博士論文

Assessment of rainfed lowland rice improvement in Thailand by participatory research and farmer field school to cope with climate change

（気候変化に対するための参加型研究と農家学校による
タイ天水田稲改良の評価に関する研究）

Pichayanun Suwanmontri

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Doctoral thesis

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Abstract

Rice production extension of Thailand had been under training and visit system for a long period since 1970s till 1990s. However, since 2000s, the system has been changed to the participatory method, and several approaches such as farmer field school, participatory research project, etc. have been implemented to make an improvement on country's rice production. This thesis made an assessment on characteristics of farmers who participated participatory approach in rainfed rice ecosystem of Northeast Thailand. Characteristics in socio-economic background, learning activeness, relationship with researcher, and awareness towards climate change were analyzed. Low average yield level of the region and yield variation at household level as well as farmer perception towards climate change phenomenon were clarified.

Based on the national statistics documentation from 1961 to 2016, it seems that the progress of rice yield increase has not been improved after the extension had converted to the participatory system. Compared to central region, the small yield increase of the northeast was due to the less ratio of dry season production (30% VS 5%), less area expansion of high-yielding modern varieties (65% VS 3%), almost half rate of inorganic fertilizer, and relatively higher yield of direct wet seeding of central region (Chapter 2).

Comparative analysis between participants and non-participants in climate adaptation research project run by Thai government sector were conducted based on a household interview survey in the research project area where climatic incidents such as drought or flood usually occurred. The first survey was conducted during 2016 (N=206） at the time when project finished while the follow-up survey was conducted again in 2017(N=185. Participants were local group members, active in learning, had close relationship with researcher, higher in farming technical efficiency, produce rice in greater amount for sale and income purpose. Yield variation among farmers from less than 1 t/ha to 4 t/ha revealed the broad yield gap of farmer. Though this could not be explained by the participation to the project, high yield gained was found to be enhanced by the good water environment of lower field in rainfed condition, and higher organic and inorganic input which associated with the market-orientation drive.

Moreover, 60% of participants who said they understood about the message of 5th Intergovernmental Panel on Climate Change (IPCC) as well as the 30% of non-participants, both of them did not actually understand the scientific meaning of climate change. The results of 84% and 96% of participants and non-participants that they did not bun the rice straw residue were not from their understanding to reduce greenhouse gas emission but because they want to conserve the soil quality and organism. Although participants had more positive response to the technologies linked with climate change adaptation, the difference in the responsive action to climate variability was not detected between participants and non-participants. Regardless to the participation. The recent change of climate such as more hot, more drought, or unpredictable climate has been widely noticed by Northeast Thailand farmers. The farmers who made a trial on the technologies (i.e. drought-tolerant varieties, flood-tolerant varieties, drill seeder) introduced by the participatory research project, although few numbers, were those who had a close relationship with researcher, active in learning, belongs to local group in their rice community, low yield loss from the climatic incidents in past (Chapter 3, 4).

Farmer field school approach to cope with climate change in North Thailand was investigated via the interview survey of twelve participant farmers. In contrast to the previous reports of farmer field school from literature review which participants could be selected from self-selection, for the case of North Thailand, farmers were selected as representatives of local group based on their potential in rice farming, accountability of community, and leadership

which they were expected to disseminate their knowledge to other farmers after finishing the school program (Chapter 5).

The thesis clarified three points. First, based on the survey of participatory research project and farmer field school, participants equipped with social skill, learning activeness, leadership, and close relationship with researcher, but they did not much surpass other non-participants in fertilizer application rates and yield level. They did not understand climate adaptation and mitigation in practice. Second, there was a large yield gap among farmers in rainfed rice ecosystem. If elite farmers who equipped with advanced technology were included in the project and expected to transfer technology to others, thus it is possible to make yield improvement of the country. Third, it is not easy to make farmers understand about the long-term climate change issue as they used to climate variability of rainfed ecosystem, thus consistency in training and policy to support farmers towards climate change is needed.

Acknowledgement

The information from the project “Strengthening farmers’ adaptation to climate change in the rainfed lowland rice system in the Northeast” was provided by the National Research Council of Thailand and Agricultural Research Development Agency under the Thailand Research Organizations Network.

I would like to say thank you to DOAE for the information of agricultural extension and allowed me to access the library to search for important documents. I really appreciated Mr. Boonrat Sukmak and Ms. Pattamaporn Khongtanakrittakorn for their collaboration during my visit.

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Chapter 1
Introduction

Rice (*Oryza sativa* L.) is one of the major crop feeding 3.5 billion of world population (Muthayya et al., 2014) and a main source of food for people in Asia. The increasing demand for rice from growing population raises concerned about food security (Ray et al., 2013; Van Nguyen & Ferrero, 2006). Increasing global rice productivity has been a challenging task because natural resources become scarce (Van Nguyen & Ferrero, 2006) while facing the risks of climate change impact (Mohanty et al., 2013).

In Thailand, rice is a major staple crop as well as an economic crop. Thailand produces rice more than 30 million tons per year (Office of Agricultural Economics [OAE], 2018e, 2018a) and exports approximately one-third (Datasource: Thai rice exporters association–2018). Thailand has been known as a top rice exporter (Muthayya et al., 2014), with its amount of export contributing 25% of world total (Datasource: Thai rice exporters association–2018). Despite with the status of world top exporter and its importance as a main food for Thai people, the average yield level of rice is still at moderate level; only around 3 t/ha (OAE, 2018e, 2018a), lower than the world average (ca. 4.5 t/ha) and other countries in Asia in 2015 (Fig 1.1, Data source: FAOSTAT2018). Thailand and other countries in South-east Asia had similar rice yield level in 1960s. After green revolution started with a worldwide spreading of technologies: high yielding rice varieties (HYVs), chemical input, mechanization, etc., other countries such as Vietnam and Indonesia had much improvement in rice yield; from 2 t/ha to ca.6 t/ha over 50 years (Tran & Kajisa, 2006), while Thailand's yield has totally increased only 1t/ha (Fig 1.1).

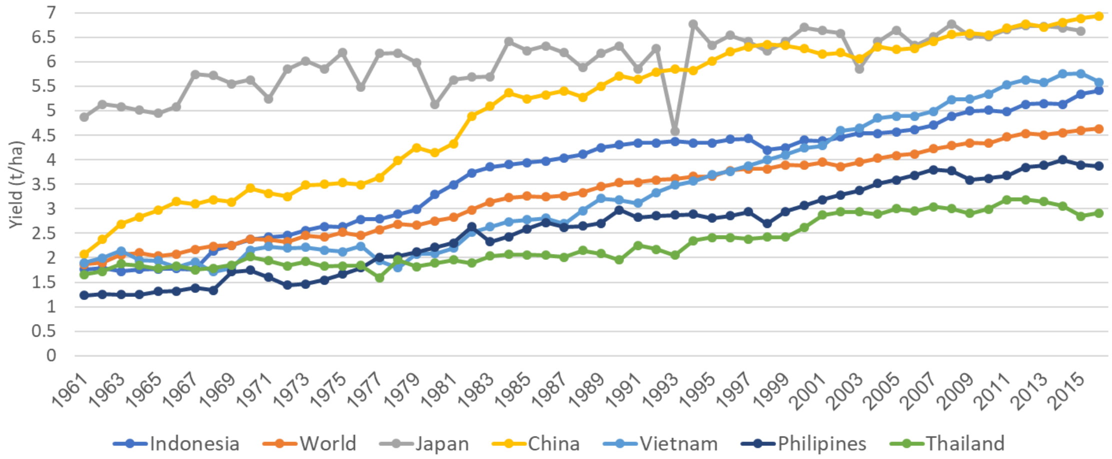


Figure 1.1 Rice yield changes from 1961 to 2016 in selected Asian countries (Data source: FAOSTAT 2018)

Towards the improvement of rice production and yield in rainfed ecosystem, a lot of studies have been conducted in breeding and agronomy to characterize rainfed environment and analyze constraints to yield (Fukai & Ouk, 2012; Haefele & Konboon, 2009; Jongdee et al., 2006; Lobell et al., 2009). These researches explained the effect of water environment, varietal performance, agronomic management condition on yield level via both on-station and on-farm (Fukai & Ouk, 2012; Haefele & Konboon, 2009; Jongdee et al., 2006; Kato et al., 2016). There have been several studies to have analyzed rice yield in farmers' fields but covered farm numbers were usually limited (Kamoshita et al., 2009; Saisema & Pagdee, 2015). Though increasing knowledge and information available from these experimental studies, there are fewer data on the actual yield of farmers and farming management at household levels including yield gap of farmers in Northeast Thailand, which can be collected by a household interview method. Information of yield variation and gap for rainfed rice farmers is still lacking in Thailand compared with the studies under the irrigated system (i.e. central region)(Laborte et al., 2012; Stuart et al., 2016).

The improvement of rice production via participatory research has been conducted in recent decades. Originally, the approach has been used since the 1980s (Bentley, 1994; Farrington & Martin, 1988) to improve crop production in marginal agricultural ecosystems. The strength of the approach is that, first, it enables better understanding in the complex situation of rainfed environment and farmer from both bio-physiological and socio-economic aspects. Second, the benefit is the research and development can be directly designed to the specific target farmers. Thus, it is effective in the dissemination of technology. There have been numbers of participatory research in Thailand and elsewhere (D. O. Manzanilla et al., 2011;

Mitchell et al., 2014; RD, 2014). However, the characteristics of participating farmers are not well understood and reported (Mitchell et al., 2014; Rahman et al., 2015; Singh et al., 2014). To what extent the farmer participatory research approach can enhance the yield level and fill the yield gap of farmers in the community is needed to be assessed.

Thai government has set the national plan in 2015 and policy to cope with global climate change ((Office of Natural Resources and Environmental Policy and Planning (ONEP), 2015). The goal is to make adaptation, mitigation (reducing greenhouse gas), and increase the capacity in information and management to cope with the impact from climate change. For agriculture, The awareness in all stakeholders on the impact of climate change as well as crop insurance for climatic damages has been planned (Ministry of Agriculture and Cooperatives (MOAC), 2012; ONEP, 2015). Research and technologies to cope with climate change is necessary and expected these knowledges to transfer to local community such as farmers via the participatory approach. For example, a participatory research project, "Strengthening farmers' adaptation to climate change in rainfed lowland rice system in Northeast Thailand via the participatory research approach" was conducted during 2012-2015 (RD, 2014). Number of Farmer Field School (FFS) have been organized as a tool for extension where participatory learning was conducted for the improvement of farming practice towards food security issue under risks from climate change.

The objective of this study is to assess the improvement of rice production in Northeast Thailand by participatory research and farmer field school (FFS) to cope with climate change. The study attempted 1) to clarify the characteristics of participants and non-participants in order to improve rainfed rice production to cope with climate change, 2) to clarify the reason for the low yield level of rainfed ecosystem, 3)to analyze farmers' perception of climate effects on rice farming, attitude, and action to cope with climate change and mitigation. The hypotheses of the study are:

1. Participants are farmers who had incentives to develop their farming thus they are active in learning, attending the local group activities, having close technical relationship with researcher
2. The small yield improvement of Thailand has been due to the presence of subsistence farmers in the northeastern region.
3. Local perception of farmers towards climate change and its impact is still weak and not in active status in northeast Thailand

The thesis structure is presented in Fig 1.1. The study contains 4 analysis chapters (Chapters 2, 3, 4, 5) after Introduction (Chapter 1). Chapter 2 gives a historical analysis analysis for small yield increase of Thailand based on the rainfed ecosystem and irrigated system. Chapters 3 and 4 studied analyzed the characteristics of farmers in relation to their participation in a research project as well as yield variation among household. Chapter 5 investigated a farmer field school in North Thailand as a participatory extension approach to make improvement on rice production under climate change. The last chapter, Chapter 6 proposes recommendation for rain from climate change is proposed in Chapter 6.

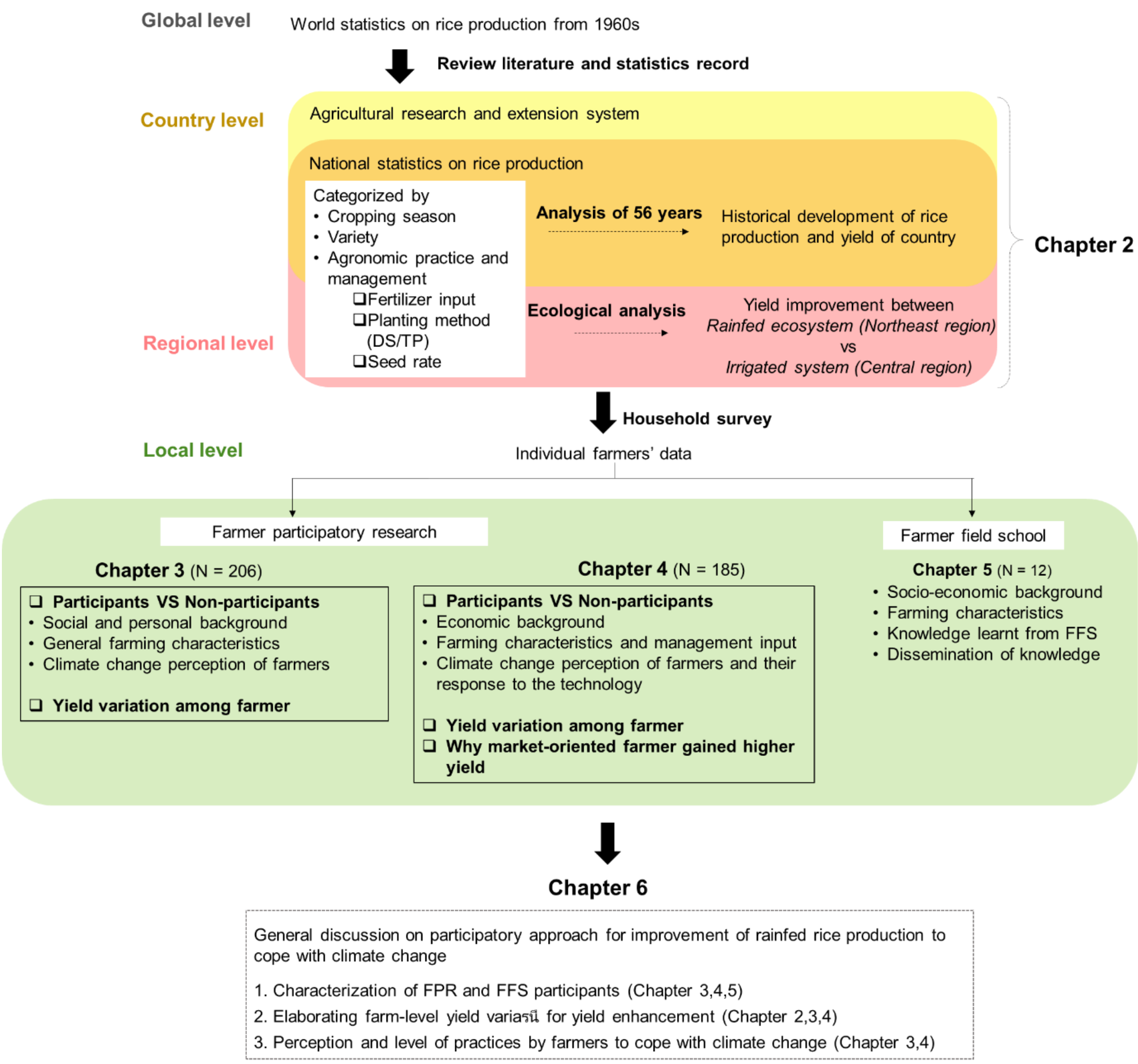


Figure 1.2 Methodological framework and thesis outline.

Chapter 2

Comparative analysis of rice production improvement between rainfed and irrigated rice ecosystem in Thailand from 1960 to 2016

2.1. Introduction

Rice extension system in Thailand has been changed from training and visit system to participatory system from early 2000's(DOAE, 2011), but it is not known whether yield increase rate has been improved by the transformation to participatory system. Participatory system may be more suitable where farmers are diverse and heterogeneous, such as rainfed rice ecosystem, while in irrigated ecosystem, farming innovation can be more quickly translated into greater yield gain. Rainfed lowland rice ecosystem is largest in area in Thailand, with its 61% and 28% areas located in northeastern and northern regions, respectively (OAE 2018c, 2018d), and with its low yield (e.g., 2.3 t/ha, OAE, 2018f) due to the occasional drought or flood (Fukai & Ouk, 2012). In Northeast Thailand, rice cultivation is a part of the culture, and farmers grow rice primarily for home consumption purpose then sale the remains (Saisema & Pagdee, 2015). The second largest ecosystem is irrigated lowland rice ecosystem which is mostly located in central region with its higher yield level.

The uniqueness of the production of northeastern region is single planting only in wet season, a wide spread use of photoperiod sensitive aromatic varieties (e.g. RD6, KDML105, RD15), less input and low yield potential, and l preference to high grain quality and taste for domestic consumption as well as for export (Grandstaff et al., 2008). In contrast, the production in central region is 2-3 cropping seasons per year under irrigated system, use of photoperiod insensitive and high-yielding varieties (HYVs) (i.e., modern varieties) responsive to high dose of inorganic fertilizer, and greater orientation to rice marketing rather than self-consumption. How the introduction of participatory extension system has affected in the contrasting two regions (i.e., northeastern vs central) would be meaningful.

The objective of this study was to assess whether transition to participatory extension system from 2000's has increased rate of yield increase in Thailand, including regional comparison between central and northeastern regions. Changes in rice production and yield from 1961-2016 have been tracked as well as the literature review of extension system. These changes were compared between northeastern region with mostly rainfed lowland rice ecosystem and central region with higher proportion of irrigated ecosystem based on key agronomic aspects; proportion of dry season rice production, rice varieties, fertilizer application rate, and planting methods.

2.2. Materials and Methods

2.2.1. Data source

Data used in this study was secondary data allocated from several sources shown in Table 2.1. The data of some parameters might not cover all years because the information was not available from the source.

Table 2.1 Data and source used for comparative analysis of rice production from 1961 to 2016 in Chapter 2.

Data	Source
World rice production statistics 1961- 2016: Average rice yield, harvested area, and production of countries in Asia and world	FAO statistical database (FAOSTAT2018)
Rice production in country and regional level 1974-2016: yield, harvested area, and production of (1) Whole year (annual production) and (2) Wet season and dry season	OAE (1983,1985, 1994,2018)
Rice production categorized by variety: yield, harvested area, and production of (1) Wet season 1989-2015 and (2) Dry season 1990-2015	OAE (2016,2018)
Farm level inorganic fertilizer application rate(kg/rai) (1) wet season from 1985 to 2015 and (2) dry season from 1990-2015	OAE (2018)
Rice production categorized by type of planting method: yield, harvested area, and production from 1989-2015.	OAE (2018)
Seed rate farmers applied by each planting method from 1989-2016	OAE (2018)

2.2.2. Data analysis

The terms in Chapter 2 were defined as below. Annual rice production in 2016, for example, was sum of wet season rice in 2016 and dry season rice harvested in 2017. Rice varieties were grouped into 3 groups of modern variety, improved variety, and traditional variety. Modern variety is a high-yielding variety (HYVs) with highly responsive to inorganic N fertilizer, typically having a semi-dwarf plant type and photoperiod insensitivity that can be grown all the year around. The first set of the modern varieties, RD1, RD2, RD3 were released in 1969 in Thailand in the national hybridization program under the collaboration with

International Rice Research Institute (IRRI)(NSTDA, 2001) where IRRI varieties were used as donors for the breeding for higher yield. As in 2018, there are 38 rice varieties in modern variety group, including widely grown SPR1, and CNT1. Improved variety is a photoperiod sensitive variety that has been improved by the breeding program without using the semi-dwarf HYVs from IRRI. KDML105 is an example of improved variety derived from line selection from traditional varieties. The other improved varieties, such as RD6 and RD15 were derived from a radiation mutation from KDML105. Traditional variety is local landrace variety that has been grown by farmers in local specific areas and not manipulated in plant breeding programs. There are still thousands of traditional varieties appearing at present. *Inorganic Fertilizer* means chemically synthesized fertilizer, and *rate of inorganic fertilizer application* is a total amount of inorganic fertilizer (kg) per unit area that farmer applied (actual rate), which is higher than the average fertilizer rate of household as calculated per total harvested area (not included in this study). *Rate of N* fertilizer application was estimated by assuming N content of inorganic fertilizer as 16%(Pongsrihadulchai, 2013). Northeast region (NE) and central region (CE) were used as a representative of rainfed ecosystem and irrigated system of Thailand respectively. All parameters used for calculation and analysis in the study had been converted into a common unit. For example, the unit used by Thai government statistics for the area is in “rai”, thus it was converted into “ha” by the following equation;

1 rai = 0.16 hectare.

The unit of yield in the statistics, “kg/rai”, was converted to “t/ha” by the following equation;

1 kg/rai /160 = 1 t/ha.

Correlation analysis was used to explain the association between two scale parameters; for example, the relationship between seed rate and yield. Analysis of yield change by time for each agricultural extension period were calculated by the yield at the end of the phase minus with the yield at the beginning of the phase. Linear regression was used to show the model predict yield change by the indicated parameters (e.g. rate of inorganic fertilizer on yield increase). This study used MS Excel to convert and calculate the value of the parameters and establish the graph while SPSS 25.0 was used for multiple regression analyses.

2.3. Results

2.3.1. Rice extension system and the progress of yield improvement

Rice production extension of Thailand had been under training and visit system for a long period since 1970s till 1990s (Table, 2.1, Fig 2.1). The system came together with the set of known green revolution technologies. Yield was increased 0.034 t/ha/year during the period. However, after 2000s, the system has been changed to the participatory method which aims to make develop on farmers to be more self-reliant. Several approaches such as farmer field school, participatory research project, etc. have been implemented to make an improvement on country's rice production. The yield increase rate from 2002 to 2016 after changing to participatory approach was 0.003t/ha/year indicating low yield development progress (Fig 2.1). Yield increase rates under training and visits and participatory systems were 0.032 t/ha/year and 0.013t/ha/year respectively in northeast region, while they were 0.065 and 0.005 t/ha, respectively in central region.

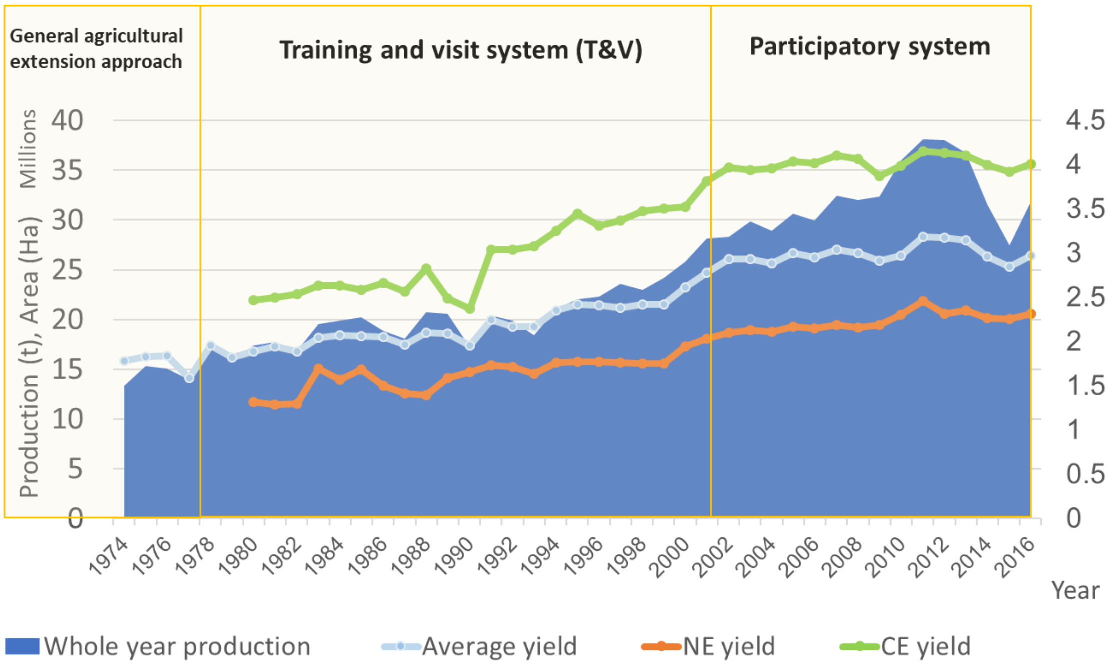


Figure 2.1 Rice yield and production changes from 1974 to 2016 in Thailand including the yield of northeastern and central regions (1980 to 2016) divided by three periods of agricultural extension; general agricultural extension (1974 to 1977), train and visit system (1978 to 2011), and participatory system (2002 to 2016). See Table 2.2 for details of each period.

Table 2.2 The 3 periods of agricultural extension system of Thailand from 1967 to 2018.

Period	Extension system	Details of system
1967-1977	General agricultural extension approach	There were many limitations such as lack of materials, tools, and support for the operation. The advice was in a general manner (Ocharoen & Panichayothai, 1998). The efficiency of technology transfer depended on the capability of the individual officer. The extension was less paid attention and valued by farmers (DOAE, 2011). New agricultural information did not reach to many farmers in the country at this period.
1978-2001	Training and visit system (T&V)	DOAE brought the intensive extension called training and visit system (T&V) for irrigated area by using the funding support from the World Bank and Asian development bank (ADB)(DOAE, 2011). The system has been successful and extended to the other areas including rainfed area. Many modern technologies of green revolution were disseminated to farmers via officer visits with a collaboration of local farmer's leaders. The officers were trained systematically. The weak point of this top-down system was that farmers were treated as recipients of technology. They had not been trained in analytical thinking skill thus they could not make a decision to cope with their problems by themselves (Ocharoen & Panichayothai, 1998). Tools and techniques were plot demonstration, poster, lecture, etc. which were one-way communication extension
2002-present (2018)	Participatory system	DOAE has adapted and improved the extension system according to the change of the 1997 Constitution of Thailand: 8th National economic and developmental plan. Tools and techniques used in this phase were more in participation manner such as learning process activities (e.g. farmer field school program, agricultural technology transfer and service center [ATSC], etc.). The system has emphasized in developing farmer to be self-reliance. Farmers have more chance to participate in agricultural development and planning. The extension at this phase considered technology suitable for the local environment and society as well as conserving the nature.

2.3.2. Low yield level and small yield improvement of country

2.3.2.1. Yield improvement progress of rainfed and irrigated system

Yield level of NE both wet and dry season are lower than the CE (Fig 2.2). Moreover, the trend of yield level for CE wet season is higher than dry season of NE after 2000s. The yield improvement progress of CE was typical like yield increase of other countries from the use of green revolution technologies but still

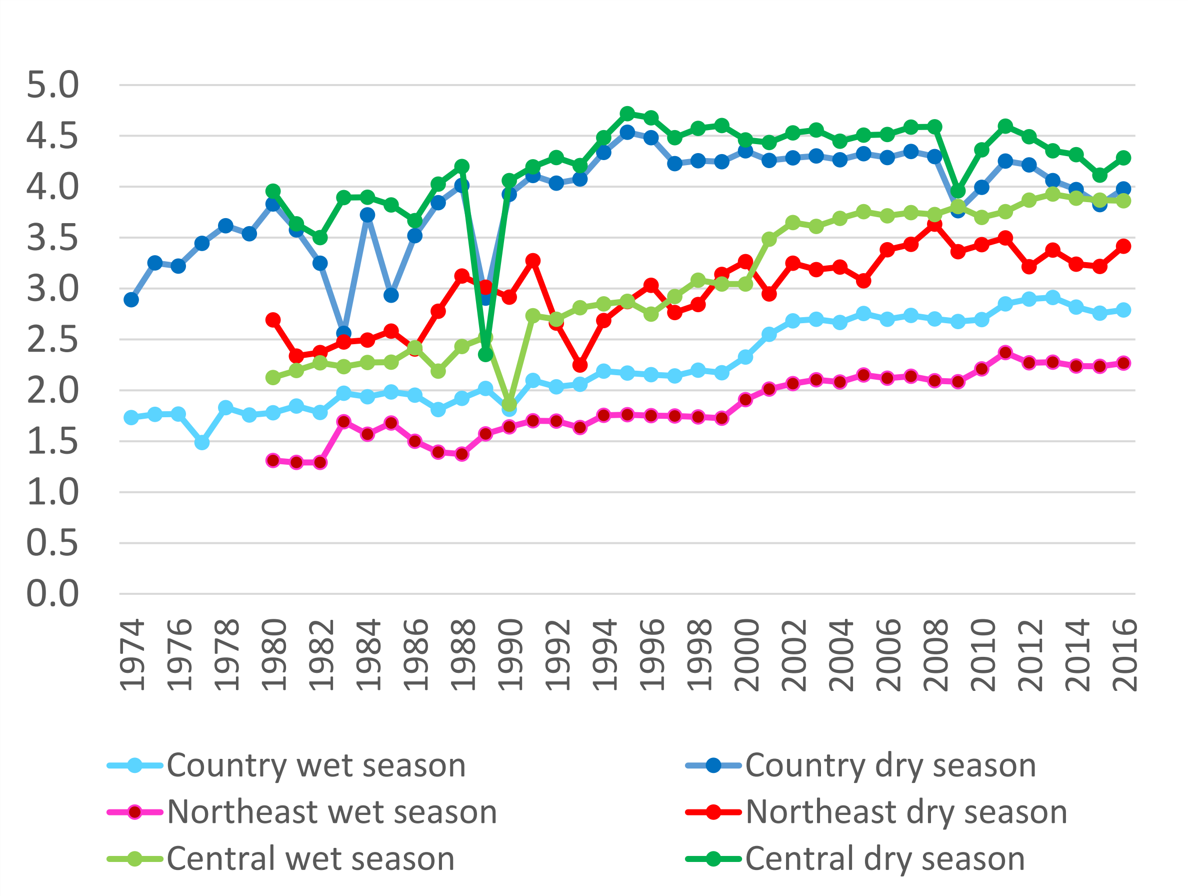


Figure 2.2 Changes in annual rice production, annual harvest area and national annual yield of rice from 1974 to 2016 in Thailand with the northeastern (NE) and central (CE) regional yield data.

2.3.2.2. Contribution of dry season production

In Thailand, the area of dry season production has been gradually increased for almost half of century since green revolution. The contribution of dry season production was at 30% in CE while only 5% in NE in recent years (Fig 2.3).

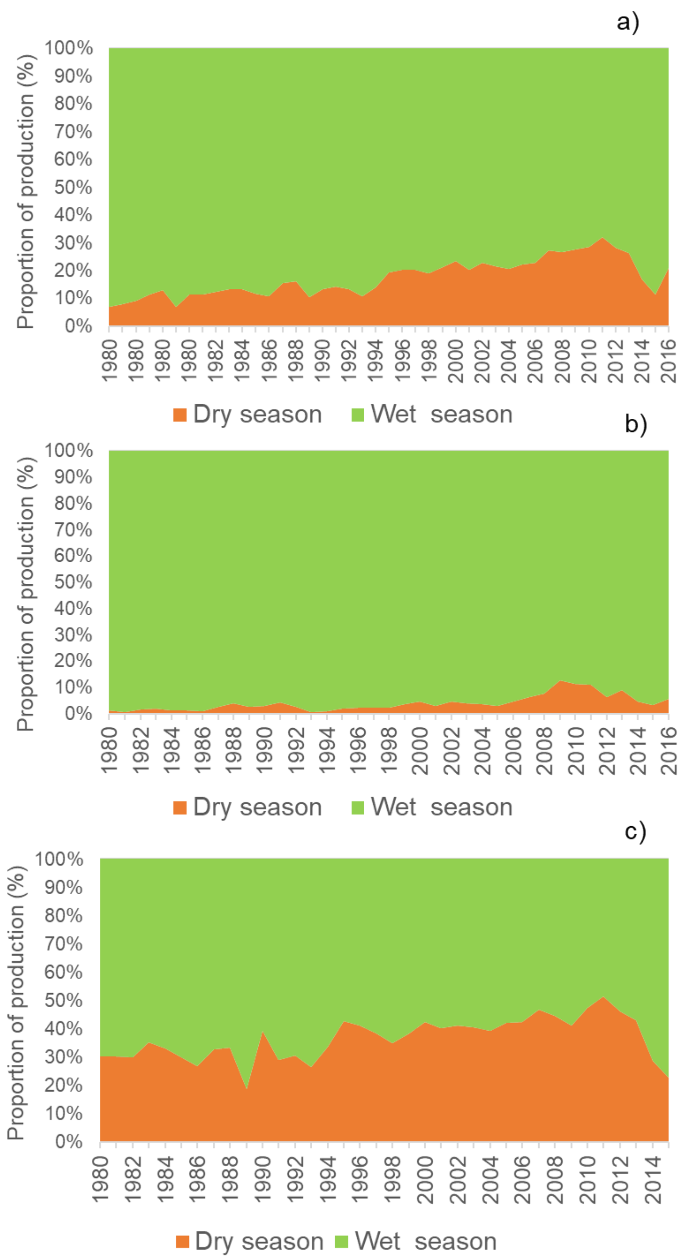


Figure 2.3 Contribution of dry season production to whole production of a) country level, b) northeastern region, c) central region.

