strong stem, big grain. - Glutinous rice, slim grain, resistant to rice blast.
2008	FK Group's Selection	Thayasirin	Glutinous rice, slim grain, resistant to rice blast.
2015	Rice Researcher and BIOTEC	A set of RD 6 resistance to rice blast	- Glutinous rice, slim grain, resistant to rice blast. - Short height and medium height.
2016	FK Group's Selection Rice Researcher and BIOTEC	- Nan 59 - RD 6 tolerance to drought.	- Glutinous rice, slim grain, resistant to rice blast, aroma. - Glutinous rice, slim grain, tolerance to drought.

As seen in Table 1, RD 6 varieties or similar characteristics varieties were preferred by FK farmers because of eating quality and market preference. All rice varieties released to FK farmers had been experimented about variety adaptation in farmers' fields. FK farmers observed and evaluated the growth stages, yields and eating quality of each variety to ensure that they can get a good quality of rice variety. In 2016, FK group and farmers networks gave the name 'Nan 59' to one stable line of RD 6 resistant to rice blast with short height plant and promoted this variety as a network rice seed product. The success of 'Nan 59' rice variety was not only for FK group and the network; the rice researchers and research institute also enjoyed success in terms of variety development and problem solving for farmers.

3.2 Process of Learning and Knowledge Inclusion in Management of Rice Varieties

This group participated in Farmer Field School (FFS) network under Joko and applied FFS approach in rice varieties development. In general, the concept of FFS was initiated by the Food and Agriculture Organization (FAO). According to the definition by Braun et al. (2006, p. 8), "the FFS was first introduced in Indonesia in 1989 to address the challenge of ecological heterogeneity and local specificity in pest management. FFS relied on the development of learning-center curricula for experiential learning that takes place in the field, allowing farmers to observe, measure, analyze, assess and interpret key agro-ecosystems. The adult education concepts and

principles that underlie the design of curricula and the learning cycle process have proven robust in all areas where FFSs have been developed".

Regarding FFS in Nan province, farmers formed a community group and learned about rice varieties by using a participatory learning approach. The participatory concept encouraged all sectors in the agricultural development scheme to understand that centralized, government-led and mainstream technology transfer was not the answer to sustainable agricultural development. Rather, it was the participatory and farmer-led approach that empowered farmers and local community to be self-reliant. Participatory Varieties Selection (PVS), Participatory Plant Breeding (PPB) and the Seed Supply System (SSS) are core contents of the FFS curriculum for rice conservation and development created by SEARICE. PVS encourages farmers to select adaptive varieties by using the participatory learning process; PPB encourages farmers to do rice breeding and select good lines so that lines became uniform or stable varieties; SSS facilitates rice seed exchange and distribution among farmer networks (Sakitram, 2005).

The FFS curriculum combines scientific and local knowledge. Joko played the role of facilitator. FK farmers learned from 'seed to seed', meaning that they learned from the first step of rice production; land preparation, seed preparation, seedbed, transplanting, field observation and data collection, removing off-type plants, harvesting and seed storage. They also learned new scientific knowledge on rice selection and breeding techniques with rice researchers and academic institutes.

3.3 Collaboration of Key Actors in Management of Rice Varieties

In the case of FK group, while farmers attempted to solve their problems, they collaborated with external organizations in terms of rice varieties management (See Figure 2).

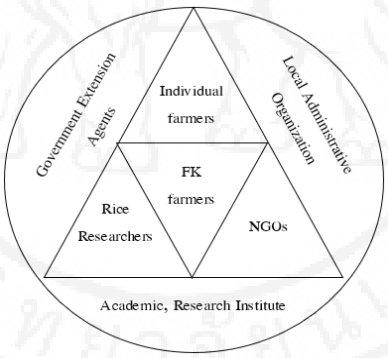

Figure 2 Key Actors and their Roles in FK Group

Figure 2 demonstrates how non-government organizations (NGO) such as Joko, rice researchers and farmers from FFS network worked closely with FK farmers in the field experiments and during rice season. Joko, as the local NGO, organized the on-farm learning session. Although this organization had technical agriculture staff, some FFS sessions required rice experts/researchers to transfer particular knowledge and techniques to FK group; for example, varieties selection, seed purification, seed quality check and seed standard check. However, Joko played a major role to coordinate farmers with rice researchers, other farmer groups and local authority. During rice season, farmers managed their own farms such as water level, fertilizers and labors.

After their registration as the community enterprise, FK group had opportunity to access in training, financial and equipment supports from government sectors. NSTDA supported the group with a harvesting machine

and transplanting machine. Nan Land Development Station provided materials with training to FK group in reducing the use of chemical fertilizers. Office of Phupieng District Agriculture contributed 5,000 packages to contain seeds for marketing and a seed cleaning machine. I found that the accomplishment of FK group in seed business was a strength that motivated other organizations to support them.

In my study, knowledge inclusion in the management of rice varieties created the integration of scientific and local knowledge and practice among farmers, rice researchers, Joko staff and other stakeholders. In FFS learning activities, farmers, researchers and development staff (NGOs) exchanged and shared knowledge related to the stages of rice growth. In addition, key actors and stakeholders also added their own experience and knowledge which other actors may or may not have. Therefore, knowledge sharing by key actors and stakeholders depended on particular actions. Figure 3 shows the knowledge contributed by each key actor and stakeholder and their implications.

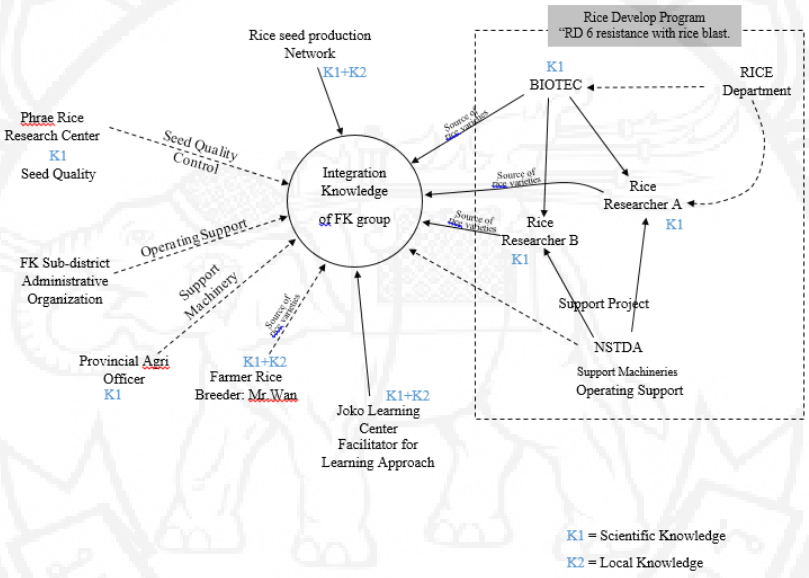

Figure 3 Integration of Scientific and Local Knowledge of FK Group

Referring to Figure 3, K1 represents scientific knowledge whereas K2 represents local knowledge. K1 is used by mostly government sectors and research institutes; such kinds of knowledge consisting of agricultural techno-scientific knowledge. In FFS activities, rice researchers applied a participatory approach in K1 in an effort to respond to farmers' needs in rice variety improvement. Rice researchers applied the PVS approach in FFS activities by distributing promising lines of RD 6 resistant to rice blast to farmers for selection. Those researchers transferred knowledge, such as rice variety selection techniques, rice growth stage observations and off-type removing techniques when they attended FFS sessions and field monitoring. Agricultural extension transferred K1, depending on emergencies and their action plan, such as outbreaks of insects and diseases and training about organic fertilizers. The RRC trained the FK group in the seed quality checking process. On the other hand, Joko, farmer breeders and farmers groups in Joko's network shared both scientific knowledge and local knowledge with the FK group. Both kinds of knowledge gained from their experiments blended together to become situated knowledge that had a mixture of scientific knowledge.

At present, there are eight farmer members in FK group. The FK group became a learning center for farmers both in Nan and other provinces and participated in both government and non-governmental organizations' development programs. Regarding the financial and income management of FK group, each member sold seeds at 23 THB per kilogram to the group. The group sold seeds to buyers at 25 THB per kilogram, with the two THB per kilogram profit saved into FK's group management fund. This money was mostly used for seed business, while some was donated to social activities in their community. In 2017, the total amount of seeds produced by the group was 49.05 tonnes with a total income of 1,219,250 THB. The average cost of production per kilogram was 6.43 THB. The data shows that farmer members earned 16.57 THB per kilogram profit from the seed business indicating that farmers earn a better income by selling seeds than by selling grain. Table 2 below shows costs of production and incomes of seed production of FK group in crop year 2017.