2.3.2.3. Proportion of modern varieties

Fig 2.4 showed whole country rice harvest area (sum of 2 crop seasons; wet and dry area) was covered by the improved varieties in the beginning with 25% of traditional varieties and about 15% of modern varieties. Later the area of traditional varieties has almost disappeared and modern varieties had covered the country rice area up to around 30%. The pattern of the contribution of each variety to production was similar to the proportion of the growing area. Modern, improved, traditional varieties contributed around 25%, 50%, 22% respectively in

1990, while they became 40%, 55%, 5% in 2015. The change of area was totally similar to the wet season while the dry season has covered by modern varieties.

Yield growth of each variety group by time and cropping season showed in Fig 2.5a. The magnitudes of yield increase of each variety group were 3.31 to 4.0 t/ha (modern varieties), 1.82 to 2.36 t/ha (improved varieties), and from 1.93 to 2.42 t/ha (traditional varieties). Modern varieties progressed in yield increase by time (approximately 1 t/ha) while both improved varieties and traditional varieties had less progress just around 0.5 t/ha only. The yield of modern varieties in the dry season was around 4 t/ha and consistent through the time period. The yield of the improved varieties and traditional varieties were more instable for the dry season and was grown until early the 2000s (Fig 2.5b).

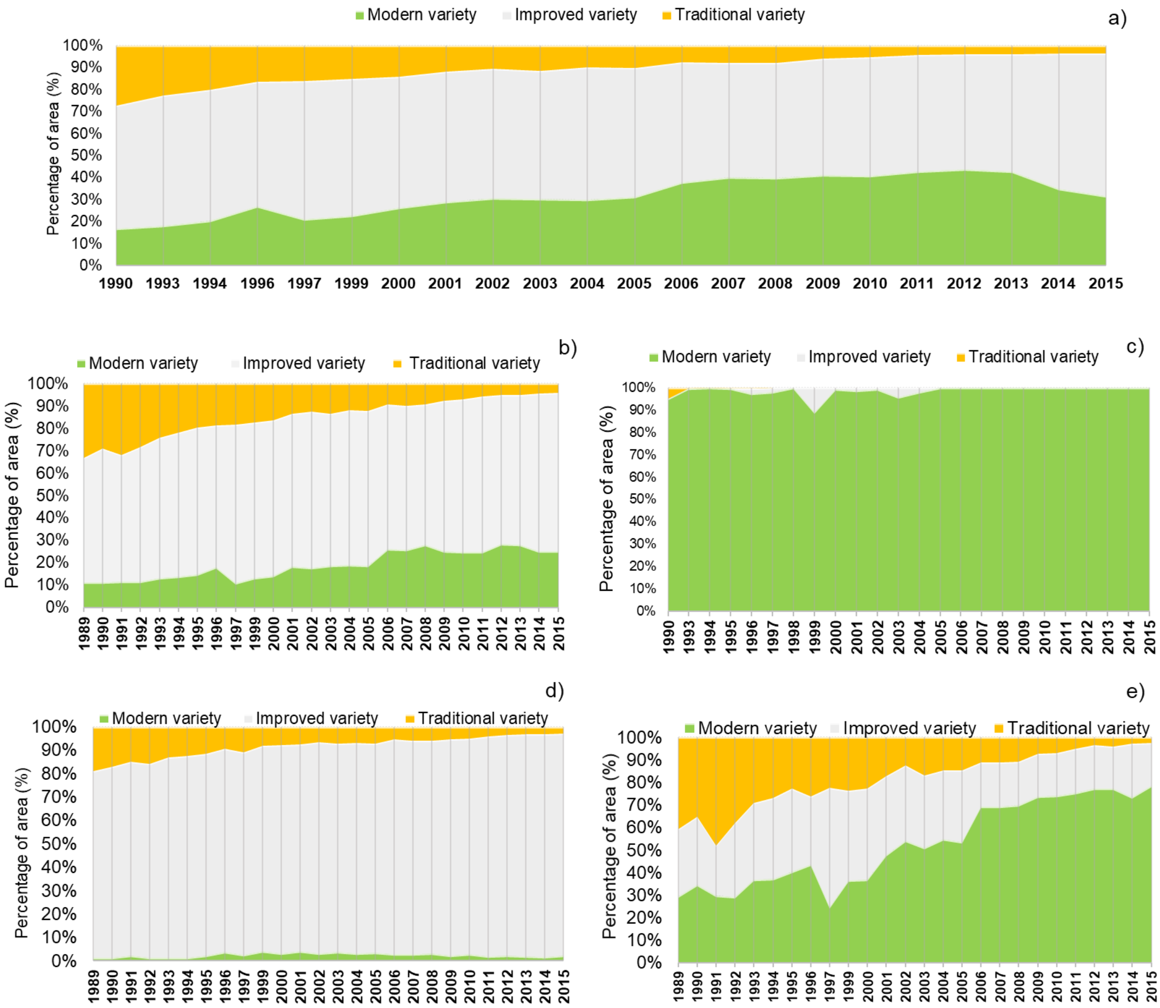
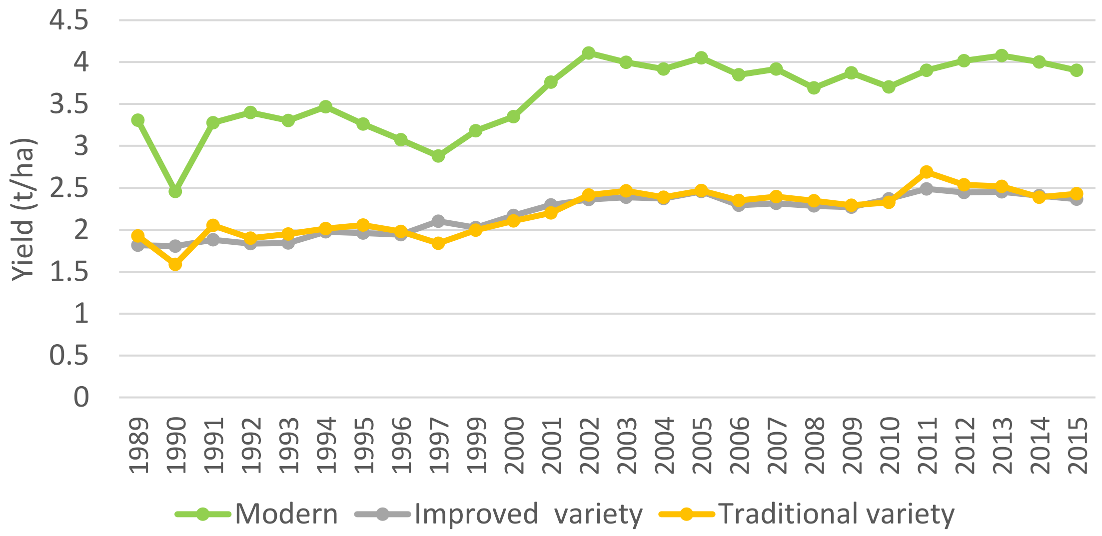


Figure 2.4 Proportion of the area harvested by each group of variety from 1989-2015 at a) country's whole production, b) country's wet season production, c) country's dry season production, d) NE wet season production, and e) CE wet season production.

a) Wet season



b) Dry season

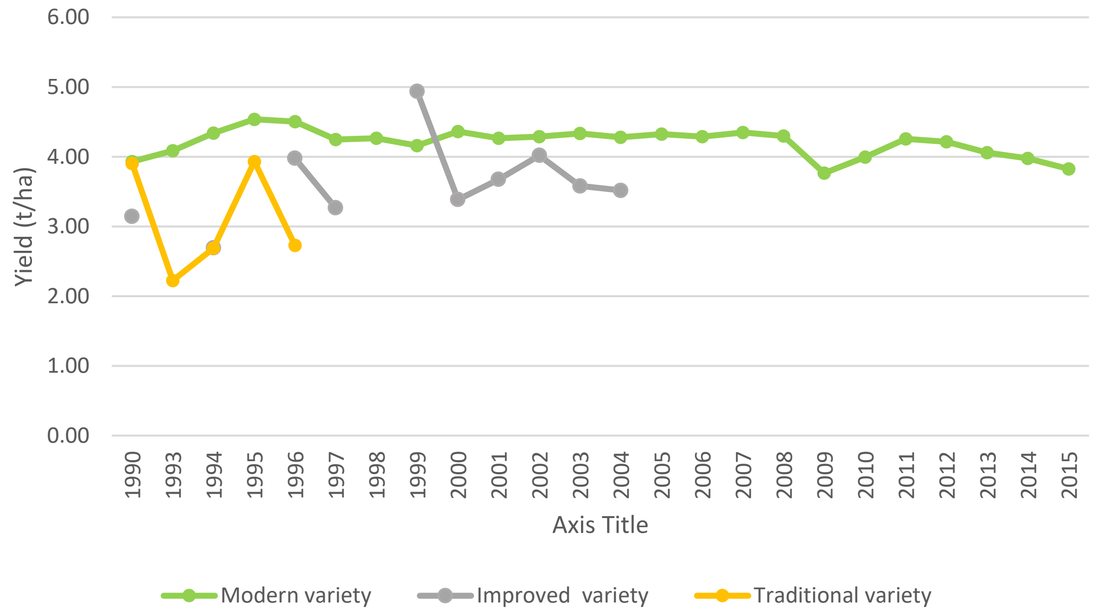


Figure 2.5 Yield growth of each variety group by year during 1989-2015 in a) Wet season b) Dry season (OAE, 2018)

Fig 2.6a shows yield improvement of RD6 and KDML105 as a representative of improved variety in NE, while SPN1 representatives for the modern varieties popular in CE region. Although with a very less proportion of RD6 and KDML105 grown in CE, it was found that the yield level of them was similar to NE production but more fluctuated. Despite SPN1 was the high yielding variety, only its high yield performance showed in CE but not in NE. SPN1 in NE was slightly higher than another improved yield for only 1 t/ha at present. Results further showed that yield of modern variety as showed by SPN1 and CNT1 in the dry season in NE was around 3.5- 4.5 t/ha which lower than CE's only around 1 t/ha (Fig 2.6b).

a)

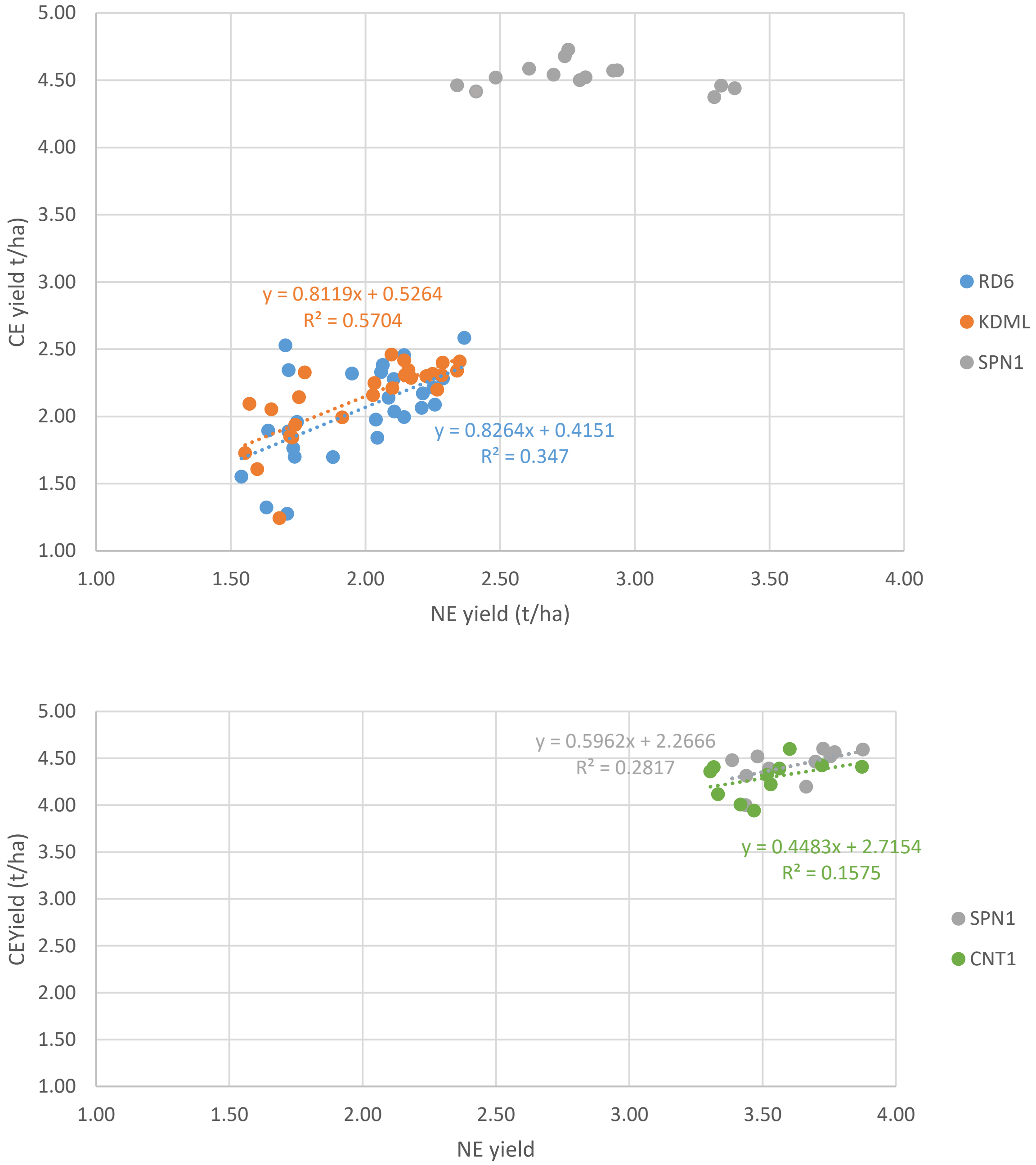
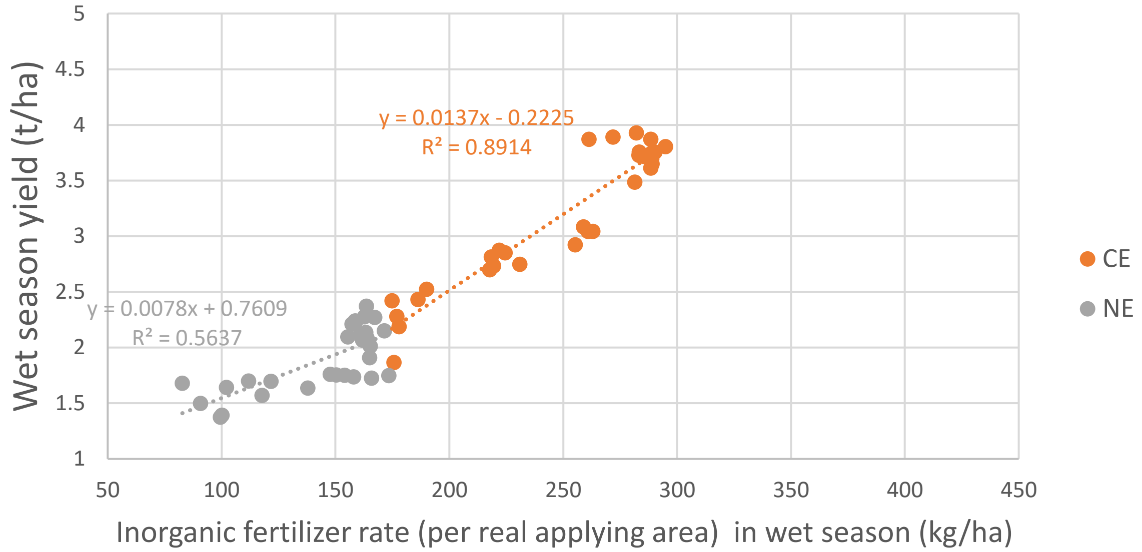


Figure 2.6 Scatter plot between the yield of a) RD6, KDML105, and SPN1 in wet season, b) SPN1 and CNT1 in dry season between northeast region and central region during 2005-2016 (OAE, 2018d, 2018b)

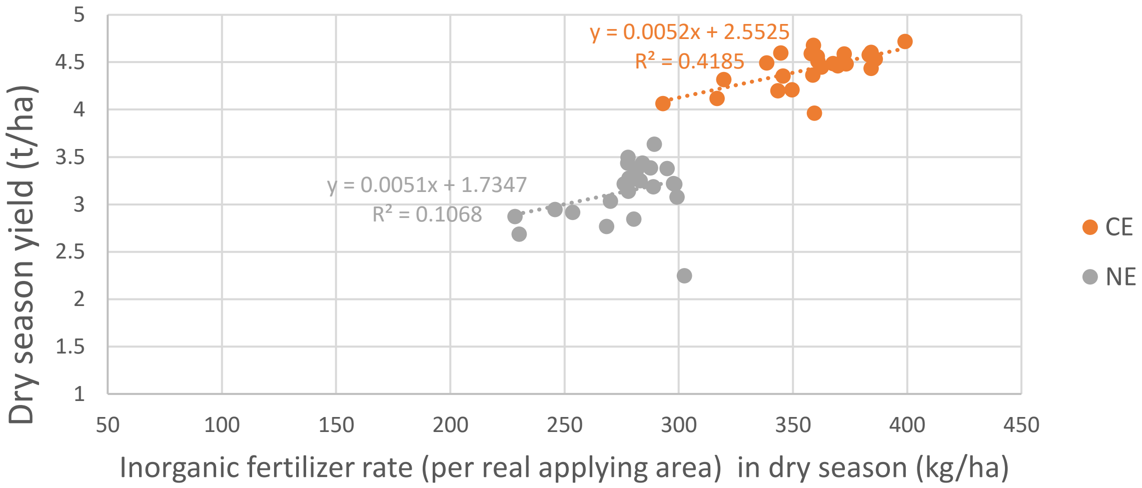
2.3.2.4. Contribution of inorganic fertilizer on rice production

The use of inorganic fertilizer has been gradually increased during 1985 till 2000, after that the rate has stagnated. The rate of inorganic fertilizer input in NE was low at the beginning. It was less than 100 kg/ha but reached to more than 150 kg/ha after 1990, while the rate used in CE has been more than 150 kg since the beginning of the graph and reached 250 kg/ha at present (data not shown). The trend in the average rate of the country close to the growth of rate used in NE. The rate of fertilizer used for dry season production was higher than the wet season in both regions. Fig 2.7 shows a scatter plot between inorganic fertilizer and wet season yield of both NE and CE region. Results of linear regression analysis showed that for NE region the effect of inorganic fertilizer to wet season yield appeared only in the early stage of green revolution period (1985-1996) while no effect of it in recent years (data not shown). Although the scatter plot of CE as shown in Fig 2.7b was not in smooth in trend line shape, when tracking through decades the trend line could be seen. Analyses by time also was conducted for CE, however because the linear regression results of both periods were similar then finally combined period was reported instead. The model results showed the effect of inorganic fertilizer on wet season yield in CE; with R^2 = 0.944, that the use of 1 kg/ha of inorganic fertilizer in this region could increase yield by 0.014 t/ha (data not shown). For dry season, the only small effect of inorganic fertilizer was found only in NE; R square = 0.421, the coefficient value of inorganic fertilizer at 0.008, while no effect was found in CE (data no shown). Fig 2.7c showed estimated rate of N apply in association with yield; the higher rate the higher yield gained.

a)



b)



c)

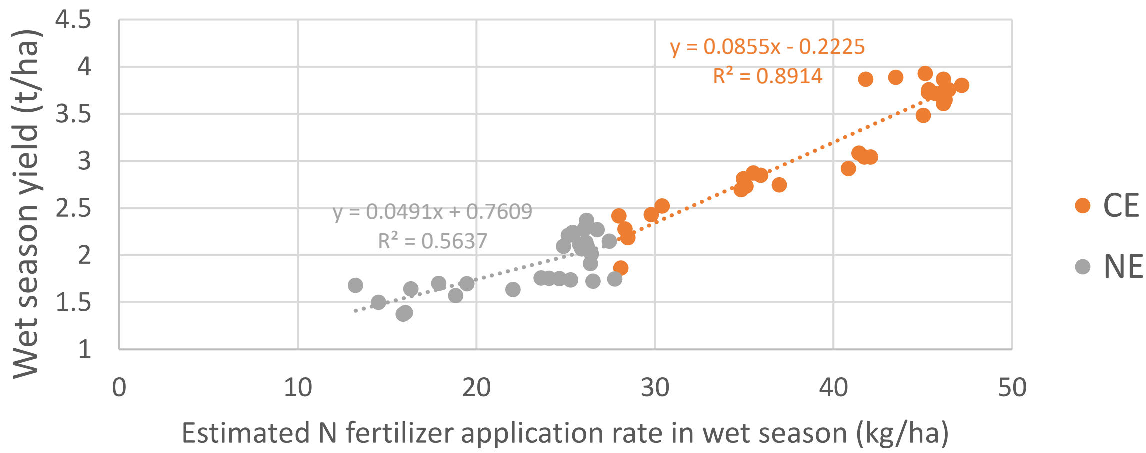
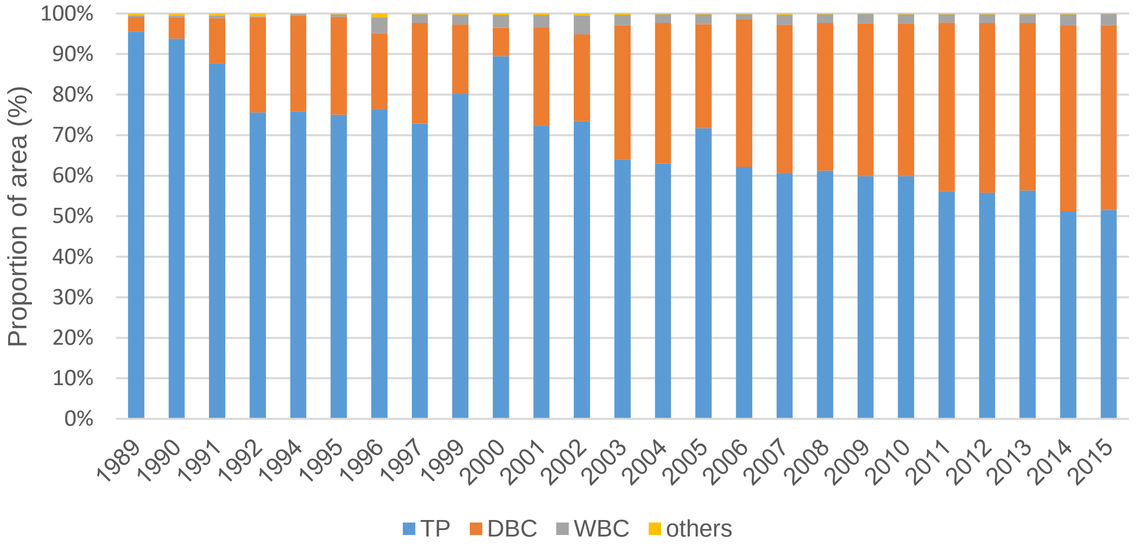


Figure 2.7 Scatter plot of yield and inorganic fertilizer application rate in a) wet season and b) dry season, and c) wet season yield and estimated rate of N application in wet season for northeast region and central region in Thailand from 1985 to 2015.

2.3.2.5. Planting method

Fig 2.8a showed transplanting area reduced sharply in recently years while dry-seed broadcasting (DBC) area has replaced approximately up to 50% of total harvest area in the wet season in NE. It was found that wet direct seeding (WBC) method was not popular in the region. In contrast, in CE, WBC had a similar proportion to transplanting (TP) and DBC had become replacing up to 75% of the area at present (Fig 2.8b). Yield level and yield growth of TP and DBC were similar in NE but the latter was slightly less than former (Fig 2.9: a & b). In CE while WBC found to be higher than TP and DBC over than 1-2 t/ha over the period, the average yield of TP in CE was obviously higher than BC. Farmers used less seed in TP method in both regions approximately around 50 kg/ha and 60 kg/ha in NE and CE respectively. Fig 2.9 showed seed rate used for DBC was low in the beginning phase (1992-2000) but reached up to around 120 kg/ha and 155 kg/ha in NE and CE respectively. A higher seed rate of DBC in NE found to be associated with higher yield (r = 0.77, *p-value* = *<0.001*). The seed rate of WBC method was largely different between two regions. CE farmers used seed rate around 180 kg/ha; 50 kg/ha higher than NE. For dry season, direct wet seeding was the major method used in both NE and CE.

a) NE



b) CE

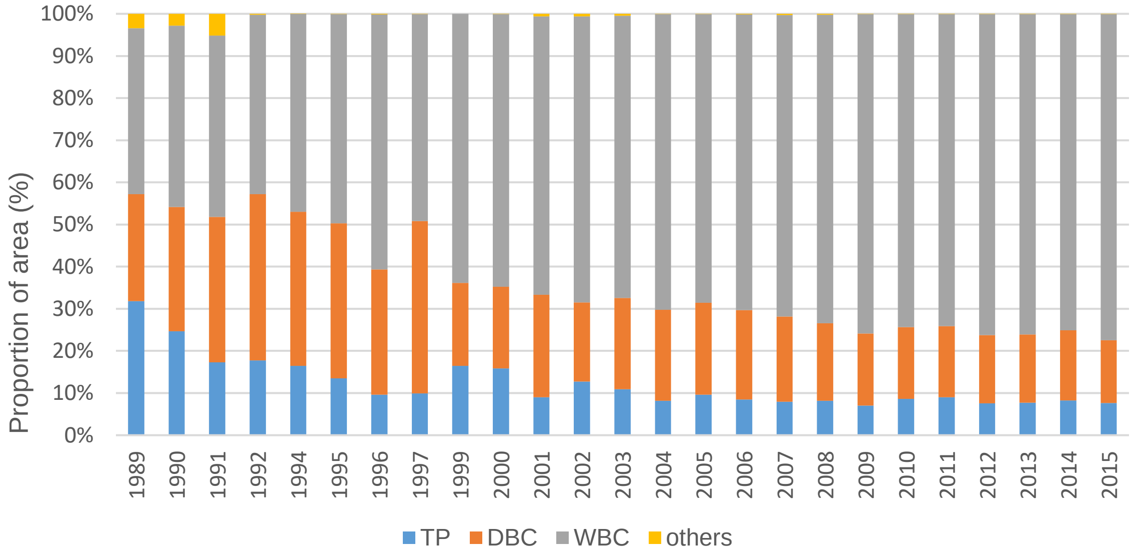


Figure 2.8 Proportion area of planting methods for wet season rice from 1989 to 2015: transplanting (TP), dry broadcasting (DBC), wet broadcasting (WBC) in a) northeastern region (NE) and b) central region (CE). Drill seeding, for example, is included in the category “others”.

Figure 2.9 Scatter plot of seeding rate and yield for wet season rice from 1992 to 2015 in northeastern region (a) and central region (b).

2.4. Discussion

2.4.1. yield increase of Thailand in participatory system

Rice yield increase rate in Thailand has not been improved after the extension had converted to the participatory system in 2002. The regional yield increases rates both in northeast and central plain have been lower during the participatory period after 2002 than that during training and visit system. However, yield increase rate in northeast region was higher than central region during participatory system, indicating that participatory system may be more effective in rainfed rice ecosystem with greater heterogeneity in farming environments. Several successes from the participatory researches for the improvement of rice production under rainfed ecosystem has been shown in Asian countries, for examples, more suitable new rice varieties for local farmers(Manzanilla et al., 2014; Mitchell et al., 2014).

2.4.2. Small yield increases and low yield level of rainfed ecosystem

Most of production area covered by RD6 and KDML105 which is not the green revolution technologies. It is because that Thailand is rice exporter country where amount of rice produced had been sufficient for the domestic consumption and also for export. Compared to Vietnam, Philippines, Japan, Thailand has less population density (United Nations, Department of Economic and Social Affairs, 2017), and the technologies to secure the food security for population such as HYVs has not been necessary. Though RD6 and KDML105 give lower yielding and not responsive to fertilizer under rainfed condition, they had market value which turn to be the income of rice farmer as well as satisfaction in taste quality for eating.

Some may argue about the yield potential of RD6 and KDML105 as limitation for yield increase of the region. However, the low yield level of the varieties was not from yield potential alone but suggested to be by the adverse condition of the farming environments such as water condition and climatic damage. Fig 2.7a showed that the yield of modern varieties grown in the rainfed ecosystem was lower than the same varieties grown in central region by around 1.5 t/ha suggesting low yield output was from water environment or agronomic practices. The yield of modern varieties in northeast region was found to be higher in dry season indicating that the lower yield of the same varieties was due to the water environment factors. Another evidence was a yield of rainfed rice production in case of Philippines and Vietnam also showed the similarly low level of yield improvement along the history (Estudillo & Otsuka, 2006; Tran & Kajisa, 2006) despite farmers in these countries adopted the modern varieties and cultivated it. This suggested the low yield of rainfed might not because of the use of RD6 and KDML105's yield potential itself but rather the adverse farming condition.

Not only the farming environment condition, but agronomic practices also played role in the small increase of yield. More intensive input in central region contributed the higher yield in compared to northeast region. These are inorganic fertilizer input and seed rate use. Expansion of BC method which has been popular in the recent decades (Watanabe, 2017) pulled down the speed of yield growth. It gave lower yield than the TP method but could save the farming cost and labor suitable for the socio-economic condition of farmers.

In summary, to fill the yield gap between two regions and improve the average rice yield of northeast region, the effective use of participatory approach is needed.

Chapter 3

Characterization of farmers engaged in participatory research to cope with climate change in Northeast Thailand

3.1. Introduction

The farmer participatory research approach has been used since the 1980s (Bentley, 1994; Farrington & Martin, 1988) to improve crop production in marginal agricultural ecosystems. Only a small portion of the total farming population—a few dozen per village or a few hundred per project—are selected to participate in each project. The manner of selecting farmers affects the progress of participatory projects and the speed and magnitude of subsequent dissemination of outputs from the projects.

Before selecting the participants, researchers usually make a preliminary visit to the target region and meet with key informants such as the village chief and experienced farmers (Manzanilla et al., 2014; Paris et al., 2011). In some cases, the key informants may call particular groups of farmers, or they may try to request that almost every farmer in the region participate in the project (Courtois et al., 2001; ICRISAT, 2001). The key informants sometimes approach farmers via local groups in announcing the project (Sanginga et al., 2006). Researchers may prefer participants with diverse economic, social, and technical backgrounds (Paris et al., 2011). However, these processes of selecting the farmers are often not transparent (Mitchell et al., 2014; Rahman et al., 2015; Singh et al., 2014).

In addition, the characteristics of participating farmers versus those of non-participants are often unclear. Participants may be more interested in research and economically better off, but the extent to which their management, production, and income in rice farming are superior to those of non-participants is not known. Hence, the effectiveness of a participatory project across the whole target region is often unclear. If participants are technically more advanced (e.g., producing higher yields) in the total population of farmers, the adoption of project achievements by the participants can be rapid and large, but the new methods may not be readily spread and accepted by non-participants due to their different backgrounds. In contrast, if participants are representative of the whole population and exhibit a wide diversity of characteristics, this might limit the speed of adoption of project outputs by the participants (e.g., adoption of a machine), but the transfer from participants to non-participants can be faster. Therefore, understanding the characteristics of participating and non-participating farmers is important both for technology transfer from the researchers to participants during the project as well as for possible secondary dissemination from the participants to non-participants.

Farmer participatory research traditionally covered topics such as plant protection and variety selection, but recently adaptation to climate change has been included as well, because of global concerns about the negative effects of climate change (IPCC, 2014; Redfern et al., 2012; Wassmann et al., 2009) and the specific nature of climatic damage that requires local farmers' knowledge and experiences for finding better solutions (Campbell et al., 2016; Lipper, 2014). In Thailand, the Rice Department (RD) of the Ministry of Agriculture and Cooperatives conducted a participatory project named "Strengthening farmers' adaptation to climate change in the rainfed lowland rice system in the Northeast" in 2012–2015 in order to study the impact of climate change on rice production and possible adaptation by farmers and to develop a sustainable rainfed lowland rice growing system in Northeast Thailand (BRRD, 2012). Participants learned about climate change from researchers and observed newly developed technologies (e.g., drought- or flood-tolerant varieties and a drill seeder machine) and then were prompted to test some of the technologies. As a next step, it would be helpful to clarify the perceptions of farmers in Northeast Thailand about climate change and their attitudes about alternative technologies, including the differences between participants and non-participants.

In this study, we conducted comprehensive interviews with both project participants and non-participants to assess the possible improvement of rainfed rice production to cope with climate change through participatory research in Northeast Thailand. The objectives were to clarify the farming characteristics of participating farmers compared with those of non-participants, to identify the sources of yield variability, and to determine the local perception of climate change in the project area. We hypothesized that participants would have a better learning attitude developed by associating with researchers, in turn making them more motivated to improve their techniques either for higher productivity or more resilient farming to cope with climate change or both. We expected the target population to include farmers who achieved higher yields via efficient farming practices as well as large numbers of subsistence farmers, and these group differences may create a large yield gap in Northeast Thailand. We also expected that rainfed farmers were used to be responsive to variable climate conditions and were not actively adapting to the long-term trends of climate change. Our findings expose key constraints hindering the development of rainfed rice production via participatory research and emphasize the importance of selecting farmers in participatory research projects, especially in the case of rainfed rice farmers who have diverse socioeconomic backgrounds, as seen in Northeast Thailand.

3.2. Methods

3.2.1. Study sites

In this study, seven sites were selected (Table 3.1, Fig 3.1). Five of these sites were selected from five provinces (Amnartcharoen, Sakonnakhon, Buengkan, Nongbualamphu, and Mahasarakam) with different topography and represented some out of the 16 sites of the participatory project conducted by the Thai government from 2012 to 2015, "Strengthening farmers' adaptation to climate change in the rainfed lowland rice system in the Northeast" (BRRD, 2012; RD, 2013b). Sites were coded according to the district name. The Huataphan (HP) site often had flooding, the Wanonniwas (WN) and Sriwilai (SW) sites often experienced both flooding and drought, and the Naklang (NK) and Borabue (BB) sites usually experienced drought. Farmers at all five sites interacted with researchers while learning about climate change, conducting experiments on advanced varieties including evaluation of eating quality, and observing demonstrations of seeder technology. Two additional sites in Ubonratchathani province were also included for comparison with the five project participation sites. At the Napo (NP) site another drill-seeder technology transfer project was conducted by the International Rice Research Institute in collaboration with the Thai government. The Donchi (DC) site is located near the Ubonratchathani Rice Research Center, with some farmers serving as laborers in the research experiments at the center. Climatic damage was less recognized by farmers at the NP and DC sites.

Table 3.1 Administrative district and demographic information (Data source: Department of Agricultural Extension 2017), numbers of interviewed farmers, numbers of participants in the research projects, common climatic problems recognized by farmers, and the related research projects at the seven survey sites.

Site code	HP	WN	SW	NK	BB	DC	NP
Site name	Huataphan	Wanonniwas	Sriwilai	Naklang	Borabue	Donchi	Napo
Sub-district name	Khamphra	Kudruekam	Sriwilai and Chumpoophon	Kudkrasu	Nondaeng	Nongkhon	Kohthong
District	Huataphan	Wanonniwas	Sriwilai	Naklang	Borabue	Muang	Khuengnai
Province	Amnartchaoren	Sakonnakhon	Buengkan	Nhongbualamphu	Mahasarakham	Ubonratchathani	
Number of rice-growing households in sub-district	1,302	1,067	1,644	1,256	2,202	1,382	1,011
Rice planted area (ha) of sub-district	2,926	2,307	4,121	2,432	5,172	2,646	2,089
Number of interviewed farmers	41	40	34	29	34	11	17
Number of participants (% of total interviewees)	14 (34%)	21 (53%)	11 (32%)	12 (41%)	8 (24%)	-	8 (47%)
Climatic problems	flood	drought-flood	Flood	Drought	drought	nil	nil
Research project	Participatory project of adaptation “Strengthening farmers’ adaptation to climate change in the rainfed lowland rice system in the Northeast” by Thai government					Some farmers provided labor for research activities at nearby Ubonratchathani Rice Research Center	Participatory project of transferring to use of drill seeder by International Rice Research Institute and Thai government

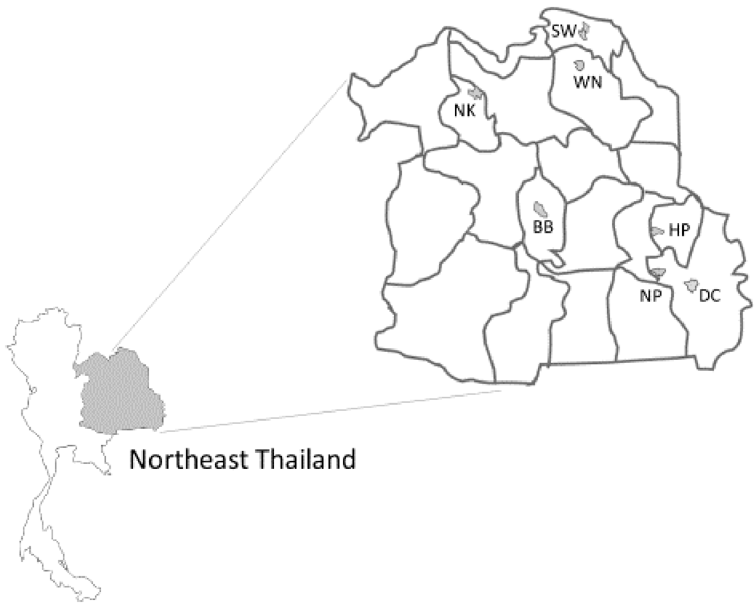


Figure 3.1 Location of 7 survey sites, Huataphan (HP), Wanonniwas (WN), Sriwilai (SW), Naklang (NK), Borabue (BB), Donchi (DC), Napo (NP) in 8 sub-districts (grey areas) in Northeast Thailand.

3.2.2. Sampling and data collection

The target population was farmers who have grown rice at the seven study sites, including both participants in the research projects and non-participants (except for DC). All farmers at the seven sites were called to freely attend the participatory project without registration, and several local farmers' groups were used for disseminating the project announcement (Dr. Boonrat Jongdee, personal communication). A quota sampling method was used for data collection so that the database would contain farmers who participated and those who did not participate in the research projects. However, we could not obtain an official registration record of the participating farmers in advance, and we could not select equal numbers of participants and non-participants. Finally, we collected data from 8 to 21 participants per site, with the proportion of the total interviewed farmers ranging from 24% to 53% among the sites (Table 3.1).

Data were collected by face-to-face interviews with a structured questionnaire, which consisted of nine parts: (1) basic household information such as age and education, (2) farming characteristics, (3) past transformation to direct seeding such as the starting year, (4) degree of engagement with researchers, (5) engagement in the current rice research project such as reasons for participation, (6) personal characteristics, (7) past climatic damages whether the farmer's fields had experienced flooding, drought, or both, (8) perception and adaptation to climate change, and (9) status of mitigation response by not burning fields. The survey was conducted from 14 to 20 January 2016, and about an hour was spent with each farmer. Twelve persons worked as interviewers and attended a training session prior to the survey, and each question was thoroughly checked during the training session.

The questionnaire was developed in English and then translated into the Thai language. The translated questionnaire was then translated back into English by a different person to confirm that the Thai version was correct. The terms used in the questionnaire and the subsequent analysis are listed in the supplementary material. Only a few farmers conducted dry season rice cropping in some years, with the majority of production coming from wet season rice. Hence, the terms "rice yield," "rice cultivated area," and "total rice production" refer to wet season rice. In Parts 8 and 9, a summary of the fifth report of the Intergovernmental Panel on Climate Change (IPCC) about scientific findings regarding climate change was read in both standard Thai and northeastern dialect with or without additional explanation on a per case basis, since not all the farmers were literate and familiar with standard Thai.

We interviewed 211 farmers. Unclear or ambiguous recorded data were rechecked by telephoning the farmers to confirm their answers. For some questions, several farmers' answers could not be confirmed, so we had to discard these responses. In total, the data for 206 farmers were used for the analysis: 178 farmers (66 participants, 112 non-participants) at the five participatory project sites, 17 farmers (8 participants, 9 non-participants) at NP, and 11 farmers at DC.

3.2.3. Data analysis

In Part 2, the proportions of total rice used for home consumption and for sale (%) were calculated. A relationship score was calculated from eight questions of Part 4 (Table S1), ranging from 0 (least close and least interactive relationship) to 15 (closest and most interactive relationship), with scores of 0 considered as no relationship, 1–4 as a low relationship, 5–10 as a medium relationship, and 11–15 as a high relationship. Activeness in learning in general was scored from two questions of Part 6 as 0, 1, or 2, whereas activeness in learning about rice issues was scored from two other questions as 0, 1, or 2, as a simple score of farmers recent study and interest in rice farming and technology (Table S2). The advanced technology knowledge score was calculated from three questions of Part 6 (0 as least knowledgeable, 3 as most knowledgeable; Table S3) to quantify the extent to which farmers knew about technologies for coping with climate change such as stress-resistant rice genotypes and drill seeders. Confidence in farming was assessed by asking if farmers thought they could solve farming problems (= confident) or not (= not confident). The attitude of farmers regarding their willingness to adapt to climate change was quantified in Part 8, with scores of 0 (little interest to learn or to act), 1 (observation of the current situation with a conditional future action only when the climate problems get worse), 2 (intention to act in the future with possibility to learn), and 3 (readiness to act now with eagerness to learn the relevant science and technology) (Table S4).

We calculated three different farm-level yields: average yield of all the surveyed farmers (e.g., Van Ittersum et al. (2013)), mean yield of best yielding farmers (i.e., top 10 percentile; which was considered as attainable farm yield EY_f by Stuart et al. (2016)), and mean yield of lowest yielding farmers (i.e., bottom 10 percentile).

Most of the comparative analysis of participants versus non-participants was conducted at the five sites of the participatory research project, as well as at the drill seeder project site (NP). Descriptive and inferential statistics were used in this study. Student's *t*-test, Tukey–Kramer and Games–Howell were conducted to assess the significance of differences in continuous variables or parameters for two or more groups, such as differences between participants and non-participants. For nonparametric tests, we used the Kruskal–Wallis test, Mann–Whitney *U*-test, and cross tabulation using the chi-squared test to check for associations between nominal or ordinal variables. Pearson correlation analysis was used to test the significance of the relationship between two parameters. The statistical analysis function in Microsoft Office (Excel) and SPSS software version 24.0 were used, and a p value < 0.05 was considered to represent a significant difference. To identify socio-economic and farming factors contributing to farmer participation in the climate change project (for more details, see Table S2), we carried out logistic regression analysis (Peng et al., 2002) with the binary dependent variable of participation (1, participate; 0, not participate).

3.3. Results

3.3.1. Differences between participants and non-participants

Participants generally had similar ages (~53 years) (data not shown) and years of education (up to primary school) as those of non-participants (Table 3.2). Participants produced significantly larger amounts of rice in the wet season than non-participants. Participants sold more than 4 t of rice, whereas non-participants sold less than 3 t ($p < 0.05$), and the difference was clearer in NK (data not shown).

Table 3.2 Characteristics of participants in the research project across the five sites (HP, WN, SW, NK, BB) in comparison with those of non-participants. Mean (SD) values are given.

Characteristic	Participant	Non-Participant	*p* value
Basic background			
Education (years)	6.8 (3)	5.9 (2.81)	0.055
Rice farming characteristics			
Rice cultivated area (ha)	2.84 (1.46)	2.55 (1.64)	0.234
Total rice production (kg)	6,560 (3543)	5,024 (4356)	0.016
Rice yield (t/ha)	2.43 (0.97)	1.99 (0.96)	0.004
Rice sale amount (kg)	4,156 (3,434)	2,943 (4,132)	0.046
Rice sale (%) from total rice	55 (29)	43 (31)	0.011
Rice income (baht/year)	45,283 (45,139)	37,497 (72,403)	0.432
Proportion of farmers who had target when designing farming (%)	85%	68%	0.012
Proportion of farmers who had confidence in farming (%)	18%	8%	0.043
Household economic characteristics			
Total income score 0 = <50,000, 1 = 50,001–100,000, 2 = >100,000 (baht/year)	1.26 (0.81)	0.78 (0.85)	0.001
Sufficiency of income for livelihood 0 = not enough at all 1 = not enough but could survive 2 = enough for well being	1.02 (0.77)	0.92 (0.65)	0.051
Social relationships			
Relationship score with researchers	6.06 (3.96)	0.54 (1.11)	<0.001
Recognition of researcher status (% of farmers who could differentiate researcher from extension officer)	49%	29%	0.007
Membership in rice-related groups in village (% of farmers)	96%	7%	<0.001
Willingness to talk and work with other farmers	97%	88%	0.033
Willingness to talk and work with persons in other jobs	96%	62%	<0.001
Learning activeness			
Activeness in learning general issues (score)	1.76 (0.53)	1.38 (0.81)	0.001
Activeness in learning rice issues (score)	1.71 (0.46)	1.04 (0.63)	<0.001

The yield of participants (mean ± SD, 2.43 ± 0.97 t/ha) was significantly higher than that of non-participants (1.99 ± 0.98 t/ha), and the difference was clearer in SW and NK (data not shown).

On average, 77% of the farmers had explicit targets in their farming, such as yield level or organic farming model. Participants, however, more commonly had the target of developing rice farming (p = 0.01) and higher confidence in farming (p = 0.04) as compared to non-participants (Table 3.2). Participant farmers tended to have more years of education (p = 0.055) and a stronger relationship with researchers (p = 0.001). Although participants had higher income, no difference between participants and non-participants was observed regarding sufficiency of their income for their livelihood. Participants had a close relationship with researchers and could better recognize the status of researchers, and they tended to like to interact with people in other jobs more so than non-participants. Among farmers, 11% had worked as research project coordinators, and they had more education than the other farmers ($p < 0.002$) (data not shown). On average 40% of the farmers were members of rice-farming groups in their villages; most participants were members, whereas non-participants were not. Among those farmers who wanted to contribute to improve the rice farming community, 67% were members of local farming groups with a higher relationship score with researchers (5.3), whereas 86% of those who wanted to minimize their relationship with the community did not belong to any local farming groups and had a lower relationship score (0.7). Participants had significantly higher active learning scores. Farmers with more years of education than primary school had a higher activeness in learning score (1.85) than those who had fewer years of education (1.45; p = 0.001). The score for activeness in learning about rice issues was higher in farmers with targets (1.43) than that of farmers who had no target (1.04; $p < 0.001$).

Farmers participated in the research projects because they needed either general or specific technical advice for their farming (data not shown). Non-participants did not attend because they never heard about the project (21%), they heard but they were not interested in it (16%), or they heard but they were unable to participate (38%) (data not shown).

Among the 36 candidate variables, three factors were selected as significantly influencing farmers' participation: (I) membership in rice-related groups in the village, (II) activeness in learning about rice issues, and (III) confidence in farming (Table 3.3). Model prediction accuracy was 94%, with Nagelkerke's R^2 of 0.876. Those who were members had a greater likelihood of participating in the research project than non-members. Farmers who were active in learning about

Table 3.3 Results of logistic regression with likelihood ratio forward stepwise variable selection for factors that influence participation in the research project.

Explanatory variables	Coefficient (*B*)	SE	Exponential *B* / Odds ratio	*p* value
(I) Membership in rice-related groups in village (1)	6.934	1.227	1026.45	<0.001
(II) Activeness in learning rice issues	2.593	0.790	13.365	0.001
(III) Confidence in farming (1) **	3.306	1.342	27.275	0.014
Constant	–8.459	1.755	0.00	<0.001
–2 log likelihood	52.07			
Model chi-squared	182.666 (*p* value <0.001)			
Model prediction accuracy (%)	94.4%			
Nagelkerke's R^2	0.876			
N = 178				

rice and had confidence in their ability to solve problems in rice farming had a higher likelihood of participating in the project.

3.3.2. Yield variability and farming characteristics

Two-thirds of the surveyed farmers had other water sources in addition to rainfall, such as canals to a river (46%) and on-farm ponds (21%; data not shown). Percentages of farmers without additional water sources reached more than 40% in SW, NK, and BB, while the values were only 12% and 23% in HP and NP, respectively. Eighty-seven percent of the surveyed farmers grew rice only during the wet season (data not shown).

The average yield of the surveyed farmers was 2.18 t/ha, with the best yielding farmers (i.e., top 10 percentile) and the lowest yielding farmers (i.e., bottom 10 percentile) having yields of 4.05 and 0.63 t/ha, respectively (Table 3.4). The yield gap between the best yielding farmers and the average farmers was 1.88 t/ha, whereas that between the best yielding and lowest yielding farmers was 3.42 t/ha. All surveyed farmers grew rice at a similar scale (mean ± SD, 2.60 ±1.54 ha). The total amount of rice produced per household was 5.5 t on average, ranging from 1.6 to 8.2 t. Households consumed 2.2 t of paddy rice on average, but the value was only 1.2 t for the lowest yielding farmers.

Table 3.4 Rice yield, rice cultivated area, total rice production, water source score, amounts and proportion of rice for home consumption or sale, rice income, proportion of broadcast (BC) area, yield by transplanting (TP) or BC methods, and yield by varieties for farmers in the top 10 percentile of yield, those in the bottom 10 percentile of yield, and average data of all the farmers. The *p* values are for differences between the best and lowest yielding farmers.

	Best yielding farmer (*N* = 20)	Average farmer (*N* = 206)	Lowest yielding farmer (*N* = 21)	*p* value (*t*-test or chi-squared)
Rice yield (t/ha)	4.05	2.18	0.63	<0.001
Rice cultivated area (ha)	1.98	2.6	2.42	0.324
Total rice production (kg)	8,205	5,536	1,630	<0.001
Water source score (0 = rainfed, 1 = pond, 2 = river)	1.15	1.12	0.76	0.366
Home rice consumption amount (kg)	2,316	2,184	1,205	0.008
Home rice consumption proportion (%)	33%	52%	83%	<0.001
Rice sale amount (kg)	5924	3362	425	<0.001
Rice sale proportion (%)	67%	48%	17%	<0.001
Rice income (baht/year)	81,434	40,811	4056	0.010
BC area (%)	60	73	80	0.144
TP yield (t/ha) *	4.41 (9)	2.58 (65)	0.71 (4)	<0.001
BC yield (t/ha) *	3.85 (13)	2.08 (165)	0.66 (18)	<0.001
Yield of cv. RD6 (t/ha) *	4.18 (18)	2.46 (176)	0.85 (17)	<0.001
Yield of cv. KDML105 (t/ha) *	3.63 (15)	2.20 (148)	0.63 (7)	<0.001

* The values in parentheses indicate actual numbers used for the calculation of the means.

Rice sold at market was 3.4 t or 61% of total production on average, ranging from 5.9 t (72%) to only 0.4 t (26%). The most popular varieties were RD6 (49%) and KDML105 (38%), and the others were improved varieties such as RD15 and local traditional varieties. On average 85% of RD6 was for home consumption, but the values were higher (96%) for the lowest yielding farmers and smaller (58%) for the best yielding farmers. On average 77% of KDML105 was sold at market, but the value was lower (31%) for the lowest yielding farmers. Average annual rice income was about 40,000 baht, which was more than double for the best yielding farmers and about only 10% of that value for the lowest yielding farmers. The lowest yielding farmers also had low total income (<50,000 baht/year).

The proportion of area planted by broadcasting (BC) was 73% on average, which was lower for the best yielding farmers (60%) and higher for the lowest yielding farmers (80%). BC yield was slightly lower than transplanted (TP) yield, and there were yield gaps of about 1.8 t/ha between the best yielding farmers and average farmers for both planting methods. Seed rate of the lowest yielding farmers was lower (85 kg/ha) compared with the average (111 kg/ha) and the best yielding (119 kg/ha) farmers (data not shown). The yield gaps for RD6 and KDML105 were 1.7 and 1.4 t/ha, respectively. Active learning scores were higher for the best yielding farmers than the average and lowest yielding farmers (data not shown).

When considering differences among sites, farmers at WN, DC, and NP had a higher percentage of area favorable for growing rice (around 70% on average) according to their perception. Farmers at HP had a higher proportion of flood-prone area (35%), and those at BB and NK had a higher proportion of drought-prone area (40–45%). Yields of rice at HP, BB and NP were higher than those at other sites, whereas NK and SW yields were lowest (Fig 3.2a). HP had the highest total amount of rice produced and a larger rice cultivation area (Fig 3.2: b & c). Median rice income was less than 10,000 baht or close to zero at BB and NK and highest at HP, WN and NP (Fig 3.2d). Farmers at NK and BB produced the least rice for sale, whereas those at HP and NP produced the most (Fig 3.2e).

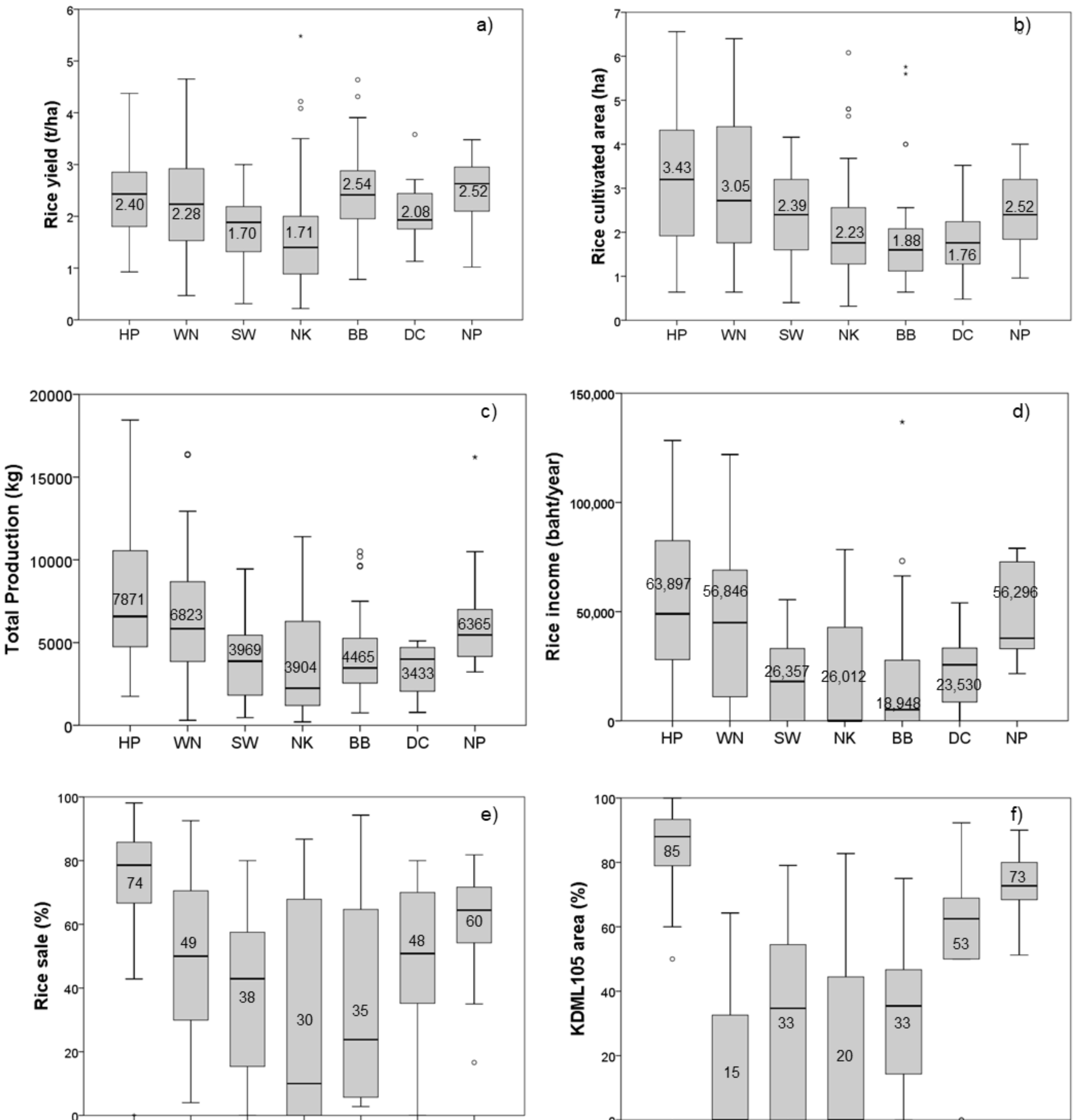


Figure 3.2 Boxplot of (a) rice yield, (b) rice cultivated area , (c) total rice production, (d) rice income, (e) proportion of rice sale from total rice production, and (f) proportion of KDML105 planted area for seven sites (HP, WN, SW, NK, BB, DC, NP) in Northeas

At HP, NK, BB, and SW, more than 80% of rice fields were planted by BC, whereas DC and NP had the highest proportion of TP (Table 3.5). At NP, 30% of rice fields were planted by using a drill seeder machine. HP had higher BC yield and higher RD6 yield than other sites (data not shown). NP had the largest proportion of cultivation area by TP and by drill seeder. At each site, TP yield was generally higher than that of BC. Yield produced by using the drill seeder introduced by researchers tended to be higher than BC yield, but not significantly so ($p > 0.05$). SW and NK had the lowest BC yield and lowest RD6 yield. The yield of RD6 varied more among the seven sites than that of KDML105 (data not shown).

Table 3.5 Percentage of area and yield by transplanting (TP) or broadcasting (BC) methods and drill seeder yield across the seven sites in Northeast Thailand.

Site	TP area (%)	BC area (%)	TP yield (t/ha)	BC yield (t/ha)	Yield by drill seeder (t/ha)
HP	6	94	3.26*	2.29	-
WN	42	55	2.54	1.97	-
SW	18	82	1.62*	1.84	-
NK	15	85	2.41*	1.72	-
BB	17	83	3.24*	2.37	-
DC	54	43	2.17*	2.39*	-
NP#	48	22	2.79*	2.04*	2.47
Average	24	73	2.58	2.08	2.47
N	205	205	65	165	10

*Number of samples used for calculation was less than 10.
NP had 30% area planted by drill seeder.

When categorizing farmers by level of rice marketing, farmers who sold less than 25% of their production had smaller rice cultivation areas, less total production, and lower yield (1.66 ± 0.80 t/ha) compared to market-oriented farmers (Table 3.6).

The yields of TP and BC were also higher for farmers who sold a greater percentage of their rice produced (Table 3.6). Market-oriented farmers had more years of direct seeding experience (i.e., 9 years) with a higher seed rate (136 kg/ha) than those of home consumption–oriented farmers (5 years and 95 kg/ha). The seed rate of the drill seeder method was 57 ± 30 kg/ha ($N = 10$), nearly half that of BC (111 kg/ha; data not shown). Yields of RD6, KDML105, and other varieties all tended to be higher in market-oriented farms than home consumption–oriented farms, and the difference was significant for RD6 ($p < 0.001$). Farmers who sold less than 25% of their rice yielded 1.85 and 1.91 t/ha for RD6 and KDML105, respectively, whereas those who sold more than 75% yielded 3.11 and 2.50 t/ha, respectively. Higher yield in the group with higher proportion

Table 3.6 General farming characteristics, growing method, varieties, activeness of learning, and mean yield of each site categorized by proportion of rice sale (0–25%, 26–50%, 51–75%, 76–100%).

	0–25% of production sold (*N* = 57)	26–50% of production sold (*N* = 37)	51–75% of production sold (*N* = 59)	76–100% of production sold (*N* = 53)	ANOVA *p* value
General farming characteristics					
Rice yield (SD) (t/ha)	1.66 (0.80) a	1.98 (0.82) ab	2.33 (0.98) bc	2.71 (0.85) c	<0.001*
Rice cultivated area (ha)	1.71 a	2.66 b	2.75 b	3.38 b	<0.001**
Total rice production (kg)	2,699 a	4,991 b	5,909 b	8,574 c	<0.001**
Home consumption amount (kg)	2,458 b	3,089 b	2,176 b	1,282 a	<0.001**
Seed production (kg) (% from total rice production)	102 a (4.1%)+	208 b (5.3%)	213 b (4.5%)	340 b (3.8%)	<0.001**
Sale amount (kg)	238 a	1897 b	3759 c	7308 d	<0.001**
Growing method†#					
TP area (%)	17	32	28	24	0.243
BC area (%)	83	68	65##	75##	0.170
TP yield (t/ha)	1.81 a (11)	2.17 ab (15)	2.74 ab (20)	3.17 b (19)	0.016*
BC yield (t/ha)	1.70 a (50)	1.82 a (30)	2.21 ab (39)	2.56 b (46)	<0.001*
BC seed rate (kg/ha)	95 a (50)	97 a (32)	111 ab (46)	136 b (47)	0.005**
Estimated year of starting BC	5.3 (51)	5.9 (32)	8.3 (50)	9.2 (48)	0.06***
Rice varieties#					
RD6 area (%)	69 c	48 bc	43 b (57)	28 a	<0.001*
KDML105 area (%)	20 a	42 b	46 b (57)	64 c	<0.001**
RD6 yield (t/ha)	1.85 a (51)	2.30 ab (31)	2.61 bc (48)	3.11 c (46)	<0.001*
KDML105 yield (t/ha)	1.91 (29)	1.95 (29)	2.23 (43)	2.50 (47)	0.079
RD6 home consumption (%) from total rice production	53 b	42 ab	33 a	18 a	<0.001**
RD6 for sale (%) from total rice production	2 a	5 ab	10 b	11 b	<0.004**
KDML105 for sale (%) from total rice production	1 a	24 b	41 c	63 d	<0.001**
Learning activeness					
Active in learning rice issues score	1.07 a	1.38 ab	1.44 b	1.49 b	0.003*
Rice yield by site (proportion of farmers in the sale category)					
HP	1.47 (2%)	2.06 (7%)	2.37 (32%)	2.49 (59%)	-
WN	1.45 (20%)	2.03 (28%)	2.43 (30%)	3.12 (23%)	-
SW	1.53 (29%)	1.78 (29%)	1.77 (32%)	1.77 (9%)	-
NK	1.07 (55%)	2.23 (10%)	2.29 (24%)	3.22 (10%)	-
BB	2.27 (56%)	1.80 (12%)	3.52 (12%)	3.12 (21%)	-
DC	1.76 (18%)	1.94 (27%)	2.24 (27%)	2.27 (27%)	-
NP	2.26 (6%)	2.45 (18%)	2.37 (53%)	2.99 (24%)	-

+ N=56, with 1 missing data.

† TP, transplanting; BC, broadcasting.

Total *N* of data in rows below is <206 farmers because not all farmers used these planting methods and varieties
Value in parentheses is *N* of each cell.
Sum of percentage of TP and BC is not equal to 100% because a few farmers planted with a seeder machine.
*, ** Multiple comparison by Tukey–Kramer and Games–Howell, respectively. Different letters indicate difference in mean proportion of rice sale among the four categories.
*** Chi-squared test by the Kruskal–Wallis method.

sold was clearly observed at HP, WN, and NK (Table 3.6). The difference in yield among groups was very small at SW, and the groups with less market proportion maintained relatively high yield at BB and NP (>2.2 t/ha). Market-oriented farmers had higher active learning scores about rice issues than home consumption–oriented farmers. The group that sold less than 25% of rice produced depended on non-rice sources of income for their household livelihood, had low total household income (<100,000 baht), and had the lowest relationship score with researchers (i.e., 2.0 of 15). Market-oriented farmers and subsistence farmers had similar years of education and social positions within their villages (data not shown).

3.3.3. Farmers' perceptions and attitudes toward climate change

Eighty percent of the surveyed farmers had experienced severe climatic damage to rice production by drought and/or flooding (Fig 3.3). Drought was experienced at every site and its overall average percentage was large (~42%), although the percentage of farmers who experienced flooding was also as large or larger at HP, SW, and NP. There were no differences between participants and non-participants in their exposure to climatic damage.