Table 2 Yields, Costs of Production, and Incomes of Seed Production of FK Group in Crop Year 2017

Farmer Samples	Planted Area (ha)	Planted Area for Seed Production (ha)	Yields (Tons)	Average Yield (t / ha)	% of Planted Area for Seed Production	Amount of Seeds Sold to Group (Tons)	Total Costs of Production (Thai Baht)	Costs of Production (Thai Baht per Kg.)	Incomes (Thai Baht)
Farmer A	3.04	3.04	16.50	5.42	100.00	16.50	141,664	8.59	412,250
Farmer B	1.28	0.50	5.04	3.93	39.06	2.00	32,993	6.55	50,000
Farmer C	2.08	1.54	12.78	6.14	74.03	9.48	60,835	4.76	237,000
Farmer D	1.44	1.08	7.2	5.00	75.00	5.4	41,420	5.75	135,000
Farmer E	2.08	1.79	9.72	4.67	86.05	8.4	57,150	5.88	210,000
Farmer F	0.64	2.70	4.44	6.93	68.00	3.00	15,240	3.43	75,000
Farmer G	0.96	0.29	5.64	5.87	30.20	1.75	54,480	9.66	43,750
Farmer H	0.80	0.47	4.26	5.32	58.75	2.52	29,180	6.85	56,250

Source: Survey 2017

The results of the operation of FK group show the success of the group in terms of rice variety management and the seed production business. The quality of rice variety can respond to eating quality, farm ecological adaptation and income generation from rice seeds. In addition, the on-farm learning approach among farmer members helped each farmer to acquire new knowledge and techniques in rice variety development, seed production and farm management. This approach also allowed other key actors to collaborate and support farmers in knowledge, materials, equipment and budget.

Discussion

The main discussion relating to the adaptive capability for self-reliance of management of rice varieties is that farmers as key actors can be ready to adapt and develop new solutions or interventions whenever new problems/constraints affect them in rice production and livelihood. The results of this research have provided evidence that the learning process is an important component of farmers' adaptive capability. This finding confirms the conclusions of George et al. (2007) and Prabuddhanitisarn (2014) who found that a learning process helps farmers to adapt by increasing knowledge and skills and to enhance agricultural and natural resource management decisions and problem analysis.

The participatory learning activities in FFS increasingly created multiple power of knowledge. FK farmers integrated scientific knowledge transferred through collaboration with the local and practical knowledge of other key actors. In addition, FFS approach fostered a cooperative relationship among key actors which also enhanced FK farmers' capacity in having an analytical mindset to make decisions in problem solving. When farmers replicated rice variety selection and related knowledge and skills in the field, they had more confidence. Each farmer member had the capacity to solve new problems and obstacles that occurred in the on-farm experiments and FFS activities. The operation of group learning, the processes of knowledge, experience sharing, and discussion influenced the individual farmer's mindset. Confidence in action created as action-oriented mindset of individual farmers which consisted of the following: 1) understanding the whole process, 2) understanding problems (simple and complex) that occur in each process, and 3) being able to know the action and risks and manage those risks.

Therefore, farmer's capacity to adapt can occur along the way in the cycle of the learning process. The key concept of adaptation is that farmers as key actors can be ready to adapt and develop new solutions or interventions whenever new problems/constraints affect them in rice production and livelihood. Farmers feel confident to solve problems because they have the experience from participating in FFS activities. The process of learning among farmer members enhanced their capacity in coping with the problems that occurred in their fields. This finding also confirms Uy et al. (2015) conclusion that offering training courses to train and encourage farmers to adopt and apply coping methods is very necessary. Farmers should be trained through practice in the field (Farmer Field School method) instead of being taught by theory. In this research, Fai Kaew farmers know how to deal with problems by using data and knowledge, and they collaborate with other actors to assist them in implementing operations to solve problems by using internal and external capital such as knowledge, rice genetic materials, budget and mandate. In the operation action, farmers and key actors can manage rice varieties that are suitable and respond to the farm ecology system, the farming social system and the seed business system.