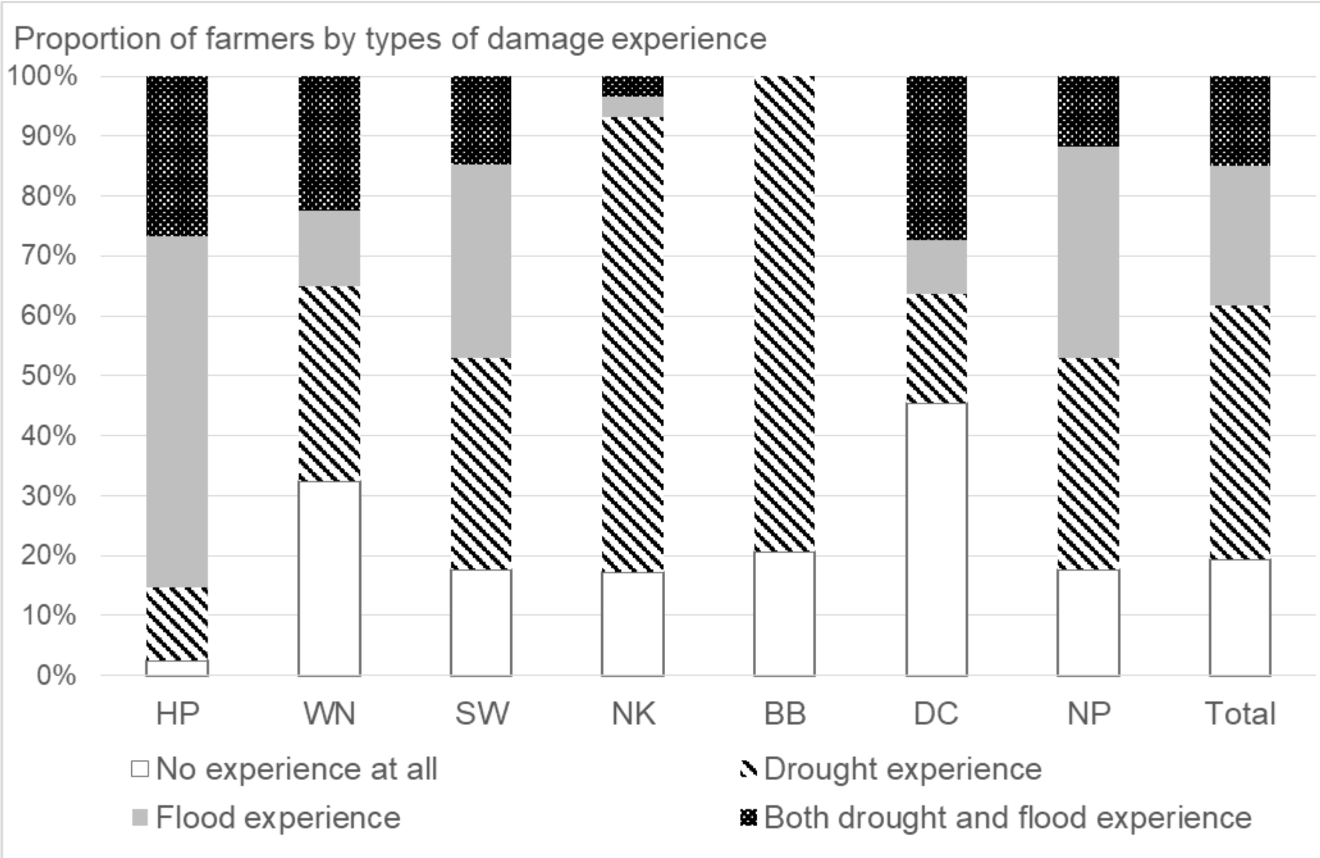


Figure 3.3 Proportion of farmers' experiences of damages by extreme climatic incidents for 7 sites (Total N = 206).

We found no difference between participants and non-participants in their perception of the climate trend since their childhood (Table 3.7). Almost all the surveyed farmers perceived that climate had changed since their childhood, noting less frequent cold days and cold nights, more frequent hot days and hot nights, more frequent and severe heavy rainfall, and more severe and prolonged drought.

Table 3.7 Comparisons between participants and non-participants regarding perceptions of climate trend, understanding of IPCC message, advanced technology knowledge score, previous experiences with climate change both in thinking and action, farmer's attitude score about adaption to climate change, rice straw burning.

Farmers' perceptions and actions toward climate change	Participants (N = 66)	Non-participants (N = 112)	p value	Effect of participation
1. Perception of climate trend based on farmer's childhood	hotter, more drought	hotter, more drought	>0.05	no
2. Understanding of IPCC message (% of farmers)	57%	31%	0.005	substantial
3. Advanced technology knowledge score (e.g., resistant varieties)	1.86	0.92	<0.001	substantial
4. Previous experience of thinking to deal with effects from climate change (% of farmers)	50%	47%	0.730	no
5. Previous experience of actions to deal with effects from climate change (% of farmer in No.4)	47% (N = 32)	63% (N = 53)	0.170	no
6. Farmer's attitude score about adaption to climate change	2.30	2.04	0.061	small
7. Rice straw burning (% of farmers)	14%	25%	0.071	small

When a brief description of climate change from the IPCC report was explained to farmers, 57% of participants said they understood the contents, whereas only 31% of non-participants did so ($p = 0.005$). The level of farmers' understanding was affected by years of education ($p = 0.001$), activeness in learning about rice issues ($p < 0.001$), membership in local rice-farming groups ($p = 0.005$), and relationship score with researchers ($p < 0.001$). Participants knew slightly more about advanced technology for coping with climate change (Table 3.7).

Despite nearly all farmers perceiving a change of climate, only 49% had ever thought to deal with adverse effects from these changes and only 27% actually took action (e.g., obtaining supplementary water resources by digging underground, building ponds, or installing pumps). Participants and non-participants did not differ in these responses (Table 3.7). Those farmers who had thought to deal with climate effects had more education ($p = 0.063$), clearer farming targets ($p = 0.024$), and active learning attitudes ($p = 0.010$). The farmers who took action tended to have additional water sources available ($p = 0.016$) such as a pond or river, however, climatic damage experience was not found to affect the decision to take action ($p = 0.715$).

Participants tended to burn less rice straw than non-participants (Table 3.7), and they were more likely than non-participants to agree that burning caused negative effects (*p* = 0.038) and that farmers should stop it (*p* = 0.058) (data not shown). Eighty-two percent of the farmers did not burn the rice straw because the land preparation option of using four-wheel tractors was readily available, while the other farmers found it difficult to prepare land without burning. Sixty-eight percent of the farmers understood that straw burning caused greenhouse gas (i.e., CO_2) emission. A stronger relationship with researchers and more years of education were significantly associated with less residue burning (*p* = 0.029 and *p* = 0.070, respectively). Practicing both dry and wet season cropping tended to enhance burning activities, although the trend was not significant; 40% of those who practiced dry season rice cropping burnt straw, whereas 19% of those who grew only the wet season crop did so.

Farmers with more education knew significantly more about advanced technologies than those who had only completed primary school (Table 3.8). Farmers with high scores for knowledge of advanced technology were more active learners, had stronger relationships with researchers, and were members of local farming groups. Those with more years of education, targets in their farming, and activeness in learning in general and on rice issues had significantly higher attitude scores about adaptation to climate change (Table 3.8). Farmers with high relationship scores also had higher attitude scores. Those who thought to deal with adverse climatic effects based on past incidents had higher attitude scores about adaptation to climate change. Those who were active learners and had higher technology knowledge scores also had higher attitude scores.

Table 3.8 Advanced technology knowledge score and farmer's attitude score about adaption to climate change by education, rice sale (%) from total rice production, targets in designing farming, confidence in farming, activeness in learning in general and rice issue, relationship with researcher, membership in local farming groups, and previous experience of thinking to deal with effects from climate change.

		Advanced technology knowledge score	*p* value	Farmer's attitude score about adaption to climate change	*p* value
Education length	≤ 6 years (*N* = 153)	1.15 a	0.034	2.06 a	0.008
	> 6 years (*N* = 52)	1.58 b		2.37 b	
Rice sale (%)	< 25% of production for sale (*N* = 57)	1.11	ns	2.21	ns
	25–50% of production for sale (*N* = 37)	1.35		2.05	
	51–75% of production for sale (*N* = 58)	1.22		2.21	
	> 75% is for sale (*N* = 53)	1.41		2.04	
Targets in designing farming	no (*N* = 47)	1.12	ns	1.70 a	<0.001
	yes (*N* = 158)	1.30		2.27 b	
Confidence in farming	no (*N* = 177)	1.2	0.060	2.08	0.038
	yes (*N* = 28)	1.62		2.46	
Activeness in learning in general	low (*N* = 29)	0.79 a	0.010	1.66 a	<0.001
	medium (*N* = 35)	1.29 b		1.89 ab	
	high (*N* = 141)	1.35 b		2.30 b	
Activeness in learning rice issues	low (*N* = 22)	0.50 a	<0.001	1.82	0.054
	medium (*N* = 92)	1.11 b		2.07	
	high (*N* = 91)	1.60 c		2.29	
Relationship with researchers	no (*N* = 90)	0.84 a	<0.001	1.99 a	0.025
	low (*N* = 58)	1.20 a		2.12 a	
	medium (*N* = 45)	1.91 b		2.29 ab	
	high (*N* = 12)	2.25 b		2.75 b	
Membership in farmer groups	no (*N* = 71)	0.91 a	<0.001	2.03 a	0.08
	yes (*N* = 107)	1.74 b		2.26 b	
Previous experience of thinking to deal with effects of climate change	no (*N* = 105)	1.22	ns	1.88	<0.001
	yes (*N* = 98)	1.30		2.42	
Advanced technology knowledge score	<1 (*N* = 48)	-	-	1.90 a	0.022
	1–2 (*N* = 78)	-		2.13 ab	
	>2–3 (*N* = 52)	-		2.38 b	

*Different letters show statistical difference by ANOVA multiple comparison by Tukey–Kramer or Games–Howell test at 0.05; ns, not significant with $p > 0.1$.

3.4. Discussion

3.4.1. Characteristics of farmers participating in research projects

We hypothesized that participant farmers would have a better learning attitude developed by associating with researchers, in turn making them more motivated to improve their farming, which was generally confirmed by our survey. Compared to non-participants, the participants had higher relationship scores, which serve as a comprehensive indicator of farmers' relationship with researchers. The participants were more active learners with confidence about not only rice farming but also general matters (despite having similar ages and levels of education as non-participants) and worked toward farming targets such as yield level or organic farming. The participants produced 22% higher yield than the non-participants (Table 3.2). A previous study in Africa also showed that farmers participating in research groups were more interested in innovation to improve their farms and more frequently contacted agricultural extension staff (Sanginga et al., 2006).

Although these personal characteristics of the participants led to higher yields, the differences in perception of climate change between participants and non-participants were much smaller. The mindset and actions of participants made them slightly more prepared to cope with climate change; this may be a positive result of the participatory project on adaptation to climate change, or it may reflect a bias that farmers who were already more aware participated in the research project. However, because the research focused on long-term changes of climate patterns in the future, which are less familiar to local farmers and less linked with their immediate economic benefits, our survey did not detect any large differences between the participants and non-participants after the 3-year research project.

Although the research project was open to all farmers at the sites, most participants belonged to local farming groups, such as rice seed production groups and organic rice groups, in their communities. This finding reflects the strength and importance of local group networks for participatory research and for subsequent technology dissemination in Northeast Thailand. Leaders might have influenced other group members to join the research project. Those who have targets while developing their farming, such as higher yield to allow for more rice to be sold, may have joined local groups to gain the knowledge and skills necessary to attain their target, and they likely joined the participatory project for similar reasons.

About 18% of the participants joined the project not to learn new rice technologies to solve problems derived from climate hazards, but because of their relationships with neighbors and/or leaders (data not shown). Relationship scores varied widely among participants (cf. large standard deviation in Table 3.6), indicating the heterogeneity and broad levels of individual farmer's interactions with researchers. Some participants were very motivated in learning research findings and testing new technologies, whereas others were more passive and affected by the behavior of other farmers (data not shown). Although the presence of a few leading farmers was expected, the presence of an inactive group of participants is not uncommon. This variation in quality of participants should be understood by researchers as a factor influencing the effectiveness of participatory projects.

Our results imply the superiority of participants to non-participants with regard to rice yield and household economics (although we did not collect detailed economic indicators such as income), but the differences between these groups were not large in some basic characteristics, such as size of landholdings and education. In a participatory wheat breeding project in the United States, large-scale farmers who grew many varieties at specific locations to attain higher quality were more willing to participate in the program (Dawson & Goldberger, 2008). On the other hand, a participatory rice variety selection project in India included farmers with broad economic statuses and with different landholding sizes (Paris et al., 2008). In Africa, both wealthier and poor farmers participated equally in research activities in a program aimed at increasing capacity of small-scale farmers (Sanginga et al., 2006) and for the development of IPM (Togbé et al., 2015). The surveyed project in northeastern Thailand focused on the testing and adoption of new rice varieties, which could be considered as scale-independent, allowing participation of farmers with different size landholdings.

3.4.2. Variation in farm-level rice yield

We recorded large yield variation among the 206 farms at the seven target sites in rainfed lowland rice ecosystems with different climate problems in Northeast Thailand. The overall average yield of the seven sites (2.18 t/ha) was similar to the regional statistical yield (2.24 t/ha; (OAE, 2018e)) and the sampled yield values of the sites in the project (RD, 2013b, 2014). The large variation of yield, ranging from 0.63 to 4.05 t/ha between the bottom and top 10 percentile of farmers, revealed the presence of not only low-yielding subsistence farmers but also a small number of high-yielding farmers who can attain more than 4 t/ha even under rainfed cultivation. Supporting evidence of higher yield attained in Northeast Thailand is available from a field survey conducted at some lower toposequence positions (e.g., Kamoshita et al. (2009)) as well as from some on-station agronomic experiments, for example, with a high nitrogen fertilizer application rate in lower toposequential fields (Haefele et al., 2010; Hayashi et al., 2007). In our study, the yield gap between the best yielding farmers and average farmers was 1.88 t/ha (85% higher), which is slightly higher than the yield gaps of 1.2 t/ha (6.2 vs. 5.0 t/ha) and 1.4 t/ha (6.2 vs. 4.8 t/ha) reported by Laborte et al. (2012) and Stuart et al. (2016), respectively, under irrigated cultivation in central Thailand. Our method for calculation of yield gap differed slightly from theirs, so these figures should be compared with caution, but we have demonstrated a substantial yield gap in rainfed lowland rice ecosystems in Northeast Thailand, as seen in irrigated rice in central Thailand, including information on the yield gap for each planting method and each major variety.

The major reason for the large yield gap was the difference in the purpose of rice production among farmers, that is, whether for sale or for home consumption. Market-oriented rice farmers had higher yields than those of subsistence farmers (Table 3.6). Market orientation could promote higher yield as a means for higher income. The highest, average, and lowest yields were 4.1, 2.2, and 0.6 t/ha, those of rice sale percentages were 67%, 48%, and 17%, and those of amounts sold were 5.9, 3.4, and 0.4 t (Table 3.4). The sites with more rice sold (e.g., HP and NP) had higher yield with small yield variability, whereas sites with less rice sold (e.g., NK) had lower yield and larger yield variability because farmers' income sources were diverse (Fig 3.2: a, d, e). Market-oriented farmers seem to have been equipped with more supplementary irrigation water, judging from the tendency for them to have more available water sources (e.g., on-farm ponds, canals connecting to a river), which allowed them to achieve higher yield, as in the case of lower toposequence fields in previous studies (e.g., Naklang et al. (1996), Kamoshita et al. (2009)). Several studies also showed that market-oriented farmers produced rice more efficiently (Ebers et al., 2017; Piya et al., 2012) also reported that many farmers in Northeast Thailand grow rice for self-consumption as a cultural norm even under severely constrained farming conditions, which were less efficient and lower yielding. The presence of many such subsistence farmers lowered the regional yield level in the national statistic record, despite some farmers with high yields.

Direct seeding by broadcasting has recently become the most prevalent planting method at the surveyed sites (e.g., higher proportion than regional average value of 47%; (OAE, 2018b)) in spite of the slightly lower yield than traditional transplanting, because of its cost and labor savings. Market-oriented farmers had a higher yield than subsistence farmers when using broadcasting, with a slightly higher seed rate (136 vs. 95 kg/ha) and with a longer period (9 vs. 5 years) since changing to the direct seeding method. Market-oriented farmers are applying a higher seed rate than the standard rate recommended by the government (94–125 kg/ha (Pongsrihadulchai, 2013)), which can be seen as a means of securing plant establishment to avoid yield reduction from abiotic stress. Subsistence farmers tended to use a lower seed rate even though their yield was reduced. Use of a seed rate above 95 kg/ha resulted in a yield increase of 21 kg/ha per kilogram of seed by broadcasting. Use of a drill seeder can reduce the seed rate, with an average of 57 kg/ha, without yield reduction (2.5 kg/ha at NP). The development of drill seeding technology that saves seeds without yield penalty would likely be attractive to subsistence farmers as well if use of the devices could be shared within farmers' groups.

3.4.3. Farmers' perceptions and actions toward climate change

Our study revealed the perspectives of northeastern Thai farmers about climate: (1) in general, drought is more recognized than flooding at the seven sites, and (2) the climate of the region has become hotter and drier since their childhood (i.e., the 1970s). In fact, the records of the Meteorological Department of Thailand from 1970 to 2009 showed temperature has increased by around 0.2 ℃ per decade in the northeastern region (Limjirakan & Limsakul, 2012) in accordance with the IPCC report (IPCC, 2013). (Limsakul & Singhruck, 2016) also reported long-term trends of less frequent precipitation events from 1955 to 2014 across most regions in Thailand, which seems to support the farmers' perceptions. The differences between participants and non-participants were generally small with regard to these perceptions. A brief summary of the IPCC report was understood by 41% of farmers, and the percentage was higher for participants than non-participants, suggesting that participants gained knowledge about climate change from researchers during the project.

Despite the common perception of long-term climate changes by northeastern Thai farmers, they have not yet seriously responded or prepared to deal with these changes. Some farmers performed some responsive actions after climatic damage to their crops, but these tended to be short-term reactions, such as water pumping during drought, rather than long-term strategic adaptation, such as adopting new rice varieties better adapted to variable climate conditions (Deressa et al., 2009; Harmer & Rahman, 2014). Some of the long-term climate adaptations that would require changes in the farming system might not be easy for farmers in Northeast Thailand to accomplish, because they are costly and labor intensive.

However, the willingness to learn new technologies, prepare for adaptation, and refrain from residual straw burning were more marked in the participants than in the non-participants (Table 3.7). The participants appear to have learned about and better understood climate change and its risks, which is a prerequisite for subsequent actions for long-term adaptation (Dang et al., 2014; Esham & Garforth, 2013; Saguye, 2017). The relationship score was also positively correlated with the advanced technology knowledge score and attitude about adaptation to climate change (Table 3.8). Therefore, if researchers continue to help farmers understand the local changes in climate conditions and the potential risks to rice production, they should become more ready to change their traditional farming methods and adopt technologies resilient to climate hazards with improved yield level and stability (Campbell et al., 2016; Chandra et al., 2017; Manzanilla et al., 2011). Several rice farming technologies for adaptation to climate change have been developed, with a strong emphasis on farm-level demonstration, such as breeding for submergence resistance (Mackill et al., 2006; Manzanilla et al., 2017) and for drought resistance (Kumar et al., 2014), planting adapted varieties (Mitchell et al., 2014), and managing crop nutrients (Jairin et al., 2017; Kato et al., 2016).

Chapter 4

Yield variation of rice farmers under risks from climate change in rainfed lowland ecosystem in Northeast Thailand

4.1. Introduction

The characteristics of participants of participatory research projects has not been well reported. Chapter 3 had shown that participants were those who were member of local group, active in learning, had a close relationship with researcher. However, whether they were more better-off than non-participants was not confirmed. The participants had higher yield and more production of rice for sale in Chapter 3; the reasons are not clarified and the magnitude of yield advantage needs to be confirmed. In some participatory project, farmers with the broad socio-economic status participated (Paris et al., 2008). Participants might be market-oriented farmers who have better income which enables their time and effort to attend the project and who have high incentive to improve their farming efficiency (e.g., higher yield) for seeking more profit.

Results from Chapters 2 and 3 showed not only lower average yield in rainfed rice ecosystems but also large household level yield variation in northeastern region. Yield gap of Norrtheast Thailand farmers were approximately around 1.9 t/ha higher than what reported for the irrigated ecosystem case in central region (Laborte et al., 2012; Stuart et al., 2016). Socio-economic aspects of farmers may be better clarified to explain such large household level yield variation within the region, together with the studies on bio-physical factors for limiting yield of rainfed rice (Fukai & Ouk, 2012). The reason for higher yield of best-yielding farmers may be related with market-orientation, or with different practice on rice farming such as fertilizer application rate or additional dry season production.

As project had been conducted for approximately 4 years, the attitude and response of farmers in the research sites towards climate change issue should be clarified. Chapter 3 reported that generally Northeast Thailand farmers perceived there was a long-term change in climate, but they did not act to cope with it seriously. Whether they considered the change of climate has affected to their rice farming production or not should be clarified. Also, there response and attitude towards the technologies (i.e. drought/flood resistant varieties, drill seeder) that the research project had offered during the project activities needed to be well clarified.

To improve rice production in Northeast Thailand under climate change by participatory research approach, this study aimed to clarify 1) whether there are differences in economic status and farming management between participants and non-participants, 2) to what factors made market-oriented farmer gained higher yield than subsistence, 3) farmers' attitude and response to the climate change coping technology. It was assumed that participants had higher economic status (e.g. annual household income) and were rice market-oriented enabling them to participate the project activities. Market-oriented farmers do more intensive farming management than subsistence farmers. It was hypothesized that farmers perceived the adverse effect of climate variability, but they do not aware about the climate change issue due to lack of scientific understanding in climate change.

4.2. Methods

4.2.1. Study sites and the target population of farmers

Follow up survey was conducted again one year after project finished only in the sites where research project activities had run earlier. Thus, only 6 sites from chapter 3 (excluded DC) from the surveyed in 2016 (See Chapter 3, Fig 3.1) were chosen for the study sites in this chapter. The target population was farmers who have grown rice in the villages where rice research activities has been conducted.

4.2.2. Sampling and data collection

Data collection was conducted from 4 to 9 January 2017 by face-to-face structed interview structured questionnaire consisting of 5 Parts (Table 4.1). The questionnaire contained 5 parts which covered farming characteristics and management, household economic information, farmer's response to project's technology, farmers' attitude about climate change and response to climate mitigation.

Total number of interviewed farmers was 185 which contained both previous farmers from 2016 survey (Chapter 3) and new farmers (Table 4.2). This is because the interview was unable to arrange with some of farmers from the last survey during survey period.

Table 4.1 Description of contents of questionnaire conducted in 2017 and its unique points compared with the previous questionnaire in 2016

Part	Contents	Unique points after the questionnaire in 2016	Numbers of questions
A	Farming characteristics (e.g., field type, water environment, production process and scale, input management, farming expenditure)	Details of yield (in multiple years, in different field conditions) Fertilizer application rates	31
B	Household economic aspect (e.g., annual income, annual household minimum expenses, livelihood, etc.)	Economic parameters	8
C	Attitude and response to the technologies brought by the project	Degrees of reception of the tested technologies after the 1 year of completion of the project	7
D	Quantitative experience in extreme climatic damages and adaptation to climate variability and climate change	Re-confirmation of farmers' level of understanding of climate change	7
E	Status and responses with regard to mitigation by stopping burning fields (e.g., current status and reasons)	Details in ice straw burning	6

Table 4.2 Numbers of surveyed farmers in 2017 by site

Site code	HP	WN	SW	NK	BB	NP	Total
Site name	Huataphan	Wanonniwas	Sriwilai	Naklang	Borabue	Napo	
Total number of interviewed farmers used in analysis	35	32	37	30	27	23	185
-Total repeat interviewed farmer (persons)	32	25	25	11	23	12	128
Participant	17	16	13	6	6	10*	68
Non-participant	15	9	12	5	17	2	60
-Total first-time interviewed farmer (persons)	3	7	12	19	4	11	56
Participant	2	4	6	3	0	8*	23
Non-participant	1	3	6	16	4	3	33

* Farmer who tested drill seeder

4.2.3. Data analysis

Definition of parameters used in this study and calculation formula was explained in the appendix section of the thesis. Difference between participants vs non-participants, best-yielding farmer vs lowest-yielding farmer, market-oriented farmer vs subsistence farmer was analyzed by T-test, ANOVA, Non-parametric test such as cross-tabulation by Pearson chi-square. Pearson correlation and scatter plot has been used for checking a relationship between two scale parameters. Forward stepwise Multiple linear regression was used to clarify factors determining yield variation at paddy level (t/ha) from the pool of X parameters in the model. Forward stepwise binary logistic regression was used in the analysis that Y was a dichotomous value such as use/not use, participant/non-participants, etc. (Peng et al., 2002) from the pool of X parameters in the model. 75 variables (Table S6) were put in the model as candidate X parameters for predicting participation to the project. Yield divided at paddy level with the data of 633 paddies covering production in two years (2015 and 2016) under three types of fields. Multiple regression analysis with forward stepwise function showed key parameters determining paddy yield level from three group of factors.

For the analysis of yield performance of individual household in the study site, each household was assigned a number ranked by their average farm yield level; for example, No.1 was assigned for the lowest yielding farmer in study site while the highest No. was assigned to the highest-yielding farmer. With the household yield rank No., each household was detected whether there were any changes in yield (e.g. yield variability) in 2015, 2016, and in three types of field topography or not. The N fertilizer application rate was calculated from the inorganic fertilizer application rate by assuming N content of inorganic fertilizer as 16% (Pongsrihadulchai, 2013).

4.3. Results

4.3.1. Difference in economic status and farming characteristics and management between participants and non-participants.

Participants had higher rice cultivated area and larger wet season rice production, slightly larger amount of rice for sale and significantly larger sale proportion than non-participants (Table 4.3). Rice yield and organic fertilizer application rate tended to be higher for participants than non-participants, but not different at 5% level. Participants had less yield variability by year in comparison to non-participants. Participants had higher rice income and higher total annual income, and they were concerned more about rice economic problem than the non-participants. Participants and non-participants did not differ in water resources and rice farming years (data not shown). Farmers who (I) were members of any rice group in the village, (II) had a position, (III) had longer education years, (IV) paid more attention to economic problems of rice farming, and (V) had a larger proportion of rice growing area, had a higher chance to participate in the research project (Table 4.4).

Table 4.3 Comparative analyses results between participant and non-participant in technical level and economic status.

	Participant (N = 69)	Non-Participant (N= 82)	T value	Pearson Chi-square value	P value
Technical level					
Dry season cropping	9.4%	12%		0.319	0.572
Average farm yield level (t/ha)	2.27	2.03	1.637		0.104
Yield variability by year	0.32	0.53	-2.414		0.012
Organic input (kg/ha)	322.87	198.00	1.627		0.107
Inorganic input (kg/ha)	135.70	171.27	-1.211		0.229
N input (kg/ha)**	35.15	33.59	0.317		0.752
Economic status					
Rice cultivated area (ha)	2.95	2.43	2.094		0.038
Total wet season rice production (kg)	6534	4950	2.400		0.018
Rice produced for consuming at home (kg)	2261	2135	0.520		0.604
Sale amount (kg)	3469	2464	1.682		0.095
Sale (%) from total rice	45	34	2.261		0.025
Total income (Baht/year)	166,726	119,558	2.314		0.034
Rice income (Baht/year)	35,585	23,743	1.981		0.049
Agricultural income (excluded rice) (Baht/year)	43,290	33,743	0.760		0.448
Non-agricultural income (Baht/year)	87,850	62,073	1.326		0.188
Problem concerned most as rice farmers (% of farmers) -Rice farming economic problems	42%	19% (N = 80)		11.950	0.007

* Showed N after excluding incomplete and missing value

** Showed data of farmers only who applied the inorganic input.

Table 4.4 Results of the likelihood ratio forward stepwise binary logistic regression in final step showed key factors determining participation of farmer to the research project. (See details of explanatory variable in Table S7)

Explanatory Variable	Coefficient (B)	SE	Exponential B / Odd ratio	P value
(I) Membership in rice-related group in village	1.453	4.278	0.449	.001
(II) Have governing position (e.g. village head)	1.616	5.035	0.610	.008
(III) Rice farming economic problem as most concerned	2.962	19.343	1.371	.031
(IV) Proportion (%) of rice area from total agricultural farming area size	0.023	1.023	0.010	.029
(V) Education years	0.217	1.242	0.097	.025
-2 log likelihood	132.84			
Model Chi-square	51.35			
Model prediction accuracy (%)	75.9			
R^2 of Nagelkerke	0.427			
N = 133				

4.3.2. Yield variation among farmers and its determinants

4.3.2.1. Yield variation among farmer in rice community

Table 4.5 showed an average yield of farmers was 2.18±0.9 t/ha while best-yielding farmers and lowest yielding farmers had a yield of 4.01 ±0.66 t/ha and 0.78±0.13 t /ha respectively. The yield gap between best-yielding farmers and average yielding and lowest yielding farmers were 1.84 t/ha and 3.23 t/ha, respectively. Best-yielding farmers gained similar high yield level in both 2015 and 2016 (data not shown). Best yielding farmers produced more rice and sold in higher proportion than lowest yielding farmers.

Best-yielding farmers applied organic fertilizer (854 kg/ha) almost twice higher than the average farmers (430 kg/ha), while lowest-yielding farmers applied at only 127 kg/ha (Table 4.5). A similar variation was found in inorganic fertilizer application rate and total N input among best-yielding farmers (203 and 40 kg/ha), average farmers (148 and 33 kg/ha) and lowest yielding farmers (98 and 29 kg/ha). Rice income was on average about 40,000 Baht, which was more than double for the best yielding farmers and about only 10% for the lowest yielding farmers.

Table 4.5 Mean value among best-yielding farmer, average, and lowest-yielding farmer in agricultural farming characteristics, rice production farming characteristics, rice farm input management, and household economic characteristics

	Best-yielding farmer (N = 18)	Average (N = 175)	Lowest-yielding farmer (N = 18)
Rice production farming characteristics			
Rice cultivated area (ha)	2.32	2.66	2.19 (N=17)
Total wet season rice production (kg) **	9,386	5,772	1,701
Yield normally gained (t/ha) **	4.01 (0.62)	2.18 (0.91)	0.79 (0.13)
Yield variability by year	0.71	0.44 (N = 174)	0.60
Yield in favorable area (t/ha) **	4.15 (N = 14)	2.29 (N = 148)	0.92 (N=10)
Yield in drought-prone paddy (t/ha) **	3.18 (N = 5)	1.77(N = 52)	0.75 (N=9)
Yield in flood-prone paddy (t/ha) **	3.97 (N = 7)	2.25 (N = 45)	0.63 (N = 8)
Rice produced for consuming at home (kg) **	2,724	2,183	1,346 (N=17)
Sale amount (kg) **	5,350	3,015	1,123 (N=17)
Sale (%) from total rice**	54	41(N = 174)	29 (N=17)
Regularly visit field (% of farmers)	78%	84%	83%
The problem concerned most as rice farmers (% of farmers) -Rice farming economic problems	39%	31%	11%
Rice farm input management			
Organic input (kg/ha) **	854	430	127
Inorganic input (kg/ha) **	203	148	98 (N = 17)
N input (kg/ha)	40	33 (N = 170)	29 (N = 17)

Household economic characteristics (From here N=)		(N=173)	(N=15)
Total income (Baht/year)	164,724	145,923	160,475 (N = 17)
Rice income (Baht/year) **	48,558	30,629	10,965
Agricultural income (excluded rice) (Baht/year)	40,756	37,387	76,778
Non-agricultural income (Baht/year)	75,411	78,330	73,376
Rice income (%) from total annual income**	32	24	10

*, **Significant different at 0.1 and 0.05 (Between best-yielding and lowest-yielding farmer only)
##Water sufficiency (Average farmer N = 180) and value simulated by sufficient additional water source = 2, insufficiency additional water source = 1, rain only = 0
###Yields by type of area were calculated only from farmer samples who had that kind of field types

4.3.2.2. Factors determining yield variation among farmers

4.3.2.2.1. Additional water source and dry season rice production

74% of farmers had an additional water source for rice farming apart from rain such as stream or canal connected with the river (51%) and on-farm pond (23%). Percentages of farmers without additional water sources reached more than 30% in SW, WN, NK, and NP while the values were only 6% in HP in which 74% of farmers connected with the river. About one-fourth of NP farmers used underground water. Almost 90% of farmers cropped only in wet season. 17% of those who had stream or canal connected with river sometimes grew a second crop (dry season rice)(Table S8). Only 5 farmers planted dry season rice in 2016 after harvesting wet season rice in 2015 (data not shown). In dry season, rice planting area was 0.6(0.3) ha, and yield was 3.4(0.73) t/ha on average. Farmers growing CNT, a photoperiod insensitivities variety, had yield around 4 t/ha. Comparative analyses between double cropping farmers and single wet season cropping farmers based on their wet season production characteristics showed that double cropping farmers often had additional water sources connecting to river, had larger rice growing area and greater rice production for sale with higher input but there was no difference in wet season rice yield (Table S8). It was found that dry season rice production was significantly associated with the burning behavior (P=0.007). Fifty % of double cropping farmers burnt rice residue which was 3 times of the farmers who grew rice only in wet season.

4.3.2.2.2. Site effect

Growing rice under favorable and flood-prone paddy provided better yield value than drought-paddy which the former had stronger impact (Fig 4.1a). The 6 sites differed in yield (Fig. 4.1b), with HP site where flood usually occurred having highest yield.

a) b)

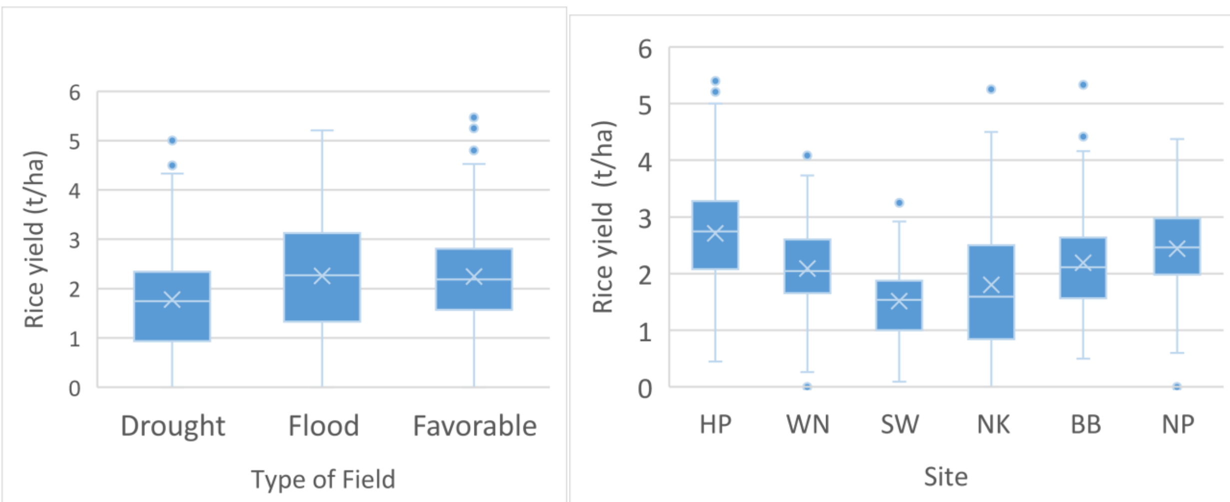


Figure 4.1 Rice yield surveyed in 2017 in 3 different field types (a) and 6 different sites (b).

4.3.2.2.3. Rice sale proportion and fertilizer application

Farmers with rice sale proportion higher than 75% had higher yield (Table 4.6) including drought-prone field. Market-oriented farmer made a significantly higher input than subsistence farmers for both organic and inorganic matter. Sale-oriented farmer made N input at 52 kg/ha in total while subsistence farmers applied only at 24 kg N/ha. Fig 4.2 showed N fertilizer application rate had a moderate positive effect on yield only for farmers who sold more than 75% of their rice

Most farmers applied organic fertilizer such as manure less than 100 kg/ha. Farmers applied inorganic N fertilizer less than government recommendation (50 kg/ha; (BRRD, 2018). Higher proportion of rice sale was related with higher inorganic fertilizer application rate (Table 4.7). Use of synthetic herbicide or pesticide positively correlated with the amount of N fertilizer input (Table 4.8).

Table 4.6 Farming characteristics, growing method, varieties planted, mean yield of each site categorized by the proportion of rice home consumption

	Less than 25% of production for sale (N = 57)	25-50% of production for sale (N = 35)	50-75% of production for sale (N = 61)	More than 75% of production is for sale (N = 20)	ANOVA p value
Rice production farming characteristics					
Rice cultivated area (ha)	2.06a	2.44ab	2.99b	3.69b	＜0.001
Total wet season rice production (kg)	3,802a	4,801a	6,701b	10,020b	＜0.001
Yield (t/ha)	1.95a	1.98a	2.31ab	2.72b	＜0.001
** Yield in drought-prone paddy (t/ha)	1.77a (N = 21)	1.67a (N = 12)	1.34a (N = 14)	3.48b (N = 4)	0.007
** Yield in flood-prone paddy (t/ha)	2.19 (N =13)	2.19 (N =7)	2.08 (N = 16)	2.62 (N = 8)	0.819
Rice produced for consuming at home (kg)	2601a	2359ab	1977b	1439b	0.009
Sale amount (kg)	147	1939	4282	9189	<0.001
Sale (%) from total rice	3	40	63	82	<0.001
Organic input (t/ha)	274	676	342	535	0.091
Inorganic input (t/ha)	105 (Med 70.04a) (N=56)	183(Med 86.71ab)	147(Med 93.53ab)	248(Med 115.80b)	0.014
N input (kg/ha)	24(N =56)	31(N = 31)	36 (N = 62)	44	0.008
Household economic characteristics	(from here, N =55)				
Total income (baht/year)	145,710	102,933	150,146	200,375	0.396
Rice income (baht/year)	1,671a	19,180b	45,442c	84,704d	<0.001
Agricultural income (excluded rice) (baht/year)	54,238	22,991	30,086	37,125	0.176
Non-agricultural income (baht/year)	89,802	60,761	74,619	78,545	0.689
Rice income (%) from total annual income	2	23	37	48	<0.001

Multiple comparison by Tukey’s Kramer and Games-Howell Homogeneity test by Levenes test < 0.05, *; at 0.1

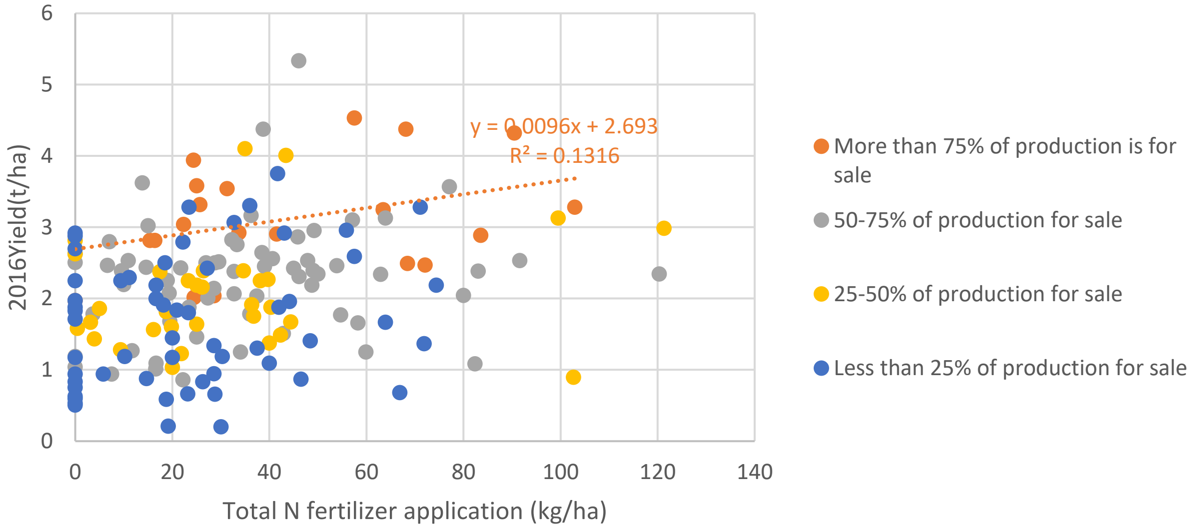


Figure 4.2 Relationship between total N fertilizer application rate and 2016 yield among farmers with different level of market-orientation.

Table 4.7 Correlation (r) between total nitrogen (N) fertilizer application for wet season rice and other farming parameters.

	Total N fertilizer application (kg/ha) for wet season rice	R	p value
Rice growing area (ha)		0.197	0.009
Home consumption (%)		-0.308	<0.001
Total sale rice (%)		0.279	<0.001
Amount of KDML105 from total rice for sale (%)		0.217	0.013
Total expenditure (Baht/ha)		0.265	<0.001
Rice income (%) from total annual income		0.247	<0.001
		T-test/ANOVA	
Use pesticide or herbicide for wet season rice			0.019
- yes/sometimes (N=55)	39		
- no (N = 122)	29		
Do dry season after wet season (double cropping)			0.028
- yes/sometimes (N =18)	53		
- no (N =159)	31		

Table 4.8 Comparative characteristics between farmers who used synthetic herbicide and pesticide and those who did not

	Use synthetic herbicide and pesticide (sometimes /always) (N =54)	Not use (N = 115)	p value
Rice growing area (ha)	3.10	2.48	0.010
Percentage of drought-prone paddy (%) in rice area (ha)	7 (N = 114)	17	0.004
Total production in general (kg)	7128	5190	0.009
Amount of rice kept for sale (kg)	4376	2417	0.003
Total sale rice (%)	52	37	0.001
Total expenditure (Baht/ha)	10,701	9,593	0.078
Total Rice income (Baht/year)	42,203	24,783	0.012
Total non-rice agriculture income (Baht/year)	36,746	39,983	0.791
Total non-agriculture income (Baht/year)	71,788	81,976	0.587
Total income/year	150,737	146,742	0.861
Rice income (%) from total annual income	30(N = 120)	22	0.064
Total N fertilizer application rate (kg/ha)	42	29	0.005

4.3.2.3. Yield stability by years of farmers

Farmers were ranked from the lowest to the highest yield on average years (Fig. 4.3a) and the yield in 2015 and in 2016 were compared (Fig. 4.3b, c). Yield in 2015 and in 2016 were positively correlated (Fig. 4.4a). The similar tendency in yield gained of same farmer was found for average farm yield, 2015 yield, and 2016 yield (Fig 4.4).

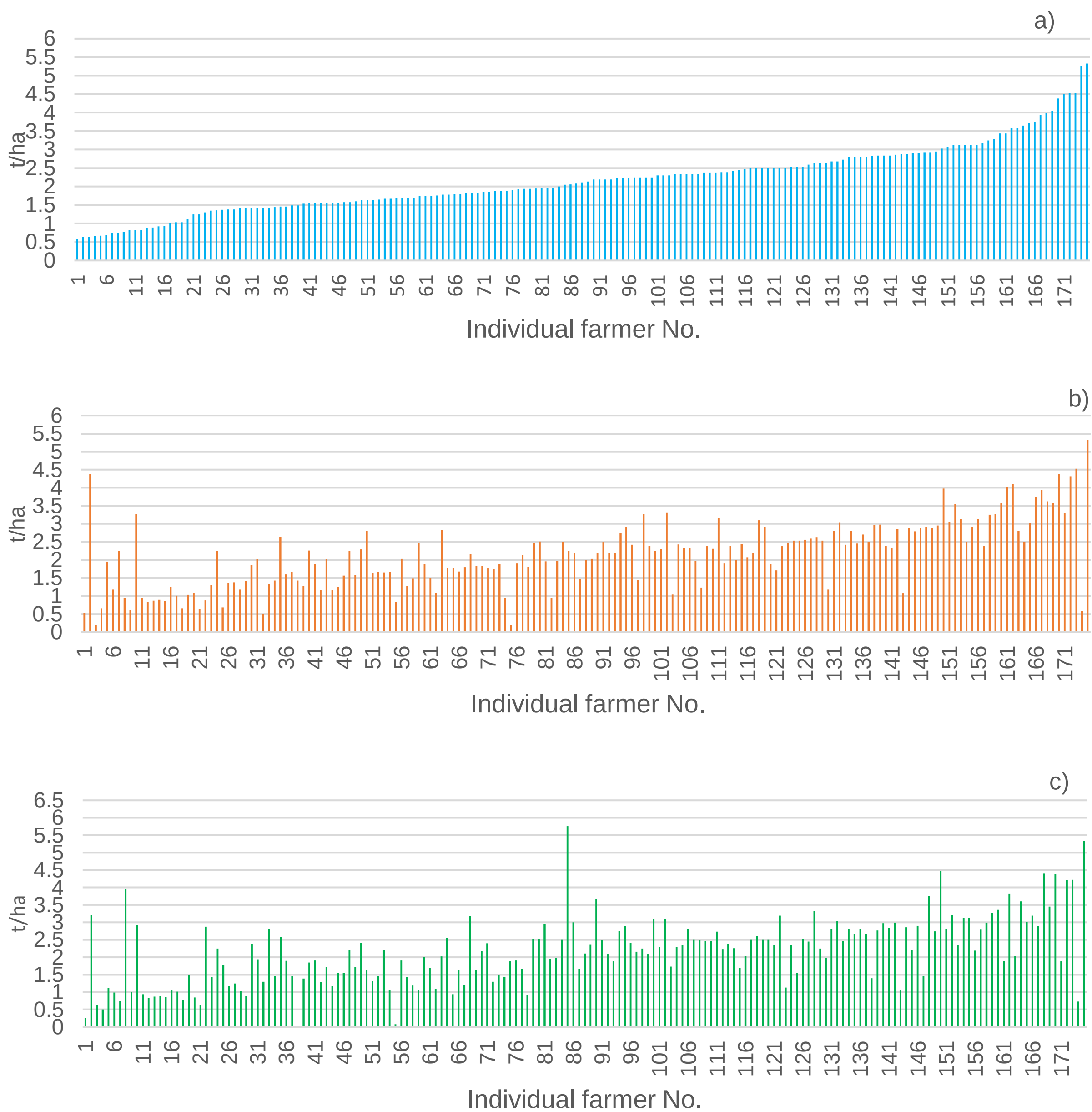
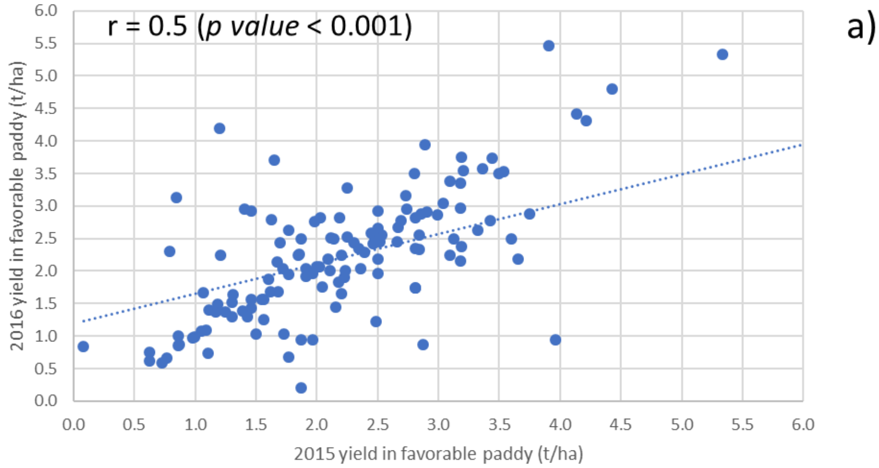
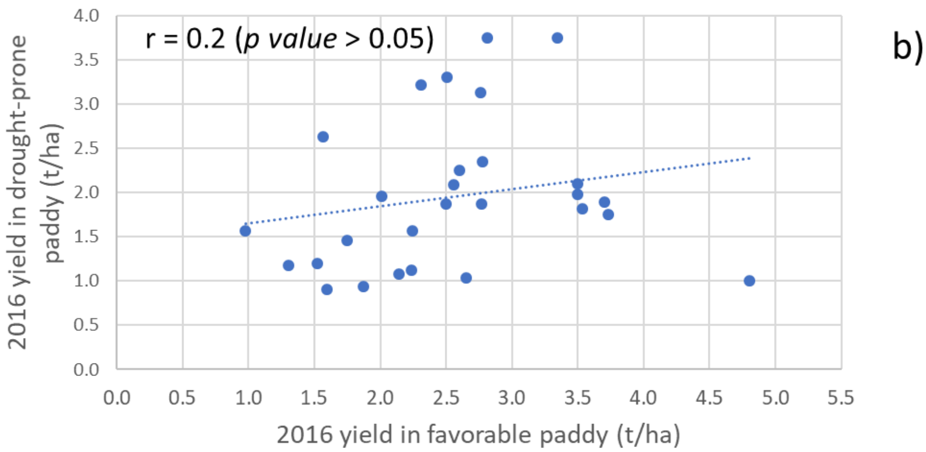


Figure 4.3 Rank of yield performance among surveyed farmers in the community (N = 175); the value in x indicated the rank of yield arranged based on the average farm-level yield farmer usually gain. A number of farmers was fixed

through all bar graph from a- c). a) rank of yield performance based on average farm yield level, b) 2015 yield, c) 2016 yield





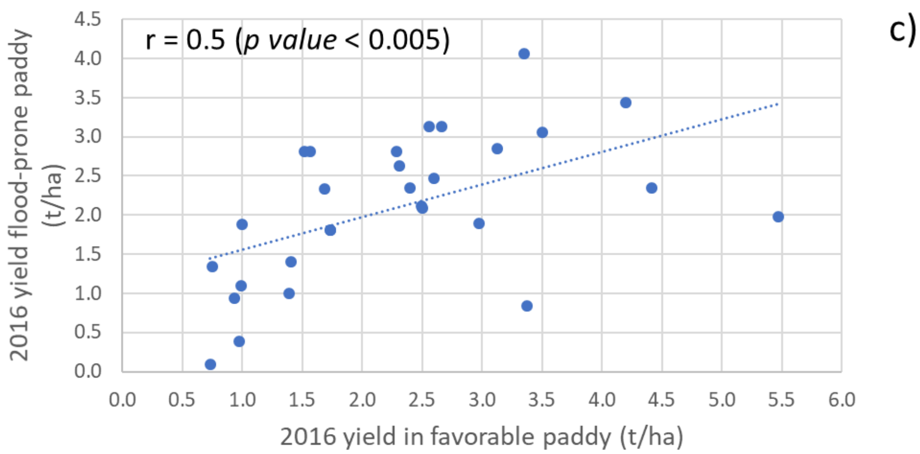


Figure 4.4 Scatter plot showed correlations of a) 2016 and 2015 yield from favorable paddy, b) 2016 and 2015 drought-prone area yield, c) 2016 and 2015 flood-prone area.

4.3.3. Status of farmers' perception and response in technology to cope with climate change

All the sites had experienced yield loss due to the past extreme climate incidents with BB site highest value of 63% (±26%) (data not shown). Farmers considered yield loss was at light, moderate, and severe level at about 25%, 35%, and 60% respectively (data not shown) which was similar in all sites. The type and level of yield loss due to extreme climatic incidents varied by site corresponding with the site field type; i.e., drought only in BB (data not shown). Yield loss was negatively correlated with percentage of favorable area significantly at p *value* < 0.001.

Participants perceived severer and more unexpected climate variability than non-participants, but both groups had high perception (Table 4.9). Both groups had mostly recognized the negative effects of climate variability on rice farming; they explained several examples such as unexpected starting of rain and difficulty to predict and plan to start planting. About 50-60% of the farmers thought to deal with the effects of climate variability, only 50-60% of them (approximately 30%) actually took some actions and only 18% of them said they succeeded, which did not differ between participants and non-participants. Only 4 farmers were found to be proactive to cope with climate change as they took coping action by changing varieties, making water source by digging a pond or start pumping water. It was found that those who thought to deal with effects of climate variability had higher relationship score with the researcher ($P = 0.045$) and tended to have additional water source apart from rain ($P = 0.02$). No relation was found between this thinking and the level of market-orientation. More than 90% of farmers in both groups were mostly unfamiliar with scientific knowledge on climate change. Those few farmers who understood science of climate change had a high relationship with the researcher ($P = 0.015$), but no relation with school education years.

Less participants (16%) burned rice straw compared with non-participants (30%) (Table 4.9). More than 90% of farmers in both groups knew that field burning practice polluted air, but this does not mean that they understood that burning produces greenhouse gas in the atmosphere causing long-term temperature rises which may affect climate conditions. The most popular reason why farmers burnt was a convenience in land preparing for new crop season despite the fact a number of farmers had time and labors to prepare land without burning. Burning farmers said they would stop burning behavior if there had alternative methods that were convenient for land preparation of new crop season (data not shown). For those who did not burn, 70% of them gave a reason that burning affected environment degradation while only 6% concerned about greenhouse gas and global climate change.

Table 4.9 Climatic exposure experience, perceptions about climate, technology needed most for rice farming, rice straw burning between participant and non-participants.

	Participant (N = 74)	Non-Participant (N = 88)	p value
Highest yield loss from incident (%)	43.12% (N = 72)	43.50%	0.943
Perceived that climate variability has been more severe and unexpected (% of farmer)	100% (N = 73)	94.3%	0.039
Perceived that climate variability affected rice farming	87.0%(N = 69)	87.3% (N = 79)	0.944
Thought to deal with effects from climate variability (% of farmer)	64.4%(N = 73)	55.7%	0.263
Did any actions to deal with effects from climate variability (% of farmer)	61.7% (N= 47)	50% (N = 47)	0.534
Knowledge about climate change (scientific meaning or heard from scientist)	9.6% (N = 52)	2.8% (N = 72)	0.104
Do the straw burning (% of farmer)	16.2%	30.7%	0.032
Give a reason why not burn that	(N = 62)	(N = 60)	0.625
burning increases gas and its impact to global climate change	6.5%	6.7%	
burning destroys organism and soil quality	45.2%	58.3%	
burning produces smoke and pollution to environment	24.2%	15.0%	

When asking about the climate change coping technologies (e.g. drought-resistance, flood resistance, drill seeder) tested in the project, it was found that many farmers were not satisfied with the technology despite they were interested. Thirty-six percent of farmers who participated in the project activities gave a reason that variety technologies (i.e. drought tolerance, flood tolerance) was not matched with their farm or socio-economic conditions or personal preference. However, 45% of farmers were interested but they have not got the materials.

In case of drill seeder technology, 45% of participant farmers had not a chance to make trial on it. The comparative time using for each planting method calculated from NP site has shown in Table (4.10). Time used in growing rice by each planting method was estimated by total hours spent per hectare in case one farmer working alone. Farmers spent 106 hours/ha for TP while only 5 and 7 hours/ha respectively for BC and drill seeder. BC and drill seeder could save time around 20 and 15 times shorter in compare to TP. Drill seeder saved more seed more than BC around 20 kg/ha by showing only around 50 kg/ha. Moderate positive correlation between yield and BC seed rate were found at r=0.328.

Table 4.10 Hours used and seed rate use in recent years in NP site categorized by type of planting method; TP, DR, Drill seeder.
*Significant difference *p-value* < 0.001 by ANOVA with multiple comparisons by Games-Howell
** Significant difference *p-value* < 0.05 by T-test
*** Incomplete data; N = 20
**** N =12

Planting Method	N	Time use (Hours/ha) *	Seed rate (kg/ha) **	N	Comparative time used (Hours/ha) within a group of farmers who planted all 3 planting methods*
TP	20	106a		11	95a
BC	23	5b***	75.54a	11	5b
Drill seeder	18	6b****	54.56b	11	7b

Analysis further clarified what kind of farmers tested the technology; drought or flood tolerant varieties or drill seeder which could be promising technologies to cope with climate change (Table 4.11). Results showed that there was no difference in farming characteristics and managements among farmers (data not shown) except in organic input. However, it was found that social (e.g. position in village) or personal background (i.e. activeness in learning) was associated with the test of the technology. Also, those who had less yield reduction from extreme climatic incidents did test the technology. When farmers were asked about kind of technologies they needed, about 50% of farmers responded that they wanted high yielding varieties for wet season with good taste and with high market value (data not shown). Surprisingly, 11% of farmers responded that they do not need any technology because they were fine with the present farming condition (data not shown).

Table 4.11 Characteristics between a farmer who tested the technology brought by the project and those who did not.

	Tested (N = 25)	Not test (N = 156)	p value
Market orientation			
Total sale rice (%)	46% (N=24)	39%(N=155)	0.339
Agronomic techniques			
Organic fertilizer input (kg/ha)	1,417	276	0.001
Burning straw	4%	24.2%	0.022
Personal characteristics			
Active in learning in general	1.46	1.76	0.045
Active in learning in rice issue	1.27	1.68	0.003
Social background			
Age	55	58	0.129
Rice farming experience	40	44	0.149
Education years	6	7	0.244
Having position in village (village head, group committee)	40%	21%	0.038
Being member of rice related groups in village	68%	45%	0.032
Like to talk and work with persons in other jobs	92%	74%	0.046
Relationship with researcher	4.5	2.6	0.027
Climate related experience			
Highest yield loss from extreme climatic incidents (% of yield reduction)	11%	45%	0.001

4.4. Discussion

4.4.1. Characteristics of farmer participating to research project

The analysis results showed participants were those local group member and had better economic status, but their farming management input was not different with non-participants. Results is consistent with the previous finding in chapter 3 that participants were a slightly better-off farmer than non-participants. However, there were no different yield and farming characteristics between two groups of farmers. The results showed the more ratio of market-oriented farmer contained in participants group was the reason explain while their yield was slightly higher. However, participants showed more stable yield compared with non-participants. There reason that can explain why the participants could gain more stable yield. First, they had goal to improve their farm via interacting with researcher, attending the local group which is a source of information and the opportunity to develop their farm. However, the yield level of participants did not differ from that of non-participants. This is because household yield level was determined by bio-physiological and socio-economic factors as mentioned in 4.4.2.

4.4.2. Factors determining yield variation among farmers

Yield variation among household in Northeast Thailand has been mainly determined by water environment of rainfed ecosystem and farming input management associate with market-orientation. For example, HP site where flood often occurred had higher yield due to more available water, as was reported higher yield in lower toposequential fields (Kamoshita et al., 2009). Market-oriented farmers inputted more resources such as inorganic and organic fertilizers, herbicide and pesticide. The N fertilizer application rate for the market-oriented farmers was approximately 50 kg/ha, which is similar to the recommendation rate by the government (Pongsrihadulchai, 2013), and it could lead to slightly better yield compared with subsistence farmers. Haefele et al. (2006) reported that N alone at 50 kg/ha could increase the yield of KDML105 by 0.61 t/ha while inputting farm yard manure with NPK could enhance yield by up to 1.05 t/ha.

Subsistence farmers were part-time farmers, and hence they tended to be satisfied with enough rice production for family members from reasonable labor input, and they had less incentive to make efforts for higher yield. Watanabe (2017) argued low rice yield should not necessarily be considered as negative as long as the subsistence farmers produced sufficient rice amount to feed their family. On the other hand, market-oriented farmers had higher incentive to improve rice yield for more profitable rice production in Thailand (Ebers et al., 2017) and elsewhere (Piya et al., 2012).

A better water environment availability enabled farmer to do additional dry season crop. This survey found 10% of surveyed farmers usually do additional dry season production (whether do every year or some years) despite northeast region has been recognized as the rainfed environment (Fukai & Ouk, 2012). The results were consistent with national statistics that only

4% of wet season rice growing area was conducted dry season cropping (calculated from OAE (2018c, 2018d)) despite 9% are under the irrigated system (OAE, 2018d, 2018c). The survey could record only 5 farmers who did an additional dry season in 2016 which a range of dry season production from less than 1 t to 3 t. All of these farmers were all in HP site; a water-rich site supported the assumption that market-oriented farmers would do dry season if they had sufficient water source along the season. Varieties grown in dry season were found to be photoperiod insensitive with a higher yield than the wet season such as CNT and farmer averagely gained yield around 3.5 t/ha. Despite these farmers had the choice to grow high yielding varieties in wet season, they prefer to grow RD6 or KDML105 that giving lower yield but has a favorable taste as well as its market value. Higher inorganic rate used by those who did additional dry season cropping indicated their field had better water environment status because the effect of inorganic fertilizer decreased in less water status field (Haefele et al., 2006).

4.4.3. Farmers' perception and technology response towards climate change

Northeast Thailand farmers perceived the adverse effect of change in climate to their rice production and farming, however they were not aware for long-term adaptation. This is because they lack well-understanding in climate change knowledge which is complicated issue. The reason why farmer refrained from burning residue was due to their concern in quality of soil or farm environment rather than their awareness in climate mitigation. The climate mitigation seemed to be farm from their livelihood to be concerned.

Small numbers of farmers tested the technology provided by the project, and their characters were 1) leadership positions in their villages, 2) membership in their local groups, 3) higher relationship with researchers, 4) fellowship with other people in conversation and in work. Such social and personal characters should be important to increase chances of farmers to test the technologies in the participatory project, and researchers and extension officers had better formulate environments in which farmers can freely and openly approach to them. Attendance at on-farm demonstration or training increased adoption of rice technologies (Mariano et al., 2012; Supaporn et al., 2013). Again, subsistence farmers may have less incentive for testing new technologies to cope with climate variability unless they face the critical shortage of rice for home. New technologies that might make rice production more resilient to climate change would be better appreciated by market-oriented farmers, as they were more ready to learn and collaborate with researchers.

Chapter 5

A case study of farmer field school (FFS) for improvement of rice production under climate change in Nan province, North Thailand

5.1. Introduction

Farmer field school (FFS) started from late 1980s in various Asian countries as a countermeasure of pest outbreak (e.g., brown plant hopper) (van den Berg & Jiggins, 2007). The positive impacts of FFS on integrated pest management (IPM) have become recognized in numbers of studies (Braun et al., 2006; G. Feder et al., 2008; Gershon Feder et al., 2004a; Huan et al., 1999; Tripp et al., 2005). Farmers participating in the FFS developed skills of analytical thinking and obtained sufficient knowledge to manage their farms efficiently (Pontius et al., 2002). FFS graduates have become to manage pest properly including the suitable use of pesticides (Pontius et al., 2002; van den Berg & Jiggins, 2007).

The global rice production is at risk from climate change, especially in rainfed rice ecosystem which is prone to drought and/or flood. While governments and researchers have worked to improve rice production to cope with climate change, individual farmers' ability for suitable decision makings must be important as well. Coping climate change can become a topic of FFS. Just as FFS on IPM has contributed to a better pest management at the local scale, the new FFS on climate change may prove its effectiveness in local adaptation and mitigation in rice farming.

When using the FFS approach, a degree of improvement of the participating farmers in the school would be the first important point. Secondly, a degree of knowledge dissemination from the participating farmers to the other farmers in the local communities would be important as well(Gershon Feder et al., 2004a), since only limited numbers of farmers could attend FFS programs due to limited investment on FFS (e.g., cost and time of researchers or extension officers) . Assessment of the possibility of the FFS approach is needed for the improvement of rainfed rice production to cope with climate change.

If the participating farmers in FFS have good farming skills and a sense of accountability for their local communities, knowledge and technology dissemination to the whole local community would be more successful. On the other hand, if the participating farmers do not have such excellent skills and senses for the community, the output of FFS may be limited to the participating farmer themselves (Rola et al., 2002). Selection of better qualified farmers would be important for the success of FFS, which project organizers should be aware of. There were a few reports about characteristics of farmers participating in FFS. (Tripp et al., 2005) reported that any farmers could participate in the FFS in Sri Lanka as long as the seat is available. While in Indonesia, (Gershon Feder et al., 2004a) reported selection by literacy. These studies worked on integrated pest management (IPM) but no studies have characterized farmers participating in FFS of rice production improvement to cope with climate risks.

In Thailand, the government sector has worked for the improvement of rice production (BRRD, 2012; RD, 2013b) (RD, 2013a) not only in yield, cost, and farming practices but also in adaptation to and mitigation of climate change. Thai Government (RD, Agricultural Land Reform Office [ALRO], DOAE) has recently collaborated with universities and NGOs in a project "Building partnership among farmer groups, non-government and government sectors in research and extension system for sustainable food security and livelihood". The goal was to develop resilient farming communities capable to manage agricultural biodiversity for food security, climate change adaptation, and sustainable livelihoods. The project was implemented in 9 provinces in the northern region and in 8 provinces in the northeastern region of Thailand by using FFS approach in part toward 75 targeted groups of farmers.

The study aimed to assess the possibility of FFS as an approach to improve rainfed rice production in Thailand under the challenges of climate change. The study emphasized to clarify 1) FFS participating farmer's socio-economic and farming characteristics, and 2) the extent of knowledge dissemination occurred in the community. It was hypothesized that FFS participating farmers are well equipped with social, economic, technical background with positive community-orient characteristics and do effort for knowledge dissemination. Thus, the knowledge and the technologies learned from FFS would reach the whole farmers' community.

5.2. Method

5.2.1. Study Site

The FFS program was conducted in the farmer participatory project carried out during 2012-2014 across northern and northeastern regions of Thailand, named “Building partnership among farmer groups, non-government and government sectors in research and extension system for sustainable food security and livelihood”. The goal was to develop resilient farming communities which capable to manage agricultural biodiversity for food security, climate change adaptation, and sustainable livelihoods. The program aimed to enhance the capacity of farmers and collaboration between farmers and sectors as a partnership towards the food security issue. FFS program had 4 times of training activity for 3 consecutive days per meeting during wet season cropping, which was called as training of farmer trainer (TOFT). The program was designed to train the representatives from farmer group via FFS learning process through four times meeting. The schedule and topics, in brief, were shown in Table 5.1. The lecture done by researcher and extension officers, workshop and discussion classes, and plot experiment practice was conducted during meetings. Three farmer representatives from each group from all sites attended the meeting's activities while exchanged their information among groups via school platform. After the meeting, they returned to their groups and shared the knowledge they learned from FFS to non-FFS farmers in the community as a rule of the group.