In the success and failure of the first stage of operation, some farmers still had confidence in solutions, and they continued to find new intervention in new conditions. This shows the dynamic adaptation of key actors. For example, FK farmers succeeded in selecting Thanyasirin variety with resistant to rice blast disease, but they learned that the aroma had decreased compared with RD 6. Because of the relationship between farmers and rice researcher, farmers reflected on this problem with the researcher who had good connections with BIOTEC. Through this connection, BIOTEC developed new sets of rice varieties and distributed them to Fai Kaew farmers to select for their rice seed production. The integrating of knowledge in the interaction of key actors synergized the adaptive capacity of farmers in rice variety management. Similarly, in Salvia & Quaranta (2015) research, the discussion in the interaction among stakeholders was the recognition of the urgent need to find common ground to share problems related to agriculture and to promote greater synergy through learning from one another and address complex problems. Thus, the management of farmers' rice varieties is a dynamic and continuous process. Farmers have the ability to collaborate with other actors, integrate knowledge, and mobilize processes of problem solving and related components.

Conclusion and Recommendations

The FK group is an empirical example in synthesizing the adaptive capacity under the operation action of farmers and key actors. This group represents the adaptability and movement of localization in self-reliance rice production. The knowledge integration was found to be a capability of farmers to be able to identify the solution

when rice blast disease attacked RD 6 variety. The learning process in FFS activities reduced the gap between a reductionist approach taken by scientists and holistic frame approach taken by farmers. FK farmers have simplified the scientific knowledge on rice varieties development into locality. The spiral of knowledge production in the operation increased capability of farmers, both in problems solving and in adapting to the rapid agricultural change. Thus, the adaptive capacity occurs when key actors have confidence in problem solving through active learning and integrated knowledge. They will apply their knowledge and experiences to create new interventions in a new loop of problem solving as can be seen in Figure 4.

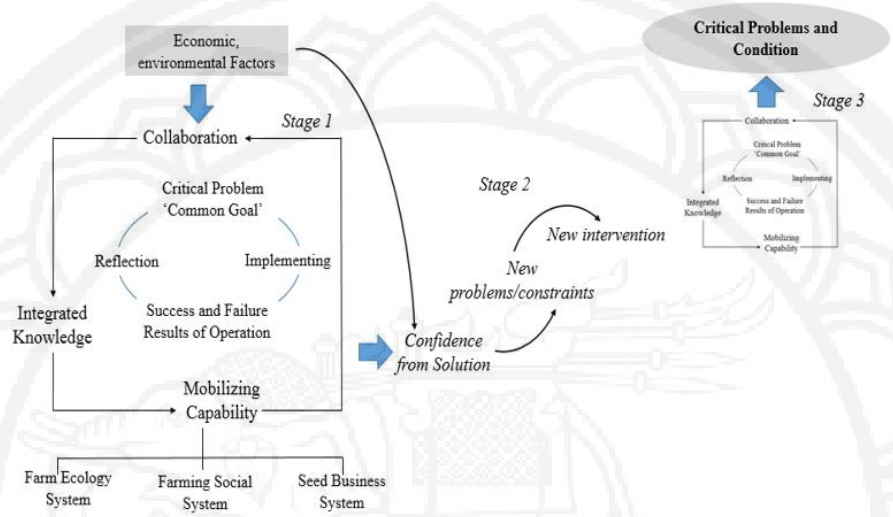

Figure 4 The Adaptive Capacity of FK Group in Rice Varieties' Management

The management of farmers' rice varieties is a dynamic and continuous process. The adaptive capability is one of the components of self-reliance of management of farmers' rice varieties. This research recommends that the adaptive capacity of farmers in current situation of rice production should be more concerned by agricultural research and extension stations, and related agencies to fill the gaps or limitations of the function-based approach in mainstream rice improvement programs. The significant components of farmers' adaptive capacity building in management of rice varieties consists of the adoption of integrated knowledge through participatory learning approach, the collaboration of key actors to find out the appropriated approaches, rice improvement programs and financial supports to farming communities, and the favorable conditions at national policy and local government to support farmers in coping with problems in rice production and external disturbances in the future.

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