Table 5.1 Brief contents of the meeting in the FFS program

Learning topics	Time schedule	Major contents	Supplement contents
1st Meeting	Nursery (July)	Rice variety evaluation	FFS concept, farmer adaptation towards climate change
2nd Meeting	Planting (August)	Rice crossing	Pest management
3rd Meeting	Tiilering or panicle initiation (September)	Yield improvement and organic standard	-Yield increase -Rice traits and local environment adaptation -Seed production
4th Meeting	Harvest (December)	Organic farming, Organic standard	Local rice variety conservation

A preliminary survey for the FFS program had been conducted in July 2014 by visiting 2 school sites in North (Nan province) and Northeast Thailand (Yasothon province). The activities of training such as lecture and practice class were observed for 3 consecutive days (15-17 July 2014) at the first meeting of the program. FFS organizers, facilitators, and participating farmers (6 farmers) were interviewed for household farming characteristics and how they came to attend the FFS farmers were collected during the observation. Finally, with the assistance of the organizers, FFS in Nan province where one-third of the project's FFS groups conducted was selected an as a study site. Nan could be a good representative site for the study.

5.2.2. Target population and sampling

Active FFS farmers who regularly attended the program was a target population. Twelve farmers were carefully selected from the 3 groups with the assistance from FFS organizer.

5.2.3. Data collection

Structured interview with closed and open questions was conducted for collecting 4 aspects of information based on the interview guide:

1. Entry process of FFS-participating farmers
2. Basic background of FFS-participating farmers
3. Technical and farming characteristics of FFS-participating farmers
4. Knowledge dissemination to community

Farmers were asked about their average yield, the highest yield (attainable yield), and lowest yield they ever gained. The process of how they do the farming was confirmed step by step since land preparation till milling. The knowledge and confidence in transferring knowledge to other farmers learned from FFS were checked based on the Table S9. FFS participating farmers were asked whether they have shared knowledge to others or not, how many persons you communicated to transfer the knowledge, and to what extent those who received information from you change their practice following to your instruction. Dissemination action of FFS farmers was evaluated based on the numbers of people they have already communicated the knowledge of each topic by the time of interview (2016). The feedback in the extent of the change in the practice of those disseminated farmers was confirmed by the interviewed FFS participating farmers (Table S.10). Only the non-participating farmer who belongs to group member can be clearly detected while this assessment cannot reach to out-group farmers change as it cannot be confirmed by the interviewed FFS farmers. Detection of change in the group-members' practice via FFS participating farmers was reliable because the group had a strong rule and system that members need to follow.

5.2.4. Data analysis

Descriptive statistics were used in the study and calculated by MS Excel software.

5.3. Results

5.3.1. The entry process of the FFS program

FFS participating farmers were leaders of groups such as committee members or representative farmers since there was a strong intention from groups. The self-evaluation of the reasons for their selection was a strong personal intention to learn (58%), the group acknowledged characteristics and qualification (25%) or their group positions (17%) in Fig 5.1. The FFS participating farmer were same farmers as the representative farmers in the other local group activities in some cases, while in other cases, FFS participating farmers were newly assigned as independent from the existing representatives of their groups.

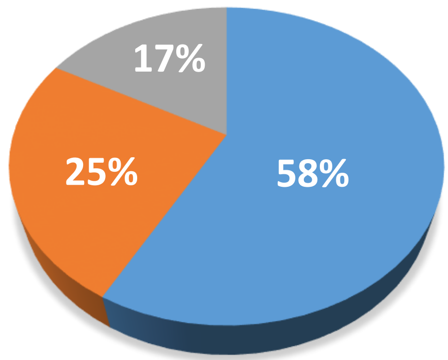


Figure 5.1 Self-evaluation of reasons to be selected to FFS.

5.3.2. Socio-economic background and farming characteristics of FFS participating farmers

FFS farmers contained 2 groups of education level. Participating farmers with primary school level were selected from ordinary farmers while those with high school or college levels were those in key governance positions in their communities (Table 5.2). Eight % of FFS participating farmer had no positions or committee membership at their villages while 33 % and 59 % of them were committee members and chief for governance, respectively. Some of them engaged more than one group. Thirty-three % of them could recognize the status of the researchers and contact with researchers or extension officers apart from the FFS program. All of them had a will to make a contribution to the community. Source of main income varied among FFS participating farmers as well as their annual income.

FFS participating farmers grew rice averagely at 0.8 ha under irrigated ecosystem as they had a source of water from river or irrigation. They produced rice around 3.5 t and kept for home 1.4 t. They were market-oriented farmers and of them also sold seed. Rice yield variability among participating farmers was found but normally they gained around 4 t (median) with the maximum they could reach was 4.3 t and minimum were 3.1 t. All of them applied organic fertilizer but with different level and diverse methods such as animal feces or green manure which difficult to determine the amount in value. Only fifty percent of them applied inorganic fertilizer which consistent with the data about their organic farming status. They concerned the environment and most of them had targets to develop farm to become organic.

For the farming process, most farmers conducted in a similar way. They hired 4-wheel tractors for ploughing during land preparation. They grew rice by TP method with their household labors and most of them exchanging labor with neighbors which could gather approximately 17 persons. Only 17% of them hired labor in addition for planning and fertilization process. Fifty percent of farmers used tractors for threshing process. Some of farmers dried harvested rice on their field. They used milling machine inside village.

Table 5.2 Characteristics of FFS participating farmer in social, economic, farming characteristics and practice (N = 12).

Characteristics	Mean (Median) / %*
Social aspects	
Age	59
Education	
Primary school (< 6 years)	42%
Secondary school (6 -9 years)	8%
High school or college (> 9 years)	50%
Positions at village	
Chief for governance (e.g., village chief)	59%
Group committee member	33%
None	8%
Numbers of engaged groups in villages (group)	1.42 (1-3 groups)
Numbers of labor gathering when exchanging labor with neighbor for rice production process (persons)	17 (10)
Number of farmers contacting researchers or extension officers apart from FFS (%)	33%
Knowing difference between researcher and extension officer (%)	33%
Number of farmers who want to contribute to community (%)	100%
Economic aspects	
Main income source (% of farmers)	
Rice	33%
Other crops	25%
Non-agriculture	42%
Rough total income	
< 100,000 (baht/year)	50%
≥ 100,000 (baht/year)	50%

Table 5.2 (continue)

Characteristics	Mean (Median) / %*
Farming characteristics and techniques	
Total agricultural area (ha)	2.66 (1.84)
Water resource for rice production	River or irrigation
Rice growing area (ha)	0.82 (0.66)
Total rice production (kg/year)	3,565
Home consumption amount of rice (kg/year)	1,437
Sale rice in paddy form (kg/year)	1,397 (620)
Seed for sale (kg/year)	199 (50)
Rice sale (%)	45% (39%)
Seed for next season (kg/year)	63 (40)
Yield	
Attainable yield (t/ha)	5.22 (4.36)
Yield usually gained (t/ha)	4.68 (4.07)
Lowest rice yield (t/ha)	3.66 (3.10)
Inorganic fertilizer use (% of farmers)	50% with low input (about 40 kg N/ha)
Organic fertilizer use (% of farmers)	100% Techniques differed by individual (ranged from 104.5 -5,667 t/ha)
Synthetic pesticide/herbicide use (% of farmers)	8%
Seed source from self-collection (% of farmers)	83%
Numbers of rice varieties	3.4 (3)
Sense of environmental conservation (% of farmers)	100%
Sense of value adding (% of farmers)	92%
Certificate system such as GAP (% of farmers)	75%
Organic farming status (% of farmers)	
Organic	25%
Transition	58%
None	17%
Target of farm development	
Organic farming	50%
Productivity enhancement (Increase productivity, integrated farming, etc.)	42%
Improving seed quality	8%

*Median showed only for the scale parameter data that is not normally distributed. % showed for the proportion of each category.

5.3.3. Knowledge and practices of FFS participating farmers after attending school and their dissemination

FFS participating farmers reported that they have changed the way of farming practice after participating in the FFS program. The examples of changes were 1) introduction of organic farming methods or minimum use of chemical input, 2) removal of contaminating varietal plants in seed production. The positive impact of such changes was 1) yield increase, 2) better soil status, 3) having the knowledge to implement on their farm. When checking the knowledge of farmers by each learning topics, it was found that not all farmers had confidence for the knowledge and skill to teach to others in some topics (Table 5.3). The topic that the farmer felt less confident about was the climate change. All of FFS Participating farmers did transfer knowledge to others (Table 5.3).

Table 5.3 List of the subjects FFS participating farmers had studied in a school meeting, their evaluation about the interestingness of topics for a general farmer in common, numbers of farmers they disseminated the knowledge, and numbers of group members who followed their instruction.

List of the study topic	Ability (level of knowledge and skill) to teach other			Is the topic interested by other farmers in general (Farmer's personal assessment)					Transfer the knowledge to the non-participating farmer (Numbers of farmers)		Numbers of a group member who followed the practice		
	Able	Somewhat	Unable	Yes	Maybe	Maybe not	No	Not sure	Within groups	Out-group	Fully action	Some action	Not at all
Seed production	75%	25%	0%	17%	42%	8%	25%	8%	19*	29*	78%	12%	9%
Organic farming	75%	25%	0%	9%*	45%*	9%*	27*%	9%*	18	22*	55%	24%	18%
Genetic conservation	50%	50%	0%	0%*	46%*	9%*	36%*	9%*	18*	18*	42%*	18%*	38%*
Varietal Evaluation	50%	50%	0%	27%*	27%*	9%*	36%*	0%*	21*	15*	77%*	9%*	13%
Climate change	36%*	45%*	18%*	20%	60%	0%	0%	20%	27*	27*	92%		
Pest	50%	42%	8%	55%*	18%*	0%*	0%*	27%*	23*	24*	81%*	11%*	5%*

*N less than 12 because of missing data, or some data collected is difficult to extract and interpret.
**Grey label shown data unable to calculate because farmers did not know the actions of the remaining farmer who they did transfer the knowledge.

5.4. Discussion

5.4.1. Characterization of FFS farmers

The common characteristics found among the FFS participating farmers were a sense of accountability to the community, high yield, and orientation to organic farming. The characteristics of participating farmers, in general, seem not greatly different with others in the community since they were small-scale farmers (<1ha) with common farming practices and a reasonable proportion of rice sale (3 t) (Table 5.2). Characteristics in concerning of the environmental conservation and marketing (Table 5.2) likely to be received from the FFS attending as the FFS program curriculum contained it (Table 5.1). Unfortunately, the survey did not cover the information on the organic status of non- participating farmer to compare. Thus, the difference between them has not been clear.

The selection process can also explain the characteristics of FFS farmers such shown from a will to make a contribution to the community together with a higher education. This is because those who attended the FFS program in the study area were well selected from the group based on the expectation that they could come back to transfer technology(Gershon Feder et al., 2004a). Their qualifications such as a sense of accountability to the community, education level, literacy, etc. (Table 5.2) were screened (Feder et al., 2004a) compatible with the learning topic such as climate change topic where high literacy and education is required. Results showed only 36% of them had confidence in their knowledge and skill about climate change as disseminator suggested high school level education might not sufficient (Table 5.2). The project organizer might need to consider more how to facilitate learning when dealing with such a complicated topic. The characteristics in which associated with the selection process might not be observed in all cases but only in some program such as the previous nation-wide IPM-FFS program in Indonesia or Vietnam (Table 5.4). While in several countries, the common characteristics might not be found because they came from the voluntary self-selection.

The yield of FFS participating farmer was slightly higher than average of Nan province which showed at 3.23 t/ha (OAE, 2018e) despite more than 50% of surveyed farmers were not market-oriented (sale rice less than 50%) and their main income was from other sources higher yield of a participating farmer in the study could be from the positive impact of school as all farmers reported they changed their practice of farming after attending. Characteristics in higher yield although is only consistent with FFS Indonesia case (Table 5.4), for the IPM-FFS case, this higher yield characteristics were not related to the positive impact from the FFS attending (Feder et al., 2004). Several studies from Table 5.3 showed that yield level of FFS participating farmer was the same as the other farmers in the community. Moreover, most of the IPM-FFS reports on positive yield impact was not international published papers (van den Berg & Jiggins, 2007). Thus, for IPM-FFS, participating farmer farmers might not superior in yield productivity. However, for the present project where agronomic management such as seed production and breeding activities had been done, the superior yield performance of FFS could be confirmed.

Table 5.4 List of the studies on farmer field school (FFS) for rice production improvement in Asian countries where comparison information about participating farmer vs non-participating farmer characteristics was described.

Published studies in international journal	Information of studied FFS Country name Scale of implementation : Numbers of FFS (Year)	Studied/ surveyed area or scope	Selection of farmers	Characteristics of FFs participating farmer in compare to non-FFS				Topics in FFS	Farmer-to-farmer Dissemination
				Socio-economic characteristics		Farming characteristics		IPM	
				Education	Economic status	Rice area	yield		
(Gershon Feder et al., 2004a)	Indonesia Nation-wide: 48,000** (1989~)**	Javanese households	Selected by village officer and farmer group leaders	Higher	More affluent, more farming asset	-	Higher	IPM	Knowledge not diffused (Gershon Feder et al., 2004b)
(Rola et al., 2002)	Philippines Nation-wide: 14,000** (1993~)**	Leganes, Santa Barbara and Zarraga, and Ilolio	Self-selected (Voluntary with encouragement from officer)	Similar (but difference in gender as more women attended)	More proportion of farmers with other sources of income, less full-time farmers	-	-	IPM	69% of FFS farmer communicated to the others but no impact in their change of practice appeared
(Rejesus et al., 2012)	Vietnam Nation-wide: 15,356 (1992~2006)	Mekong delta	Selected based on criteria: leadership role, wealth, level of education/skills, willingness to attend	higher	Less non-farm income, rice-rice-rice cropping pattern farmer	Slightly less	Similar	IPM	-
(Huan et al., 1999)			-	-	-	Slightly lower	Slightly lower		-
(Tripp et al., 2005)	Sri Lanka Nation-wide: 600 (1995-2002)	Southern province	Self-selected	Similar	less farm labor job	Higher (p value <0.1)	Similar	IPM	Communicated but not reach to others
(Praneetvatakul et al., 2007)	Thailand Nation-wide: 810 (1999-2006)	Angthong, Chainat, Kampaengpetch, Udon Thani and Kalasin provinces	Self-selected (Voluntary)	-	-	-	Similar	IPM	-
This study	Thailand North and northeast region: 75 FFS (2012-2014)		Selected by group	Broad background (low-high)	Broad background (low-high)	Similar*	Higher	Refer Table 5.2	Communicated with members and non-member. Action feedback found

#All studies showed a positive impact on knowledge of FFS or relevant positive actions towards farming practice such as reducing pesticide input, etc. The only report of Thailand showed project publication studies as no studies from published international journal was found.
- Data or information is not available or unclear
*compare to an average farmer from national statistics record.
**Referred from Braun et al., 2006; value including other crops

5.4.2. Dissemination from FFS participating farmer to other farmers

In this study, the dissemination of the technology from FFS to the community was detected based on the information confirmed in the interview. FFS participating farmers disseminated the knowledge they learned to the community to non-participating farmer both within their group and other farmers outside the group. The information can be reliable because all group members need to work together and follow the group system and regulation. The FFS group activities also were monitored by the FFS facilitators from the project. The results confirmed that knowledge was reached to the members efficiently in general as the group members followed the instruction and took actions what they told. However, this is not always in some topics. Some FFS participating farmers even could disseminate to other persons beyond group member because they had a governing position or village role that enable them to share information with villagers. Unfortunately, FFS participating farmers could not elaborate on the out-group members due to their limitation in observing (i.e. live in another village). Unfortunately, this study could not provide more descriptive information about how they followed but reporting what FFS participating farmer assessed instead.

This study confirmed that farmer-to-farmer extension had occurred and succeeded at some level since FFS participating farmers could convince farmers to change the farming practice. In contrast, reviews and several studies usually revealed no success in farmer-to-farmer extension appeared from FFS (Tripp et al., 2005; van den Berg & Jiggins, 2007) as shown in Table 5.3. This difference in success of farmer-to-farmer dissemination can be explained. First, the present project carefully did select the participating farmer who could surely disseminate the knowledge to communities and trained them to become farmer trainers. While in other studies, the quality of selection based on this criteria were not confirmed. Rola et al. (2002) reported that the inappropriate selection of participating farmer such as the overrepresentation of women affected the dissemination success of FFS in the Philippines. Authors point out that woman was not a farm decision maker in general nor treated as an important source of farming information. Thus, dissemination impact could not be detected. Second, the knowledge learnt from FFS associated with the decision-making process and ecosystem on IPM topics is not easily to transfer by informal communication(Gershon Feder et al., 2004b). However, the present FFS had contained agronomic topics which some can be easily to be understood such as organic farming. This came together with the point that the local group who joined FFS had regulation which non-participants need to follow practices of participants after they returned to their community.

In conclusion, based on the qualified participating farmer and their success in dissemination, this study approved the possibility of FFS as an extension approach to improve rainfed rice production to cope with climate change. Future FFS project organizer should survey the farmers' characteristics data of the target area before arranging activities to see the possible extent of the approach. Planning FFS based on the training of farmer (TOFT) purpose which participating farmers were qualified as representatives for the farmer-to-farmer dissemination such found in this FFS is recommended. It could guarantee that participating farmer would have sufficient ability to disseminate knowledge as well as shape the selection process to screen the qualified participating farmer.

Chapter 6

General Discussion

6.1. Characterization of FPR and FFS participants

Participants equipped with social skill, learning activeness, leadership, and close relationship with researcher (Table 3.2-3, Table 4.4). They also tended to have higher and more stable yield, but the degrees of their superior performance to the other non-participants were small (Table 3., Table 4.). They did not understand climate adaptation and mitigation in practice. The characteristics in leadership and social skill can be understood as the pattern of participatory approach. Usually, the village chiefs were included at the starting stage of the approach due to their power to organize project activities and calling other farmers in the area (Paris et al., 2011b).

The degrees of success in yield improvement and climate change adaptation of farmers in the study area were related with the capacity of participants to attain high yield and to understand importance of adaptation and mitigation to climate change. They were similar to other non-participants farmers in the area in agronomic performance, etc. To enhance the efficiency of participatory approach, elite farmers who have potential in farming and equipped with social skill should be more included in the participants. This elite farmer could be a good collaborator for the research project. They quickly received the new technologies transferred during project activities and could perform to other farmers in community.

6.2. Elaborating farm level yield variation for yield enhancement

One point that makes rice production in Thailand unique and different from another country in terms of development is that the major production area: which is rainfed ecosystem, of the country has never been replaced by the modern varieties. The improved varieties; RD6, KDML105, and RD15 (more recent released variety) have a preferable taste for the farmer for both consumption and market-value. Obviously, the varieties' yield performance cannot compare to the modern varieties or hybrid (Chapter 2). However, the study revealed that the yield of RD6 and KDML105 can be more than 3.5-4.0 t/ha if grown by farmers who are market-oriented (chapter 3-4). Also, several studies reported high yield can be gained from these varieties (Boling et al., 2011; Naklang et al., 1996). (Kamoshita et al., 2009) report yield from field monitoring could reach 4.6 t/ha for the low toposequence field. Random crop cutting and the participatory project (RD, 2013b) also showed a maximum yield of rice from farmers' field in many sites such as HP and NK to be at 3.59 and 4.11 t/ha respectively. Therefore, the yield potential of this group of varieties might not be the problem at present as its yield potential is moderately high. Thus, if these varieties are grown under the favorable condition or grown by market-oriented farmers it is possible to gain a good yield level.

Fulltime (market-oriented) or part-time rice farmer is not discrete because the range of rice sale level is broad from 0% to 100%. The choice of whether farmers will be a fulltime or not might be associated with the farming water environment condition. If the farm is equipped with more water supply, thus doing rice farming could give them a fruitful outcome then they may want to do rice farming as fulltime and the main job. But if the water supply system is not secured, they need to find other alternative crops or non-agricultural jobs for their survival. Enhanced water supply system could facilitate farmers to become fulltime (or more market-oriented) resulting in a better average yield of community.

The current yield gap for the rainfed ecosystem in Northeast Thailand is approximately 1.8 t/ha which similar to the random crop cut reported by the project (RD, 2013b). Broad yield gap of the region (Chapter 3 and 4) occurred because rice communities contain both subsistence farmer and market-oriented farmer. The market-oriented farmer who has incentives to improve their farming is always active to learn more about technologies and manage farm more efficiently resulting in higher yield (Ebers et al., 2017). In contrast, substantial subsistence farmers who are all around the region produce rice to meet their home consumption (Watanabe, 2017) mind about production amount rather than yield efficiency. They are satisfied as long as the total amount of rice is enough for family consumption, even if rice is grown in unfavorable environment condition such as poor soil quality (Saisema & Pagdee, 2015). Yield level of each household usually stays at the same rank (Chapter 4) regardless of paddy field type and year. This confirmed the important role of socio-economic factors maintained the yield gap remains in the rice community.

6.3. Perception and level of practices by farmers to cope with climate change

Farmers in Northeast Thailand perceived a long-term change in climate has happened based on their experience rather than the knowledge or information received from the government. They recognized temperature and drought and flood occurrence had changed compared to their childhood period (Chapter 3). The result was consistent with the scientific report that temperature has increased 0.2 ℃ per decade in the northeastern region (Limjirakan & Limsakul, 2012). They reported climate becomes unexpected making the planning of cultivation more difficult (Chapter 4). What they perceived is consistent with the evidence showed by climate study for Thailand or Asian country (IPCC, 2013; Limjirakan & Limsakul, 2012). The perception of farmers in Thailand is similar with what happened in other countries in Asia and Africa (Ayanlade et al., 2017; Swe et al., 2015; Tripathi & Mishra, 2017). Despite the common perception of long-term change, most of them cope with the climate problem in a short-term manner. While only those who well plan to cope for long-term understand about the scientific meaning of climate change such as 4 proactive farmers reported in Chapter 4. Sufficient knowledge and awareness in risks from climate change is a prerequisite for adaptation actions of farmers (Dang et al., 2014; Esham & Garforth, 2013), especially long-term planning which might not be easier for northeast farmers who have limitation from the socio-economic condition. The results of participants were likely to understand the brief message of IPCC and had the higher attitude to cope with climate change (Chapter 3) was actually they did not understand the word "climate change" in scientific meaning. This could be explain: first, low education of Northeast farmers to catch up with the topic where education is an important indicator of climate change awareness (Lee et al., 2015)., second, the climate change incidents are not easily observed or clear enough for the farmer, thus once the project finished (in 2015) farmers may totally forget or not pay attention to it. Third, the weak connection between rice community and research sector to sustain climate change knowledge in the community. Despite government had set climate change issue integrated into national strategy, it seems information has not delivered or even delivered but still cannot be maintained inside the community. Thus, more communication from government to rice community in climate issue is necessary.

Technologies to cope with climate change is on-going (Manzanilla et al., 2017). Adoption of high yielding varieties with good resistant to drought and flood might be possible for market-oriented farmers, as long as a government provides a market system for them. If researchers could demonstrate the performance of technologies and communicate farmers understand the usefulness of it for long-term coping via farmer participatory research, substantial changes in rice community resulting in higher yield level and yield gap could be filled.

6.4. Conclusion

Rainfed lowland rice production is under risks from the climate change, and this makes rice yield improvement quite challenging. The thesis clarified three points to effectively improve rice production in Northeast by the participatory approach. First, participants were equipped with social skill, learning activeness, leadership, and close relationship with researchers, but they did not much surpass other non-participants in grain yield level. They did not understand climate adaptation and mitigation in practice. Second, there was a large yield gap among farmers in rainfed rice ecosystem. If elite farmers who equipped with advanced technology were included in the project and expected to transfer technology to others, thus it is possible to make yield improvement of the country. Third, it is not easy to make farmers understand about the long-term climate change issue as they used to climate variability of rainfed ecosystem, thus consistency in training and policy to support farmers towards climate change is needed.

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Appendix

Definition and calculation

Basic information

Education means total years in schooling

Number of family member means number of member who live in the surveyed farmer's household at present

Position in village means any position that farmers might have in the village during the surveyed time

Rice farming experience means years of growing rice

Farming characteristics and managements (part 2)

Wet season rice production means production of rice during wet season which is roughly from April (planting) till November or December (Harvesting)

Dry season rice production means production of rice during dry season

Dry season farmer means farmer who does dry season rice production at least some of the years

Additional water source means source of water for rice production in addition to rainfall; this can be categorized into (1) rivers of different size and natural ponds and lakes (referred as river in our survey), and (2) on-farm pond.

Agricultural area means whole agricultural cultivation area (ha)

Wet season rice area means rice planted area in wet season.

Favorable area means rice planted area with favorable conditions without drought nor flood damages as perceived by farmers

Varieties means rice varieties that household grow, which are categorized into RD6, KDML105, and other varieties

Total wet season rice production means total amount (kg) of rice produced by individual household during wet season

Proportion of rice home consumption means proportion of amount of rice used for home consumption to total rice production presented as percentage

Proportion of rice sale means proportion of amount of rice for sale including both for food and seed to total rice production presented as percentage

Non-rice agriculture means any agricultural activities other than rice production

Non-agriculture means any non-agricultural activities

Transplanting (TP) method in this survey include only manual transplanting. No surveyed farmers used transplanting machine

Direct seeding (DR) method means sowing rice seeds directly to the paddy fields including dry seed broadcasting, wet seed broadcasting, and drill seeding, with the first method most popular in this survey

Seed rate means rate of seed used for planting (kg/ha)

Main income means main source of income for farmers, identified as rice, non-rice agriculture, or non-agriculture

Satisfaction on income means farmers' perceived degrees of satisfaction to their income level

Food security means farmers did not have shortage of food for their livelihood

Agricultural area means whole area (ha) used for agriculture

Land ownership (%) indicated from total area farmers have been practicing agriculture, how many percent of area farmers owned it.

Rice growing area (Ha) means total area farmer grows rice per wet season

Proportion (%) of rice area means percentage of rice area farmer grows in wet season to total agricultural farming area

Paddy yield (t/ha) means rice yield that farmer gained from each type of paddy topography

Average farm level yield (t/ha) means rice yield level that farmer usually gained in wet season

Yield from favorable paddy (t/ha) usually gained means rice yield level that farmer usually gained in favorable area in wet season

Yield from drought-prone paddy (t/ha) usually gained means rice yield level that farmer usually gained in *drought-prone paddy* in wet season

Yield from flood-prone paddy (t/ha) usually gained means rice yield level that farmer usually gained in *flood-prone paddy* in wet season

Yield variability by year (t/ha) were the extent of yield difference of 2015 and 2016 yield in wet season compared based on average farm level yield. The formula used is

Yield variability by year (t/ha) = (|yield in 2015- average farm level yield| + |yield in 2016- average farm level yield|)/2

Problem concerned most as rice farmers means the problem that farmer thought it is the most important which could be divided into four types: 1) rice farming technical problem, 2) rice farming economic problems, 3) economic problem, 4) other problem apart from above.

Organic input (t/ha) means total amount of organic input farmer applied per hectare (e.g. manure, fermented residue)

Inorganic input (t/ha) means total amount of inorganic input (e.g. chemical fertilizer) farmer applied per hectare

N input (t/ha) means total Nitrogen per hectare farmer applied which calculated from N proportion from inorganic input

<u>Calculation example</u> If farmer applies 400 kg of 16-20-0 per ha, then it means he applies nitrogen rate at 64 kg/ha. Farmer can applied many formula thus the calculation was conducted for total amount of inorganic input.

N input proportion by rice growing stage means percentage of N from total N which divided into four stages:

- Planting stage
- Tillering stage
- Panicle initiation stage
- Booting stage

Total expenditure (Baht/ha) means expenditure farmer spent per hectare in average for their rice farming in wet season

Rice income (baht/year) is total income farmer gained from selling rice

Agricultural income (baht/year) is total income farmer gained from doing agriculture excluding rice (e.g. crop selling, livestock)

Non-agricultural income (baht/year) is total income farmer gained from doing agriculture (e.g. crop selling, livestock)

Proportion of rice income (%) means percentage of rice income from total income

Total income (baht/year) means total income farmer gained per year calculated by some of rice income, non-rice agriculture income, and non-agriculture income

Highest yield loss from climatic incidents (%) means highest yield damage from the most extreme damage incident farmers ever met calculated from amount of damage production in that year to total production that farmer usually gain.

Relationship means farmers' relation with researchers and quantified as *relationship score, which was* calculated from the 8 questions of Part 4 (Table S1.1), ranging from 0 (least close and least interactive relation) to 15 (most close and most interactive relation). Relationship score was used to categorize levels of relationship into no relation (score 0), low relationship (1-4), medium relationship (5-10), and high relationship (11-15).

Table S1 Relationship score with researchers from P4Q6, P4Q7, P4Q12-P4Q17.

	Total score 15 points	Total score by aspect
Chance to meet researcher		5
Q6 indicates the experience of meeting with researcher (researcher visited or surveyed at their village, etc. which can be formal or informal meeting)	0-1 Choice point (0, 0.5, 1)	
Q7 indicates the experience of attending event arranged by researcher in recent 3 years (This can be any event such as workshop at university, sector, etc.)	0-4 Choice point (0, 1, 2, 3, 4)	
Research project engagement experience		5
Q12 indicates involvement/collaboration in research or experiment	0-1 Choice point (0, 1)	
Q13 indicates how often farmer involves /collaborates in research or experiment	0-2 Choice point (0, 1, 2)	
Q14 indicates the role of farmer as a coordinator on research project	0-2 Choice point (0, 1, 2)	
Communication with researcher		5
Q15 indicates general communication (asking question) with researcher	0-2 Choice point (0, 1,2)	
Q16 indicates discussion and knowledge exchange with researcher	0-2 Choice point (0, 1, 2)	
Q17 indicates keeping contact with researcher	0-1 Choice point (0, 0.5, 1)	

Activeness in learning was evaluated from Q5 to Q8 of Part 6. Activeness in learning in general was scored as a sum of Q5 and Q7 (0, 1, 2). Activeness in learning about rice issue was scored as a sum of Q6 and Q8 (0, 1, 2) (Table S1.2).

Table S2 Scoring method of activeness in learning from P6Q5-P6Q8.

	Question	Scoring
Activeness in Learning in general *Total score (0, 1, 2)*	P6Q5 Farmer likes learning	Yes = 1, No = 0
	P6Q7 Farmer has things in mind to learn in future	Yes = 1, No = 0
Activeness in Learning about rice issue *Total score (0, 1, 2)*	P6Q6 Farmer has studied about rice farming recently	Yes = 1, No = 0
	P6Q8 Farmer gets interested when heard about rice-related technology	Yes (with or without conditioned) = 1, No = 0

Technical knowledge about advanced technology means farmers' knowledge about advanced technologies in this survey in rice varieties resistant to drought and/or flood, and drill seeder, which are considered useful to cope with climate change and proposed by the participatory project. Knowledge score was calculated from Q12-Q14 in Part 6 (0 as not knowing, 1 as knowing) to indicate the extent of farmers knowledge about the technology (Table S1.3).

Table S3 Advance technology knowledge score from P6Q12 to P6Q14.

	Question	Scoring
Advanced technology knowledge score *Total score (0 - 3)*	P6Q12. Have you heard about submergence tolerant rice? Do you know it?	1 = Yes, and I know. 0.5 = Yes, but I do not know. 0 = No, and I do not know.
	P6Q13. Have you heard about drought tolerant rice? Do you know it?	1 = Yes, and I know 0.5 = Yes, but I do not know. 0 = No, and I do not know.
	P6Q14. Compare drill seeder with broadcasting, do you know which one use less amount of seeds?	1 = Drill seeder uses less than BC 0 = other answers

Table S4 Farmer's attitude score about adaption to climate change from P8Q11.

Choice selected	Score
(3) I want to learn scientific prediction and new technologies, and I want to prepare to cope with the climate change in advance, even from now.	3
(2) I could learn scientific prediction and new technologies when I have time, and I will later prepare to cope with the climate change.	2
(1) If the problem of climate change should become clearer and more severe, I will start preparing to cope with climate change.	1
(0) It is not top priority for me now. I have more important matters such as	0

Table S5 List of 36 explanatory variables used in the forward stepwise binary logistic regression for determining participants (Chapter 3).

Dependent variable		Description	Unit
	Participant	1= Participant, 0 = Non-Participant	Binary
Explanatory variable		Description	
1	Age		Years
2	Education		Years
3	Rice farming experiences		Years
4	Position	Set of 3 dummies; "No position" was set as reference level Dummy (1) = '1' if being head of village or related governing position, and "0" for otherwise Dummy (2) = '1' if being village, group, and center committee, etc., and "0" for otherwise Dummy (3) = '1' if being others than above which has role towards community such as local volunteer, and "0" for otherwise	Category
5	Number of family agricultural labors per total agricultural area		Person
6	Membership in rice related groups in village	Dummy 1= Yes, 0 = No	Binary
7	Drought area		Percentage
8	Flood area		Percentage
9	Water resource	Set of 2 dummies; "Depending on rain only." was set as reference level Dummy (1) = '1' if pond inside field, and "0" for otherwise Dummy (2) = '1' if river, and "0" for otherwise	Category
10	Dry season rice cropping	Dummy 1= Every year or some years, 0 = No	Binary
11	Rice yield		t/ha
12	Agricultural area		Ha
13	Rice cultivated area		Ha
14	Total rice production		Ton

15	Rice sale (%) from total rice		Percentage
16	Rice sale amount		Ton
17	Growing other crops in addition to rice	Dummy 1= Yes, 0 = No	Binary
18	Growing varieties other than KDML105 and RD6	Dummy 1= Yes, 0 = No	Binary
19	Burning	Dummy 1= Yes, 0 = No	Binary
20	Rice income		Baht
21	Main income	Set of 2 dummies; "Rice" was set as reference level Dummy (1) = '1' if non-rice agriculture, and "0" for otherwise Dummy (2) = '1' if non-agriculture, etc., and "0" for otherwise	Category
22	Total income score	Set of 2 dummies; "Lower than 50000 Baht/year" was set as reference level Dummy (1) = '1' if 50,001-100,000 Baht/year, and "0" for otherwise Dummy (2) = '1' if more than 100,000 Baht/year, etc., and "0" for otherwise	Category
23	Income estimation	Set of 2 dummies; "not enough at all" was set as reference level Dummy (1) = '1' if farmer considers not enough but could survive, and "0" for otherwise Dummy (2) = '1' if farmer considers enough for well-being, etc., and "0" for otherwise	Category
24	Satisfactions on income	Dummy 0 = Not satisfied to somewhat satisfied 1 = Very satisfied	Binary
25	Testing advance technology from project	Set of 2 dummies; "not test" was set as reference level Dummy (1) = '1' if farmer is not sure or will observe neighbor first, and "0" for otherwise Dummy (2) = '1' if farmer will test, etc., and "0" for otherwise	Category
26	Satisfactions on rice farming	Dummy 1= Yes, 0 = No	Binary
27	Targets in designing rice farming	Dummy 1= Yes, 0 = No	Binary
28	Confidence in farming	Dummy 1= Yes, 0 = No	Category
29	Solving problem	Set of 2 dummies; "Solve by myself" was set as reference level Dummy (1) = '1' if farmer consults researcher or agricultural extension officer, and "0" for otherwise Dummy (2) = '1' if farmer consults neighbor, etc., and "0" for otherwise	Binary
30	Activeness in learning in general		Score
31	Activeness in learning about rice issue		Score
32	Relationship with other farmers	Dummy 1= Yes, 0 = No	Binary
33	Relationship with people in other jobs	Dummy 1= Yes, 0 = No	Binary
34	Leadership in community	Set of 4 dummies; "Successful and community leadership" was set as reference level Dummy (1) = '1' if farmer wants to work with other farmers together so that he/she improve him/herself and my family, and "0" for otherwise Dummy (2) = '1' if farmer just wants to have a good relationship with other farmers, and "0" for otherwise	Category

		Dummy (3) = '1' if farmer wants to be him/herself and minimize relationship with other farmers, and "0" for otherwise Dummy (4) = '1' if farmers had other attitudes beyond provided choices, and "0" for otherwise	
35	Climatic damage experience	Dummy 1=Ever had, 0 = Never	Binary
36	Previous experience of thinking to deal with effects from climatic change	Dummy 1= Yes, 0 = No	Binary

Table S6 List of explanatory variables used in the binary logistic regression analysis determining dry season production (Chapter 4)

Dependent variable		Description	Unit
	Dry season	1= Do dry season , 0 = Do wet season only	Binary
Explanatory variable		Description	
1	Site	Set of 4 dummies; "HP" was set as reference level Dummy(1) = 'WN', and '0' for otherwise Dummy(2) = 'SW', and '0' for otherwise Dummy(3) = 'NK', and '0' for otherwise Dummy(4) = 'BB', and '0' for otherwise Dummy(5) = 'NP', and '0' for otherwise	Category
2	Water resource	Set of 2 dummies; "Depending on rain only." was set as reference level Dummy(1) = '1' if pond inside field, and "0" for otherwise Dummy(2) = '1' if river, and "0" for otherwise	Category
3	Yield		t/ha
4	Yield variability during 2015-2016		t/ha
5	Agricultural area		Ha
6	Rice area		Ha
7	Proportion of rice area (%)		Percentage
8	Percentage of favorable area		Percentage
9	Total Production		Ton
10	Sale proportion		Percentage
11	Sale amount		Ton
12	Home proportion		Percentage
13	Amount of KDML105 from total rice for sale (%)		Percentage
14	Total amount of organic fertilizer		Kg/ha
15	Total amount of inorganic fertilizer		Kg/ha
16	Total N Apply		Kg/ha
17	Use pesticide or herbicide		Binary
18	Total expenditure		Baht/Ha
	Total rice income		Baht/year
19	Total income		Baht/year
20	Rice income (%) from total income		Percentage
21	Number of family agricultural labors per total agricultural area		person
22	Economic status	Set of 2 dummies; "I had debts/ big spending" was set as reference level Dummy(1) = '1' if farmer had lots of spending apart from daily life, and "0" for otherwise Dummy(2) = '1' if farmer had no expenses apart from daily life, and "0" for otherwise	Category
23	Membership in rice related groups in village	Dummy 1= Yes, = 0 No	Binary

Table S7 List of explanatory variables used in the forward stepwise binary logistic regression for determining participants (Chapter 4).

Dependent variable		Description	Unit
	Participant	1= Participant, 0 = Non-Participant	Binary
Explanatory variable		Description	
1	Age		Years
2	Gender	1= Male, = 0 Female	Binary
3	Education		Years
4	Rice farming experiences		Years
5	Position	Set of 3 dummies; “No position” was set as reference level Dummy (1) = ‘1’ if being head of village or related governing position, and “0” for otherwise Dummy (2) = ‘1’ if being village, group, and center committee, etc., and “0” for otherwise Dummy (3) = ‘1’ if being others than above which has role towards community such as local volunteer, and “0” for otherwise	Category
6	Number of family agricultural labors		Person/Ha
7	Water resource	Set of 2 dummies; “Depending on rain only.” was set as reference level Dummy(1) = ‘1’ if pond inside field, and “0” for otherwise Dummy(2) = ‘1’ if river, and “0” for otherwise	Category
8	Do dry season in addition	1= Yes, = 0 No	Binary
9	Land ownership		Percentage
10	Proportion of rice area		Percentage
11	Average rice growing area		Ha
12	2015 rice growing area		Ha
13	2016 rice growing area		Ha
14	Percentage of favorable paddy in rice area		Percentage
15	Percentage of drought paddy in rice area		Percentage
16	Percentage of flood paddy in rice area		Percentage
17	Average total production		kg
18	2015 total production		kg
19	2016 total production		kg
20	Average farm level yield		t/ha
21	2015 farm level yield		t/ha
22	2016 farm level yield		t/ha
23	Yield variability by year		t/ha
24	Amount of rice kept for consuming at home		kg
25	Amount of rice kept for sale		kg
26	Total home consumption		Percentage
27	Total sale rice		Percentage
28	Proportion of RD6 produced for home consumption from total rice		Percentage
29	Proportion of KDML105 produced for home consumption from total rice		Percentage
30	Proportion of other varieties produced for home consumption from total rice		Percentage
31	Proportion of seed for next season		Percentage
32	Total amount of sold paddy rice		Percentage
33	RD6 amount sold as paddy rice		Percentage

34	KDML105 amount sold as paddy rice		Percentage
35	Other varieties amount sold as paddy rice		Percentage
36	Use other additional input such as hormone or liquid	Dummy 1= Yes, 0 = No	Binary
37	Use natural pesticide	Dummy 1= Yes, = 0 No	Binary
38	Use synthetic pesticide or herbicide	Dummy 1= Yes, 0 = No	Binary
39	Total amount of organic Fertilizer (kg/Ha)		kg/Ha
40	Total amount of inorganic Fertilizer		kg/Ha
41	Total expenditure		Baht/Ha
42	Total rice income		Baht/year
43	Total non-rice agriculture income (Baht/year)		Baht/year
44	Total non-agriculture income (Baht/year)		Baht/year
45	Total income		Baht/year
46	Percentage of rice income		Percentage
47	Economic status	Set of 2 dummies; "I had debts/ big spending" was set as reference level Dummy (1) = '1' if farmer had lots of spending apart from daily life, and "0" for otherwise Dummy (2) = '1' if farmer had no expenses apart from daily life, and "0" for otherwise	Category
48	Minimum spending of household		Baht/year
49	Income estimation	Set of 2 dummies; "not enough at all" was set as reference level Dummy (1) = '1' if farmer considers not enough but could survive, and "0" for otherwise Dummy (2) = '1' if farmer considers enough for well-being, etc., and "0" for otherwise	Category
50	Often visiting farm	Dummy 1= Yes, = 0 No (growing and harvest time only)	Binary
51	Food security	Dummy 1= Yes, = 0 No	Binary
52	Priority problem	Set of 4 dummies; "No problem" was set as reference level Dummy (1) = '1' if rice farming technical problems for production, and "0" for otherwise Dummy (2) = '1' if rice farming economic problems, and "0" for otherwise Dummy (3) = '1' if Non-rice farming technical and economic problems, and "0" for otherwise Dummy (4) = '1' if socio-economic related problem such as strength of farmer group, etc., and "0" for otherwise	Category
53	Technology need	Set of 6 dummies; "I don't need" was set as reference level Dummy (1) = '1' if high-yielding good taste variety but no need of market value, and "0" for otherwise Dummy (2) = '1' if high-yielding good taste variety with market value, and "0" for otherwise Dummy (3) = '1' if cost or expenditure saving, and "0" for otherwise Dummy (4) = '1' if labor saving, and "0" for otherwise	Category

		Dummy (5) = ‘1’ if easier or more convenient to my process of production, and “0” for otherwise Dummy (6) = ‘1’ if others from above, and “0” for otherwise	
54	Farmer perception on climate variability	Dummy 1= Yes, = 0 No	Binary
55	Thought about coping climate variability	Dummy 1= Yes, = 0 No	Binary
56	Burning	Dummy 1= Yes, = 0 No	Binary
57	Know impact of greenhouse gas	Dummy 1= Yes, = 0 No	Binary
58	Yield variability by year		t/ha
59	N fertilizer apply rate around TP or DR stage		kg/ha
60	N fertilizer apply rate at tillering stage		kg/ha
61	N fertilizer apply rate at panicle initiation stage		kg/ha
62	N fertilizer at Booting stage per Ha		kg/ha
63	Total N fertilizer apply rate		kg/ha
64	Education years		Years
65	Membership in rice related groups in village	Dummy 1= Yes, 0 = No	Binary
66	Activeness in learning in general		Score
67	Activeness in learning about rice issue		Score
68	Solving problem	Set of 2 dummies; “Solve by myself” was set as reference level Dummy (1) = ‘1’ if farmer consults researcher or agricultural extension officer, and “0” for otherwise Dummy (2) = ‘1’ if farmer consults neighbor, etc., and “0” for otherwise	Binary
69	Relationship with other farmers	Dummy 1= Yes, = 0 No	Binary
73	Relationship with people in other jobs	Dummy 1= Yes, = 0 No	Binary
74	Leadership in community	Set of 4 dummies; “Successful and community leadership” was set as reference level Dummy (1) = ‘1’ if farmer wants to work with other farmers together so that he/she improve him/herself and my family, and “0” for otherwise Dummy (2) = ‘1’ if farmer just wants to have a good relationship with other farmers, and “0” for otherwise Dummy (3) = ‘1’ if farmer wants to be him/herself and minimize relationship with other farmers, and “0” for otherwise Dummy (4) = ‘1’ if farmers had other attitudes beyond provided choices, and “0” for otherwise	Category
75	Yield reduction due to climatic incident		Percentage

Table S8 Comparative data of wet season rice production between double rice cropping farmers and wet season rice farmers.

Wet season data	Wet season (N = 153)	Double season (N = 16)	*p value* (T test/Chi-square test)
Rice growing area (ha)	2.49	4.49	0.003
Water source (River = 2, pond = 1, rainfed = 0)	1.22	1.75	0.045
Percentage of drought-prone paddy (%) in rice area (ha)	14 (N = 152)	7	0.044
Total production in general (kg)	5,348 (N = 151)	10,239	0.001
Amount of rice kept for sale (kg)	2,613	7,154	0.002
Total home consumption (%)	53	32	0.007
Total sale rice (%)	40	58	0.02
Total amount of organic fertilizer (kg/ha)	376	954	0.166
Total amount of inorganic fertilizer (kg/ha)	139	259	0.012
Total rice income (baht/year)	25,817	73,688	0.007
Total income/year	144,788	178,913	0.348
Rice income (%) from total annual income	23	38	0.027
Total N Apply (kg/ha)	30.97	53.66	0.061
Applying synthetic herbicide or pesticide (% of farmer)	29%	56%	0.028
Burning straw	18%	50%	0.003
Being member of rice related groups in village	46%	70%	0.040

Table S9 Topic Learned by FFS participating farmer (Chapter 5)

Topic	learning	Having skill and knowledge enough to teach other after attending FFS		
		Fully	Somewhat	not at all
1.Seed production	(1) Yes (0) No			
2. Organic farming	(1) Yes (0) No			
3. PGR conservation	(1) Yes (0) No			
4. Varietal evaluation	(1) Yes (0) No			
5.Climate change	(1) Yes (0) No			
6.Others ( )				

Table S10 Dissemination of knowledge by FFS participating farmers (Chapter 5)

Topic	dissemination	Is general farmer interested in this topic?	Have you told what you learned in FFS to other farmers?	Will the farmers (whom you told about FFS) start practicing any of the topics? <extent of success in dissemination>		
			If Yes, will you answer to whom and about how many you shared about the FFS?	Fully	Somewhat	not at all (They did not understand and have no interest to what you told).

12.Seed production	(1) Yes (0) No	(4) Sure (2) Maybe (1) May not (0) No (77) Not sure	(1) Yes. To whom ………. and how many……… (0) No.			
13.Organic farming	(1) Yes (0) No	(4) Sure (2) Maybe (1) May not (0) No (77) Not sure	(1) Yes. To whom ………. and how many……… (0) No.			
14.PGR conservation	(1) Yes (0) No	(4) Sure (2) Maybe (1) May not (0) No (77) Not sure	(1) Yes. To whom ………. and how many……… (0) No.			
15.Varietal evaluation	(1) Yes (0) No	(4) Sure (2) Maybe (1) May not (0) No (77) Not sure	(1) Yes. To whom ………. and how many……… (0) No.			
16.Climate change	(1) Yes (0) No	(4) Sure (2) Maybe (1) May not (0) No (77) Not sure	(1) Yes. To whom ………. and how many……… (0) No.			

Questionnaire of 2016 Survey

Code Number

Date of Survey…………………...Time……….
Name of recorder…………………………….
Evaluation ………

Farmer's name………………………Surname…………………………….
Location ☐DS ☐NP **☐HP ☐WN ☐SW** ☐NK **☐BB**

PART 1 Basic information (7)

1. Gender
(1) M
(2) F

2. Age
……….

3. Rice farming experiences (Number of year growing rice)
…………..

4. Your highest level of education (P3, H3, graduate, etc. please calculate into…………years of schooling later)
……….

5. Number of family member living in house at present
……….

6. Number of family member for main agricultural labor
……….

7. Do you have a position or role in your village (e.g., chief, vice-chief, farmer association committee etc)
……….

PART 2 Farming characteristics (50)

1. Do you grow other crops except for rice? (exclude household backyard that you grow for household eating, non- sell production purpose)
   (1) Yes. ……………………………………
   (0) No, only rice.

2. Do you grow dry season rice in addition to rainy season rice?

(1) Yes, both rainy season rice and dry season rice every year.
(2) Yes, but only some years dry season rice is added
(3) No, always only rainy season rice.

3. Do you have water sources for other than rainfall for rice farming during wet season?

(1) Yes, canal or creek connected with river or natural water reservoir (including irrigation dam)
(2) Yes, on-farm water pond
(3) No, completely rainfed.

<Overview of rice production and utilization>

	Memo
4. total agricultural field size …………………..…. (rai)	
5. total rice field size ……..…………… (rai)	5.1 Favorable field…….rai (= ..%) 5.2Drought-prone field..rai (=…..%) 5.3Flood-prone field……rai (=….%)
6. How many places of your field? (number of place) ………..………	

Please tell me all rice varieties you grow in you field and reason you grow for

7. RD6 (1) Yes grow for………………………………….. (0) No
8. KDML105 (1) Yes grow for………………………………….. (0) No
9. other varieties (1) Yes (0) No
……………………... grow for…………………………………..
………………………. grow for…………………………………..

	Amounts (kg, bags, bucket)	Memo (1 bags/bucket = …….kg)
10. total rice production ………(kg/yr)	* write unit and calculation result	
11. home consumption ……….(kg/yr) …………………….variety …………………….variety	 ………………………… …………………………	
12. seed for next season……. (kg/yr)		

	Amounts (kg, bags, bucket)		Memo (1 bags/bucket = …….kg)

13. sale as paddy rice for eating (kg/yr) …………………Variety…….….(kg/yr) …………………Variety…..…….(kg/yr)		 To whom to sell ……………… To whom to sell ………………	*refer unit told by farmer from previous village Unit price…………Baht/kg paddy rice Unit price…………Baht/kg paddy rice
14. sale as milled brown/white rice for eating (kg/yr) …………………Variety…..…….(kg/yr) …………………Variety…..…….(kg/yr)		 To whom to sell……………… To whom to sell………………	 Unit price…………Baht/kg brown/white rice Unit price…………Baht/kg brown/white rice
15. sale as paddy rice for seed(kg/yr) …………………Variety…..…….(kg/yr)		To whom to sell …………..	Unit price ………… Baht/kg seed
16. sales of non-rice agricultural products Product names …………………….. …..…….(kg/yr) …………………….. …..…….(kg/yr)		 To whom to sell ……………… To whom to sell ………………	 Unit price ………. Baht/kg Production cost……..(rough) Unit price ………. Baht/kg Production cost……….
17. non-agricultural income Job name …………………………… Job name ……………………………		 Where to work …………….. Where to work ……………..	 …………………Baht/year …………………Baht/year

<variety, planting method information for 2015>

Please answer about your 2015 rainy season rice farming from Q19 to Q27.

18. Please comment first if rice variety, planting methods, yield of 2015 rainy season rice in your farm are more or less similar to other years. If your 2015 data should be different from other normal years, please explain how different.

(1) Yes, my 2015 rainy season rice was similar to other years.

(0) No, my 2015 rainy season rice was different from other normal years

……………………………………………………………………………………………………

Recording yield as (………kg/rai) is a standard. If farmers should prefer to answer by bag numbers and in the total area for each variety, memo how much kg for 1 bag (1 bag = …. Kg), and record by (………. bags in ……….. rai).

	TP		broadcasting		Drill-seeding (walking type)		Drill-seeding (4 wheel type)	
	Area (rai)	Yield (kg/rai)	Area (rai)	Yield (kg/rai)	Area (rai)	Yield (kg/rai)	Area (rai)	Yield (kg/rai)

19. Overall (if farmers not sure of variety-specific information)								
20. RD6								
21. KDML105								
22. ……….								
23. Test variety A………..								
24. Test variety B …………….								

Recording seed rate as (………kg/rai) is a standard. If farmers should prefer to answer by bag ·container numbers per rai, memo how much kg for 1 bag ·container (1 bag ·container = …. Kg), and record by (………. Bags/rai).

25. How much seed rate (kg/rai) for broadcasting?
………. kg of dry seed in …….. rai of field

26. How much seed rate (kg/rai) for drill-seeding by machine?
………. kg of dry seed in …….. rai of field

27. How much seed rate (kg/rai) when making nursery for transplanting?
………. kg of dry seed in …….. rai of transplanted field

<variety, planting method planning information for 2016>

Please answer about your plan for 2016 rainy season rice farming from Q28 to Q33.

	TP		broadcasting		Drill-seeding (walking type)		Drill-seeding (4 wheel type)	
	Area (rai)	Yield (kg/rai)	Area (rai)	Yield (kg/rai)	Area (rai)	Yield (kg/rai)	Area (rai)	Yield (kg/rai)
28. Overall (if farmers not sure of variety-specific information)								
29. RD6								
30. KDML105								

31.								
32. Test variety flood tolerant............								
33. Test variety drought tolerant								

<Rice farming works>

Please put ✓ on the farming works farmers will use. Please X in front of Q number if farmer does not do that work

Farming work	household	Machine and facility owned by family	Bigger machine and facility for cooperative use	Exchange labors (no payment)	Hired labor *record number of labor and day of each process e.g. 3 labors/day 7 days hiring
34 field burning					
35. ploughing ไถดะ					
36. harrowing ไถแปร					
37. seeding (direct seeding)					
38. nursery seedling					

(transplanting)					
39. transplanting					
40. fertilizer application					
41. pesticide application					
42. harvesting					
43. threshing					
44. drying					
45. dehulling					
46. polishing					

47. What is your main income?

(1) Rice

(2) Non rice agriculture (e.g., non rice crops)

(3) Non agriculture (Please specify ………………………………)

48. Can you evaluate to how far you satisfy your income status? Please circle

0 1 2 3 4

Not satisfied at all somewhat not satisfied Neutral somewhat satisfied very satisfied

49. Do you think your household income alone (without fund or loan, etc) at present is enough for household livelihood?

(0) Not enough at all

(1) Not enough but can survive somehow

(2) Enough for well-being livelihood

50. Does your household suffer from shortage of rice for home consumption in any months of the year?

(1) No. I have never suffered such shortage of rice.

(2) I suffered in the past but nowadays never.

(3) I suffered in the years of severe climate disaster but nowadays in normal years never.

(4) Yes, I sometimes suffer (Please indicate which months ……………………..(Input all months name such as April and May).

Skip for farmers who always do 100% TP till now

PART 3. Past transformation to direct seeding (case 1) (8)

One of the most significant changes in rice farming in Northeast Thailand the last 30 years is change from transplanting to direct seeding. How this change has occurred is interviewed in PART 3, and later to be analyzed in relation with the data mainly from PART 2, 4, 5 and 6.

1. Compare to the time you were child, does direct seeding increased in your rice fields?
(1) Yes.
(0) No.

2. Do you remember when you started increasing direct seeding in your fields?
(1) 1-5 years ago (2010-2015)
(2) 6-10 years ago (2005-2009)
(3) 10-20 years ago (1995-2004)
(4) before 20 years ago(-1994)

3. Do you remember % of direct seeding around 20 years ago (1995)? If you do not remember the % around 1995, please answer % of direct seeding in other year as you could memorize.

TP……% DS….% around 1995

If not clear about 1995, TP……% DS….% in the year of ……………..

4. Do you remember why you started increasing direct seeding?
(1) labor shortage
(2) higher cost of TP workers
(3) cope with flood
(4) cope with drought
(5) others ……………………..

5. How direct seeding was started in your farm in the past?
(1) I learned from researchers
(2) I learned from extension officer
(3) I learned from my neighbor farmers
(4) I learned from my own experiences
(5) others ……………………………………………………………………………………………..

6. How do you assess good points of direct seeding now?
(1) it is labor-saving
(2) it is cost-saving
(3) it can cope with flood
(4) it can cope with drought
(5) others ……………………..

7. How do you assess problems of direct seeding now?
(1) yield reduction
(2) weed infestation
(3) lodging
(4) establishment failure
(5) others ……………………..

8. How have you tried to cope with these problems?

(1) Yes, I tried to cope with discussing/working with researchers. Please specify ……………….. …………

(2) Yes, I tried to cope with discussing/working with extension officers. Please specify

(3) Yes, I tried to cope by discussing/working with my friend farmers. Please specify ………….…………

(4) Yes, I tried to cope by my own efforts. Please specify ……………………..….

(5) others ………….………………

(0) No, I have never tried to cope with the problems

PART 4. Degree of engagement with researchers (17)

In PART 4, general questions to check farmers perception about differences between researchers (and research projects) and extension officers (and extension projects) at the beginning (Q1-Q5).
PART 4 mainly asks farmers' degree of contact, participation to researchers' events, and engagement in the general research projects (Q6-Q19)

1. Do you know the difference between researcher and extension officer.

Farmer's explain
…….
………………………………………………………………………………………(if farmer give wrong answer, select No)

(1) Yes

(0) No

Interviewer explains :
Researcher means scientist who do research on rice and farming who work in research institutes such as Rice Department or University.
Extension officer means officers in government such as Department of Agricultural Extension (DOAE) or ,Department of Land Reform or in NGO who works on group activity, rural development, distribute materials or equipment, training jobs, etc.

2. Do you think rice farming research projects and extension projects are different?

Farmer's explain ………………………………………………………………………………………………

(1) Yes, they are different.

(2) I do not know.

(3) No, I do not think they are different

Interviewer explains simple definition of research projects and extension projects.
"Research project focuses to clarify underlying reasons for the problems and to test new technologies by using scientific procedure/method(results is needed and repeat experiment has been conducted), while extension project focus to disseminate general and promising new knowledge and technologies, as well as to provide agricultural services, to develop potential products, to promote group activity, to develop potentials of farmers by training etc."

3. Which do you like, research projects or extension projects? Please give your reason too.

(1) I like research projects more because ……………………………………..

(2) I like extension projects more because ……………………………………..

(3) I like both projects equally because …………………………………………

(4) I do not like both projects.

4. How do you evaluate researchers?

(3) They know better than me about new technologies and rice farming.

(2) They know better than me about new technologies, but I know equal about rice farming.

(1) They know better than me about new technologies, but I know more than them about rice farming.

(0) They know less than me about new technologies and rice farming.

(77) Others ………………………………………………….

5. How do you evaluate extension officers?

(3) They know better than me about new technologies and rice farming.

(2) They know better than me about new technologies, but I know equal about rice farming.

(1) They know better than me about new technologies, but I know more than them about rice farming.

(0) They know less than me about new technologies and rice farming.

(77) Others ………………………………………………….

Meeting chance with researchers

6. Have you ever met with researchers before?

(0) No. I have never met (and this interview occasion is the first time).

(1) Yes. I have met and had a short conversation with researchers.

(2) Yes. I have met and helped researchers (e.g., I have guided researchers in/around the village as requested).

Participation to events organized by researchers

7. Have you ever attended events organized by researchers or research institutions (i.e., including Rice Department, universities) such as lecture, workshop, demonstrations of plot (variety, machine)?

When and where have you attended? Please tell me the time and place……………., ………………………….

Name of this event (including the type of activity)…………………………………………………………

Name of organizer of this event ……………………………………………………

How many times have you attended the events organized by researchers in the recent 3 years?

(4) More than 10 times ( ) times

(3) 7-10 times

(2) 4-7 times

(1) 1-3 times

(0) 0 times

For those answering 1-4 in Q7,

8. Why did you come to attend the researchers' events ?

(1) I needed the specific solutions or technical advices for my farming

(2) I needed general technical advices for my farming.

(3) The events were attractive because they provide souvenir/return.

(4) The events were attractive as my neighbors attended.

(77) other reasons ....

For those answering 0 in Q7,

9. Why have you never attended the researchers' events ?

(1) I have never heard about them

(2) I have heard about them but I was not interested

(3) I have heard about them, I was interested, but I had no chance

(4) other reasons ....

(Next , Please go to Q12)

For those answering 1-4 in Q7,

10. What did you get from the researchers' events?

(1) specific solutions or technical advices for my farming(recent new technology, new aspect)

(2) general advices for my farming

(3) small attractive souvenir/ return

(4) enjoyable time with other people

(5) others................................

(0) nothing much

11. How do you evaluate the researchers' events after attending?

Usefulness	Interest
(2) useful to improve my farming (specify ....)	(2) very interesting (specify ....)
(1) somehow useful (specify ....)	(1) somewhat interesting (specify ....)
(0) not useful (specify ....)	(0) not interesting (specify ....)
(77) others	(77) others ....

Engagement in research project

12. Have you ever engaged in research projects, such as to test (together with researcher i.e., experiments) in your fields to evaluate new rice varieties / new machines / new cultivation methods (e.g., baby trial) and reported the results to the researchers?

(1) Yes. I have ever done before.

Please describe more.

When it was? ....

What was the purpose? ....

How was the evaluation result? ....

(0) No, I have never done before.

13. How frequent do you conduct the test in Q12?
(2) Very often / mostly every year.
(1) Not so often / only some years.
(0) Nearly not/ No

14. Have you ever worked as a coordinator in research projects?
(2) Yes. I ever and very often.
(1) Yes, I ever but not so often.
(0) Never.

Communication

15. Have you asked questions to researchers in any occasions?
(2) often/ every time when I meet researchers
(1) sometimes, occasionally when I meet researchers
(0) Never, nearly not

16. Have you ever discussed with researchers deeper in any occasions? For example, answering to researchers' questions with details, expressing your opinions, and exchanging ideas and knowledge with researchers?
(2) often/ every time when I meet researchers
(1) sometimes, occasionally when I meet researchers
(0) Never, nearly not

Skip if you answer 0 in Q12

17. After the research project finished, do you or will you (in case only have current project) usually keep contact with the researchers (for example, 3 years after project finished when no more related project activities)?
(2) Yes, I keep a close contact with the researchers.
Why and how …..
(1) Maybe, sometimes by chance
Why and how ………………………………………………………………
(0) I don't know/ No
Why …………………………………………………………………………..

PART 5 Engagement in the current rice research project (17) Total SCORE…….

Many farmers would already participate to the current rice research project(s) organized by Dr Boonrat or IRRI, while some interviewees not participated until now. PART 5 asks farmers' degree of participation or engagement in the current rice research project. Participation or engagement in the other projects is not included in PART 5. At the beginning, farmers' participation to any other rice groups in the villages is asked (Q1).

1. Before the main questions in PART 5, please tell me if you belong to any farmer groups in the village about rice and rice farming? Please list the group you belong to. Please tell me how active you are in participation of each group you belong to.

(1) Yes, I belong to ………………………….. (active / in active member)

…………………………….. (active / inactive member)

…………………………….. (active / inactive member)

………………………………(active / in active member)

(0) No, I do not belong to any groups.

2. When did you join the current rice research project?
Since ………….. (month) ………… (year)

(2) 2 -3 years continuously
(1) just 1 year (this include farmer who just attended from 2015, and those who joined before for 1 year but now stopped)
(0) No, I have not yet joined.

Why did you join the project? Why did you not join?
……….

Skip If answer (0) in Q2
If you answer (1) and (2) in Q2,
3. Why do you join the project?
I join because
(1) I needed the specific solutions or technical advices for my farming
(2) I needed general technical advices for my farming.
(3) The events were attractive because they provide souvenir/return.
(4) The events were attractive as my neighbors attended.

(77) other reasons ……………………………

Skip If answer (1),(2) in Q2
If you answer (0) in Q2,
4. Why do not you join the project?
I do not join because
(1) I have never heard about them
(2) I have heard about them but I was not interested
(3) I have heard about them, I was interested, but I had no chance
(4) other reasons …………………………….

Skip If answer (0) in Q2
5. What do you expect from the current rice research project?
(1) specific solutions to the specific problems of my farming
(2) general new information and knowledge for my farming
(3) attraction such as souvenir / return
(4) enjoyable time with other farmers and researchers
(5) others…………………………………………………..

(0) nothing much

Skip If answer (2-6) in Q5

If you answer (1) in Q5,

6. How confident are you for your expectation?

(3) I am sure that the new technologies will solve my farming problem.

(2) I am wishing that the new technologies will solve my farming problem.

(1) I am not very sure but the new technology may contribute to solve my farming problem.

(0) I am not sure at all.

7. Do you know the purpose of current rice research project?

(1) Yes

(0) No

8. Could you please tell me what is it?.

Farmer said

………

……

…

If farmer say answers match 50% to message below, select yes.

For, Huatapan, Wanonniwas, Sriwilai, Naklang, Borabue site

Project purpose :

To make farmer understand and learn about climate change occurring in rainfed agricultural area

To increase capacity of self-reliance of farmer by adapting production/agricultural system suitably and sustainably under climate change

For Napo site

Project purpose : To increase efficiency of rice productivity by using machine (i.e., drill seeder)

To reduce cost of rice productivity by using machine

(1) Yes

(0) No

9. Do you know the current rice research project has brought new rice varieties and/ or seeder?

(1) Yes

(0) No

Please tell me what you know

Which new varieties……………………………………………………..

Flood tolerant   drought tolerant

Type of seeder……………………………………………………………..

2 wheel seeder   4 wheel seeder

Score …………

Skip   If answer (0) in Q2

10. What do you expect from researchers when you attend the meetings of the current research project?

(3) I expect the researchers to advise about the new technology from the project"

(2) I expect the researchers to advise about overall rice farming not limited to the new technology in the project.

(1) I expect the researchers other things ……………………………….............

(0) I expect nothing (/much) from the researchers.

11. How have you been participating in the project?

☐ I have conducted trial plot together with researcher in my field, collecting data, and giving result to researcher

☐ I have discussed/exchanged opinions with researcher in issue related to project

☐ I have helped researcher for their research such as harvest, plot preparation, provide small plot for them, etc.

☐ I have worked as a coordinator of the project.

Count from ☑

(4) All of the 4 choices

(3) 3 choices

(2) 2 choices

(1) 1 choice

(0) 0 choice

12. Do you often attend meeting of the current rice research project? For example, when researchers called you 10 times in 2-3 years, how many times you attended?

(2) Yes, I attended most of the time.

(1) Yes, but I attended only sometimes.

(0) No, I nearly not attended

Why do you attend/not attend the meeting of the current rice research project?

Skip if (0) in Q12

If you answer (1) and (2) in Q12,

13. Why do you attend the meeting?

I attend because

(1) I am looking for research results, researcher's opinions and advices.
(2) I want to get new knowledge or information.
(3) I want to show my opinion
(4) I can get a small attractive souvenir/ return
(5) my neighbors attend
(6) other reasons ……………………….

Skip if (1) or (2) in Q12

If you answer (3) in Q12,

14. Why do you not attend the meeting?

I do not attend because

(1) talks on research is difficult for me
(2) I need to do other business
(3) I do not feel necessity of research project for my farming
(4) Other reasons …………………………..

15. If the current rice research project can produce promising technologies, will you test it in your fields?

(2) Yes, I will

(1) I am not sure / I have to see neighbored first.

(0) No, I won't.

16. Have you joined to test the new technology of the current rice research project (i.e., Boonrat or IRRI) in your field in 2015, or are you going to join to test in 2016?

(3) Yes, I joined in 2015, and I will join again in 2016.

(2) Yes, I joined in 2015, but not sure in 2016.

(1) Yes, I did not join in 2015 but I will join in 2016.

(0) No, I did not join in 2015 and no plan to join in 2016.

17. How do you evaluate the current rice research project so far?

Usefulness	Interest
(2) useful to improve my farming (specify ………………………………………………….)	(2) very interesting (specify ………………………………………………….)
(1) somehow useful (specify ………………………………………………….)	(1) somewhat interesting (specify ………………………………………………….)
(0) not useful (specify ………………………………………………….)	(0) not interesting (specify ………………………………………………….)
(77) others …………………………………………………	(77) others ………………………………………………..

PART 6. Personal characters (15)

In PART 6 personal characters of farmers are characterized by (i) goal and aim of rice farming, (ii) self-confidence, (iii) learning attitude, (iv) knowledge level, (v) relationship with other people. The previous question *as for farmers belonging to village groups (Q1 in PART 5) can be identified as having a similar meaning as (v).*

Goal and aim of rice farming

1. Are you satisfied with your rice production and farm?

(1) Yes why…………………………..

(0) No why…………………………..

2. Do you have a goal in farming? What is your goal? Such as expected production level,etc

(1) Yes. My goal/target of rice farming is ……………………………..…………………………….

How to reach the goal…………………………………………………………………

(0) No.

Self confidence

3. Do you have confidence that you can cope with difficulty/problem in farming? (such as climatic damages)

(2) Yes, I am confident that I can manage to handle any problems. Why…………………………

(1) It depends on each problem. Some problem I have confident, some problem I do not.

(0) No, I am not so confident that I can make. Why…………………………

4. When you confront problem in farm, what will you do at first place.

(1) I ask researchers for help.

(2) I ask extension officers for help.

(3) I ask neighbor farmers for help.

(4) I try to solve by myself.

(5) others ………………………………………………

Learning efforts

5. Do you like learning?

(1) Yes, I like to learn ……………………………….., for example.

(0) No, I do not like to learn.

6. Do you study something about rice farming recently? What and how?

(1) Yes. I studied ……………………………. by ………………………………………………..

(0) No.

7. Do you have something in mind which you want to learn in future?

(1) Yes, I want to learn …………………………….

(0) No.

8. If you hear about a new rice-related technology, will you get interested and want to know more about it?

(2) Yes, I want to know more.

(1) Yes, I want to know more if I hear it from reliable persons. (farmer has conditions)

(0) No, I am not interested to learn.

Relationship with other people

9. Do you like to talk and work with other farmers?

(1) Yes.

(0) No.

10. Do you like to talk and work with persons in other jobs?

(1) Yes.

Whom do you like to talk/work?

. a. researcher,

b. extension officer,

c. miller,

d. agricultural shop,

e. middleperson in marketing

f. consumer who eat your rice

g. others …………………………….

(0) No.

11. How do you want to have relationship with other farmers in village?

(1) I want to contribute to help the other farmers and village. I already gain successful leadership role to help others.

(2) I want to work with the other farmers together so that I can improve myself and my family.

(3) I want to have a good relationship with other farmers.

(4) I want to be myself and minimize relationship with other farmers.

(5) others ………………………………

Knowledge levels of recent technology

12. Have you heard of submergence tolerant rice? Do you know it?

……

(2) Yes, I have heard of it and I know.

(1) Yes, I have heard of it, but I do not know at all.

(0) No, I have never heard of it and I do not know at all.

13. Have you heard of drought tolerant rice? Do you know it?

……..

(2) Yes, I have heard of it and I know.

(1) Yes, I have heard of it, but I do not know at all.

(0) No, I have never heard of it and I do not know at all.

14. Compare drill seeder with broadcasting, do you know which one use less amount of seeds?

………

** Drill seeder uses less amount of seed compare to DS. Check whether farmers know or not*

(1) Yes

(0) No

15. Do you know climate change?

……

Don't read below to farmer, just keep for your checking

** Climate change is a long-term change (decades, century level)of climate in the earth's climate, or of a region on earth. Climate change can be identified by changes in mean and/or variability of its properties such as air temperature and rainfall. For example, average air temperature is higher in 21^{st} century than 20th century. Precipitation pattern is changing. Frequency of extreme weather events is increasing.*

Human activities such as gas emission from agriculture, secondary industries and cities cause global climate change.

(Interviewer check farmer answer)

(1) Yes

(0) No

PART 7. Past climate damages (5)

1. Do you encounter with climate problems? Please list 3 major climate problems usually happened at your farm starting from the most important one. Please also show how severe they usually are, and how frequent they are.

(1)

type ……………

severity ………… (e.g., …% of production compared with non-damage years)

frequency …………… (e.g., ….. times in 20 years)

(2)

type ……………

severity ………… (e.g., …% of production compared with non-damage years)

frequency …………… (e.g., ….. times in 20 years)

(3)

type ……………

severity ………… (e.g., …% of production compared with non-damage years)

frequency …………… (e.g., ….. times in 20 years)

2. Do you remember the past severe climate problems (i.e., climate disasters such as flood, drought, other extreme events) since you were a child? Can you list them?

	Type of climate damage	Year, month, if you can remember	Memo Farmers' comments on climate damages such as severity, reduction of yield or harvest area
e.g.	flood	Sep, 2011	Very severe, some fields longer than 10 days submergence, small yield reduction, more reduction in harvest area (-20 - -30% *if farmer can indicate quantitative information of reduction in yield and reduction in harvest area in number, please write)

1			
2			
3			
4			
5			

Skip Q3 – Q5 if farmers have never encountered climate problems and disasters in their field.

3. When the climate problems severely damaged your farming as above lists, who did you consult during the rice growing period when the problem was still undergoing?

(1) Yes, I tried to reduce damage by discussing/working with researchers
(2) Yes, I tried to reduce damage by discussing/working with extension officers.
(3) Yes, I tried to reduce damage by discussing/working with my friend farmers.
(4) No, I tried to reduce damage by my own efforts.
(5) Yes, I tried to reduce damage by (others) when (1)-(4) are not applicable
……………………………………
(0) No, I did nothing

4. When the climate problems severely damaged your farming as above lists, how did you do after the rice growing period finished?

(1) Yes, I asked for government relief support.
(2) Yes, I borrowed money from agricultural bank.
(3) Yes, I borrowed money from my relatives.
(4) Yes, I did (others) …………………………………
(0) No, I did nothing

5. When the climate problems severely damaged your farming as above lists, whom did you consult to plan next season rice farming?

(1) Yes, I asked for technical advices from researchers.
(2) Yes, I asked for technical advices from extension officers.
(3) Yes, I asked for technical advices from my friend farmers.
(4) Yes, I asked for technical advices from other people. (Please specify whom……………….)
(5) Yes, I did others …………………………………
(0) No, I had no plan. Grow rice in the same manner in the next season.

PART 8 Perception and adaptation on climatic change (11)

From 5th report of Intergovernmental Panel on Climate Change (IPCC) which assesses climate change based on science, states as below;

- *It is highly likely that* ***number of cold days and cold nights decreased and hot days and hot nights were more frequent*** *in almost all the land in the world for the last 60 years since 1950.*
- *This change is predicted as highly possible in 2016-2035 (next 30 years), and as absolutely sure in 2081-2100 (next 70-90 years).*
- *It is likely that the more land area increased* ***higher frequency and severity of heavy rainfall and increasing amount of total rainfall*** *in the world for the last 60 years since 1950.*
- *This change is predicted as highly possible in many land area in next 30 years, and as extremely highly possible in next 70-90 years in almost all the middle latitude and humid tropical area.*
- *it is likely in several regions there is* ***increases in intensity and longer duration of drought*** *for the last 60 years since 1950, although low confidence on this in global scale*
- *This change is predicted as low confidence in next 30 years, but as highly possible in next 70-90 years from regional scale to global scale.*

1. Do you understand the above explanation of a part of summary from 5th report of IPCC?

(3) Yes, I understand
(2) I partially understand some points
(1) I am quite not understand the contents
(0) No, I totally not understand

What's about climate conditions at your village? Do you think there are any changes compare to condition at the time you were child?

Do you think there is change in?	Strongly agree	agree	not sure	disagree	Strongly disagree
2. less frequent cold days and cold nights					
3. more frequent hot days and hot nights					
4. more frequent and severe heavy rainfall					
5. more severe and prolonged drought					
6. others ……………………………					
7. others ……………………………					

8. Do you think climate conditions in your village have changed compared with the past when you were a child?

(1) Yes. Please specify ………………………………………………………………………..
(0) No, it is more or less similar.

9. Have you ever thought that you can do something to cope with the adverse effects caused by climatic change?

(1) Yes.
(0) No.

10. Have you taken some actions to cope with climate change?

(2) Yes, I have done, and it has worked well.
Why do you think it has worked well? ……………………………………………………………
(1) Yes, I have done, but it has not worked well.
Why do you think it has not worked well? ……………………………………………………………
(0) No, I have never taken any actions.
Why have not you taken any actions? ……………………………………………………………

11. 5th report of IPCC predicts less cold days and cold nights, more hot days and hot nights, more frequent and severe and more rainfall, more severe and prolonged drought after 70 years (2081-2100). Researchers also work to develop new technologies to cope with climate change to be available for farmers.

What is your attitude to cope with climate change?

(3) I want to learn scientific prediction and new technologies, and I want to prepare to cope with the climate change in
advance, even from now.
(2) I could learn scientific prediction and new technologies when I have time, and I will later prepare to cope with the climate change.
(1) If the problem of climate change should become clearer and more severe, I will start preparing to cope with climate change.
(0) It is not top priority for me now. I have more important matters such as ………………………..,
……………………., ……………………………………………………

PART 9 Status and responses with regard to mitigation by stopping burning fields (case 3) (5)

Field burning practice emits gas called CO_2 from crop residue and soil carbon stocks, causing increase in CO_2 in atmosphere. If CO_2 concentration increases much in the atmosphere, the heat resides on earth and air temperature starts increasing. This is called as "greenhouse effect", which is considered as main cause for global warming. Global warming is predicted to cause various changes in climate conditions such as less cold days, more hot days, more frequent flood, more severe drought in future. In order not to increase concentration of CO_2 in the atmosphere, researchers list avoiding burning of crop residues among other practices in 5th report of IPCC. If field burning can be stopped, it will help to mitigate climate change.

1. Do you understand the above explanation of a part of summary from 5th report of IPCC?

(3) Yes, I understand
(2) I partially understand some points
(1) I am quite not understand the contents
(0) No, I totally not understand

2. Do you agree that field burning practice produces CO_2 and increase CO_2 concentration in the atmosphere which is one of the causes for global warming and climate change?

(1) Yes
(0) No

5th report of IPCC advises to stop field burning practice to mitigate climate change.

3. Do you think farmers had better stop field burning?

(2) Yes, I agree to stop field burning.
(1) No, I can understand the viewpoint of IPCC but it is difficult for farmers to prepare fields without field burning.
(0) No, I do not understand the viewpoint of IPCC and I do not agree to stop field burning.

If you are burning your fields, please answer Q4-5. (Skip for non-burning field farmer)

4. If new cultivation method is freely introduced to farmers to solve your concerns about land preparation, will you stop field burning?

(1) Yes. (Because……………………………………).
(0) No. (Because……………………………………..).

5. Will your farm to be burnt or not in land preparation for rainy season rice 2016?

(2) Yes, the field will be burnt.
(1) I do not know yet.
(0) No, the field will not be burnt.

Farmer's Address…………..………………………………………………………

Mobile number…………………………………

Interviewer's comment on the farmer's responses;

(A) all very clear
(B) OK
(C) some unclear answers

For (C), specify unclear question No…………………………………………………

Collaboration of farmer

(A) Good
(B) Fair
(C) Not good

Questionnaire of 2016 Survey

Code Number

Date of Survey…………………...Time……….

Name of recorder…………………………….

Evaluation ………

Farmer's name………………………Surname…………………………….

Location ☐NP ☐HP ☐WN ☐SW ☐NK ☐BB

Part A Farming characteristics

1.Do you grow dry season rice in addition to rainy season rice?

(4) Yes, both rainy season rice and dry season rice every year.

(5) Yes, but only some years dry season rice is added (Explain why you did in some year …………..……………….)

(6) No, always only rainy season rice.

2. 2.1Did dry season in 2015

1) Yes

(0) No

2.2 Did dry season in 2016

(1) Yes

(0) No

3.Do you have water sources for other than rainfall for rice farming during wet season?

(4) Yes. And I never have experience in shortage of water for production by using this resource. Circle it (canal or creek connected with river or natural water reservoir (including irrigation dam), on-farm water pond, others)

(5) Yes. However, there were a shortage of water from this resource for production. Circle it (canal or creek connected with river or natural water reservoir (including irrigation dam), on-farm water pond, others).

(6) No, completely rainfed.

4.total agricultural field size that you have…………………..….. (rai)

<Overview of rice production and utilization for on average>

Note : Favorable field means area that has no risk from drought or flood which means perfect for production

Drought-prone field means area that has risk in insufficient water for production during crop season

Flood-prone field means area that has risk in flood occurring during crop ยพนกีแรนีseason

	Usual area	usual amount(bags, 1 bag = ..kg)	usual yield
5.Total rice wet season field size……………… (rai) (usual years)	5.1 Favorable field…….rai (= ....%)		yield I usually gain…………………kg/rai

	5.2 Drought-prone field…rai(=…..%)		yield I usually gain…………………kg/rai
	5.3 Flood-prone field……rai (=….%)		yield I usually gain…………………kg/rai

	Area 2016WS		Amount per rai(bags, kg/bag) (2016WS)	Yield 2016WS
6.Total rice 2016 wet season field size……………… (rai)	6.1 Favorable field.……rai (= ....%)	……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
	6.2 Drought-prone field…rai(=…..%)	……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
				yield…………kg/rai
	6.3 Flood-prone field……rai (=….%)	……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
		……….Variety…….rai		yield…………kg/rai
				yield…………kg/rai

	Area 2016DS		Amount per rai(bags, kg/bag) (2016DS)	Yield 2016DS

7. Total rice 2016 dry season field size……………… (rai)	7.1 Favorable field…….rai (= ....%)	……….Variety…….rai		yield………..kg/rai
	7.2 Drought-prone field…rai(=…..%)	……….Variety…….rai		yield………..kg/rai
	7.3 Flood-prone field……rai (=….%)	……….Variety…….rai		yield ………kg/rai

	Area 2015WS		Amount per rai(bags, kg/bag) (2015WS)	Yield 2015WS
8. Total rice 2015 wet season field size……………… (rai)	8.1 Favorable field…….rai (= ....%)	……….Variety…….rai		yield………..kg/rai
		……….Variety…….rai		yield………..kg/rai
		……….Variety…….rai		yield………..kg/rai
				yield………..kg/rai
	8.2 Drought-prone field…rai(=…..%	……….Variety…….rai		yield………..kg/rai
		……….Variety…….rai		yield………..kg/rai
		……….Variety…….rai		yield………..kg/rai
				yield………..kg/rai
	8.3 Flood-prone field……rai (=….%)	……….Variety…….rai		yield………..kg/rai
		……….Variety…….rai		yield………..kg/rai
		……….Variety…….rai		yield………..kg/rai
				yield………..kg/rai

Rice production and income of household in wet season 2016

	Amounts (kg, bags, bucket)	Memo (1 bags/bucket = …….kg)
9.total rice production ………..……….(kg/season)	* write unit and calculation result	
10.home consumption ……….(kg/season) …………………….variety …………………….variety	………………………… …………………………	
11.seed for next season……. (kg/season)		
12.sale as paddy rice for eating (kg/season) …………………Variety……..….(kg/season) …………………Variety…….….(kg/season)		*refer unit of this year Unit price…………Baht/kg paddy rice Unit price…………Baht/kg paddy rice
13.sale as milled brown/white rice for eating (kg/season) …………………Variety…….….(kg/season) …………………Variety…….….(kg/season)		Unit price…………Baht/kg brown/white rice Unit price…………Baht/kg brown/white rice
14.sale as paddy rice for seed(kg/season)…………………Variety…….….(kg/yr)		Unit price ………… Baht/kg

Rice production and income of household in Dry season 2016

	Amounts (kg, bags, bucket)	Memo (1 bags/bucket = ….kg)
15. total rice production ………(kg/season)	* write unit and calculation result	
16. home consumption ……….(kg/season) …………………….variety …………………….variety	………………………… …………………………	
17. seed for next season……. (kg/season)		
18.. sale as paddy rice for eating (kg/season) …………………Variety……..….(kg/season) …………………Variety…….….(kg/season)		*refer unit of this year Unit price…………Baht/kg paddy rice Unit price…………Baht/kg paddy rice

19.. sale as milled brown/white rice for eating (kg/season) …………………Variety………..(kg/season) …………………Variety………..(kg/season)		Unit price…………Baht/kg brown/white rice Unit price…………Baht/kg brown/white rice
20.. sale as paddy rice for seed(kg/season) …………………Variety………..(kg/season)		Unit price ………… Baht/kg

Q21-23 Only use for NP site

21. Total working hours per Rai of each planting method from 2014 wet season to 2016 wet season.

	Transplanting method	Direct seeding	2-wheel drill seeder	4-wheel drill seeder
Total working hours Example	16 hours/Rai	3 hours/Rai		
Record	2 labors* 8 hours(1 day)	Calculate from 1 labors* 3 hours		

Recording seed rate as (………kg/rai) is a standard. If farmers should prefer to answer by bag ·container numbers per rai, memo how much kg for 1 bag ·container (1 bag ·container = …. Kg), and record by (………. Bags/rai).

22.How much seed rate (kg/rai) for broadcasting?

………. kg of dry seed in ……….. rai of field = …………….kg/rai

(list all varieties)

23.How much seed rate (kg/rai) for drill-seeding by machine?

………. kg of dry seed in ………. rai of field

List of Fertilizer used for total household rice farming (per total rice area)

2015 wet season and 2016 wet and dry season are similar

(1) Yes (0) No. specify by writing separately below…………………………

24.Basal organic fertilizer (e.g., farmyard manure, before land preparation)

Timing…………………………, Fertilizer name ……………………………………

Amount…………………………… kg

Organic fertilizer at other timing (e.g., farmyard manure

Timing…………………………, Fertilizer name ……………………………………

Amount…………………………… kg

1st fertilizer (e.g., for TP, before or after TP, for DS, 1 month after sowing)

Timing…………………………, Fertilizer formula ……………………………………

Amount…………………………… kg

2nd fertilizer (e.g., for TP, tillering or panicle initiation, for DS, tillering)

Timing…………………………, Fertilizer formula ……………………………………

Amount……………………………. kg

3rd fertilizer (e.g., for TP, panicle initiation or booting, for DS, panicle initiation …)
Timing…………………………, Fertilizer formula …………………………………….
Amount……………………………. kg

4th fertilizer (e.g., for TP, maybe not, for DS, booting or maybe not)
Timing…………………………, Fertilizer formula …………………………………….
Amount……………………………. kg

List of pesticide used

25. synthetic pesticides use

*Ask for wet season first. Then for dry season rice farmers, ask the information for dry season.

Wet season	Dry season
• Regularly used pesticides (circle) herbicide, insecticide, fungicide, rodenticide, others	• Regularly used pesticides (circle) herbicide, insecticide, fungicide, rodenticide, others
• Sometimes used pesticides (circle) herbicide, insecticide, fungicide, rodenticide, others	• Sometimes used pesticides (circle) herbicide, insecticide, fungicide, rodenticide, others
• No use of pesticides (circle) herbicide, insecticide, fungicide, rodenticide, others	• No use of pesticides (circle) herbicide, insecticide, fungicide, rodenticide, others

26. natural pesticide use(circle)

Regularly, sometimes, no use

27. natural enemy(circle)

Regularly, sometimes, no use

Total Expenditure of rice farming of household

Farming work	Ranking expenditure you spent most(1) moderate(2), less(3)	labor expenditure ………(Bhat/season) " Ask if farmer spend differently by season and note the different.	Non- labor cost (buying, rental payment, etc.) " Ask if farmer spend differently by season and note the different.	Total Expenditure
28.Land preparation				
field burning	-			

ploughing +harrowing, etc.	2			
29.Growing rice				
Seed				
Direct seeding	2			
nursery seedling (transplanting)	1			
transplanting	1			
fertilizer application	2			
Weeding	1			
Herbicide application	3			
insecticide application	-			
Fungicide application	-			
Other pesticide application (……….)	-			
harvesting	1			
threshing	2			
drying	3			
polishing	-			
Others	-			

Non-l rice income

30. sales of non-rice agricultural products Product …………………….. amount…..……..(kg/yr) Product…………………….. amount…..……..(kg/yr) Product…………………….. amount…..……..(kg/yr)	Unit price ………. Baht/kg Production cost………. Unit price ………. Baht/kg Production cost……….. Unit price ………. Baht/kg Production cost………..	Total income from non-rice agriculture…………Baht/yr
31. non-agricultural income Job name …………………………… Job name …………………………… Job name …………………………… Job name ……………………………	…………………Baht/year …………………Baht/year …………………Baht/year …………………Baht/year	Total income from non-agriculture…………Baht/yr

Part B Household economic aspect, livelihood and its priority, type of farmer

1. Please tell me about your livelihood and how you live
   (1) My livelihood bases on utilizing resource I have in my household. I can survive without depending on selling crops or working outside.
   (2) My livelihood depends on rice selling along with selling other crops
   (3) My livelihood depends on rice selling along with non-agriculture
   (4) My livelihood depends on rice selling along with selling other crops and non-agriculture
   (5) My livelihood depends on non-agriculture. (working outside, getting money from son/daughter)
   (6) My livelihood depends on rice selling only(100%).

2. Main source of your income
   (4) Rice
   (5) Rice equally to non-rice crop, or rice equally to non-agriculture
   (6) Non-rice agriculture (e.g., non-rice crops)
   (7) Non-agriculture (Please specify ………………………………)

3. Can you tell me the situation of your household economic.
   (1) I have big expenses (loan, borrowing) or debt to pay.
   (2) I have much expenses apart from daily life (Children tuition fee, etc.)
   (3) I do not have much expense apart from daily life.

4. Minimum money required to spend per year (for household economic to be survived)
……………………………… Baht.

5. Do you think your household income alone from crop selling or non-agricultural income at present is enough for household livelihood?
   (0) Not enough at all
   (1) Not enough but can survive somehow
   (2) Enough for well-being livelihood/having satisfied life. (Can get things you want for your livelihood)

6. Does your household at present suffer from shortage of food for consumption at present? Or in any months of the year?
   (5) No. I have never suffered such shortage.
   (6) I suffered in the years of severe climate disaster or pest but in normal years never.
   (7) I suffered in the years that crop (that I grow) market price is very low.
   (8) Yes, I sometimes suffer (Please indicate which months ……………………….(Input all months name such as April and May).

7. Do you work in field along rice growing season?
   (1) Yes, I go to field almost every day to farming works or checking or take caring my field
   (0) No, I go only at growing and harvesting time. I do not visit my field much.

8. What is the priority and important problem relating to your farming as a farmer to solve now? (Not include public, politics, social problem, etc.) Select which is close from list

(1). Rice farming technical problems for production (select one)

a. Pest (weed, insect, disease, rodent, etc)

b. Variety

c. low yield

d. unpredictable climate conditions or damage relate to climate such as drought, flood, etc.

(2). Rice farming economic problems

a. Low income due to low rice price

b. Low income due to limited rice sale

c. High expenditure of rice farming (Specify 1 or 2 items) …………………………….

(3). Non-rice farming technical and economic problems (Specify…..e.g. poverty, debts)

(4). Socio-economic related problem such as strength of farmer group, establish farmer cooperative for rice sale in community, etc.

(0) No problem

Part C Test and Openness to technology or changing farming practice

1. Have you ever attended the flavor taste of many rice varieties meeting from project? (Flood and drought tolerant varieties)

(1) Yes

(0) No

2. Have you ever visited or attended rice varieties or machine experimental plot meeting from project? (Flood tolerant, and drought tolerant varieties, seeder)

(1) Yes

(0) No

3. For above, please tell me the reason why you visited or tasted (If farmer want to answer (1), and (2) ask them to rank the order which is the most priority expectation of them)

(1) I want to know or hear more about new technology or varieties

(2) I thought there is specific solutions or technology or technical advices for my farming during the event

(3) I just needed general technical advices for my farming. (This does not relate to new technology what the event done, but I think it a chance to get some advice or discuss with researcher)

(4) The events were attractive because they provide souvenir/return.

(5) The events were attractive as my neighbors attended.

4. Tell me if you tested the above technologies willingly by yourself (not just providing field for experiment)

	Project conducting year					Overall evaluation of the test
Tested technology from Boonrat's project	2013	2014	2015	2016	2017(will test) write supporting action such as borrowing seed, etc.	

-Variety						
Flood tolerant						
Drought tolerant						
RD18						
……….						
……….						
-Drill seeder						
-Utilization of rain gauge (rainfall record) data						
Tested new technology of IRRI project (only NP) -Drill seeder						

If you answer Yes in E1 and E2 but not do E4, please tell me why you did not test the technologies above.

5. For variety technology.

(1) I am interested but the technology does not match my needs
  a. Not match with my field conditions
  b. Not match with market conditions (e.g., quality)
  c. Not match with my taste standard (I do not like the flavor for self-consumption)
  d. Not match with my livelihood as I do not have to innovate my rice farming much
(2) I am interested and the technology looks good but I have not got the materials
(0) I am not interested. Explain …………………………………………….… (one possibility is self-consumption oriented and less needs for technology innovation)

6. For drill seeder technology.

(1) I am interested but the technology does not match my needs
  a. Not match with my field conditions
  b. Not match with profitability (e.g., investment, cost-benefit)
  c. Not match with my ability (e.g., I can not handle as it is too difficult for operation, I have no strength)
  d. Not match with my livelihood as I do not have to innovate my rice farming much
  e. Not match with my personal working style(e.g. I am lazy and don't want to learn new method)
(2) I am interested and the technology looks good but I have not got the machine
(3) I am not interested. Explain ………………………………………………

7.What kind of rice technology you need or want to adopt most.

(1) Favorable taste varieties with high yielding under wet season condition that I have which no need to relate to market.
(2) Favorable taste varieties with high yielding under wet season condition that I have which has market value.
(3) Cost or Expenditure saving
(4) Labor (working hours) saving
(5) Easier or more convenient to my process of production
(6) Others. Explain………….
(0) I don't need any. I am fine with my farming at this stage.

Part D Climate damages and adaptation to climate variability and extreme climate incidences

Please tell about your severe rice yield reduction from past due to extreme climate incidences (not simple yield reduction)

1. Maximum yield reduction you had ever got (experience in whole life) due to extreme climate incidences (e.g. flood) ……………………….in……………year

Type of crop loss e.g. crop death or complete failure of yield formation

……………………………………………………

You think this yield reduction is mild / moderate/ severe (select one)

Yield reduction ……………. /rai

Calculate from crop loss……………..…rai per total planted area I grow that year………….. rai

I got total …………………. bags while it should be total ……………. bags if this extreme climate incidence did not happen

Is this usually happening to you or not

(1) Yes write how often every…………… years (e.g. every year, every 2-3 years, in recent 5 years only)

(0) No write how often every…………… years (e.g. once in 40 years)

Recognition in climate variability and climate change

3. Do you think climate conditions have became more variable and more unpredictable compared with the past?

(1) Yes. Explain how …………………………………………….

Does it make your rice farming more difficult? (Yes…………… No………………)

(0) No.

4. Have you ever thought that you want to cope or do something with the problem caused by climate variability?

(2) Yes.

(2) No.

5. Have you taken some actions to cope with problem occurring in your rice farming caused by climate variability?

(3) Yes, I have done, and it has worked well to my farm. Tell what you have done…………………………

Why do you think it has worked well? ……………………………………………………………

(2) Yes, I have done, but it has not worked well with my farm. Tell what you have done…………………………

Why do you think it has not worked well? ……………………………………………………………

(1) Yes, I have done, but I still have not know the result yet. Tell what you have done…………………………

(1) No, I have never taken any actions.

Why have not you taken any actions? ……………………………………………………………

Scientists predict that climate conditions will change in longer term, known as “climate change”.

6. Have you ever heard this long term climate change and have you ever thought you want to cope or do something with the problem caused by long term climate change?

(3) Yes.
(3) No.

7. Have you taken, or are you going to take some actions to cope with long term climate change predicted to occur?

(2) Yes. Explain why and what you do …………………………
(2) No. Explain why ……………………………….

PART E Status and responses with regard to mitigation by stopping burning fields

1. Did you burnt and are you going to burn rice field in

1.11 2015 Wet season	1.21 2016 Wet season	1.31 2017 Wet season
(1) Yes (0) No	(1) Yes (0) No	(1) Yes (0) No
1.12 2015 Dry season 2016	1.22 2017 Dry season	1.32 2018 Dry season
(1) Yes (0) No	(1) Yes (0) No	(1) Yes (0) No

2. Do you know that field burning practice produces a gas and its increase in the atmosphere causes long-term temperature rises which may affect climate conditions? (incase new farmer, read Part9 before and ask whether they just know now or know before we read)

(3) Yes
(2) No (new farmer never known before)

3. Do you hire tractors to plough/harrow your field for land preparation before starting rice season (1) Yes (0) No

4. If you burnt, please tell me reason why you burnt it.

(1) Labor saving (because I have few household labors)
(2) Money saving than hiring labor to prepare the land by hand
(3) It is convenient for farm preparing. (I have labor and money but I prefer burning because it easy and convenient)
(4) It is time saving for farm preparing. (I have labor and money but I prefer burning because it is time saving)
(5) It is convenient for preparing new crop season such as easier for plough and harrowing land .
(6) It is convenient and cheaper when hiring machine for plough and harrowing when preparing new crop season.
If I do not burn the tractor owner will charge me more for ploughing cost.
(7) Others. Please specify…………………………………………………

5. If you burnt at present, please tell in which condition your will change your practice of burning (stop burning)

(1) If there is any alternative method that could save working labor (because I have few household labors) rather than burning
(2) If there is any alternative method that is money saving rather than burning
(3) If there is any alternative method that It is convenient for farm preparing rather than burning (Farmer has labor and money but he prefers burning because it easy and convenient)
(4) If there is any alternative method which is time saving for farm preparing rather than burning (Farmer has labor and money but he prefers burning because it is time saving)
(5) If there is any alternative method which is convenient for me for preparing new crop season such as easier for plough and harrowing land rather than burning.
(6) If there is any alternative method which is convenient, paying same cost or cheaper when hiring machine for plough and harrowing when preparing new crop season.
(7) Others. Please specify…………………………………………………..

6. If you do not burn, please tell me reason why you do not burnt it.

(3) I can easily prepare land without burning
(4) I know burning is convenient for land preparation but I do not like it because it will kill many living creatures
(5) I know burning is convenient for land preparation but I do not like it because it will degrade soil quality.
(6) I know burning is convenient for land preparation but I do not like it because it will produce smoke and polluting environments.
(7) I know burning is convenient for land preparation but I do not like it because it will increase gas emission which affect global climate.

Others. Please specify…………………………………………………

Farmer's Address…………..……………………………………………………………

Mobile number…………………………………

Interviewer's comment on the farmer's responses;

(D) all very clear

(E) OK

(F) some unclear answers

For (C), specify unclear question No…………………………………………………

Collaboration of farmer

(D) Good

(E) Fair

(F) **Not good**