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Factors Associated with Farmers' Adaptation Practices to Weather Variability in Rice-based Farming System in Myinmu Township, Sagaing Region, Myanmar

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ABSTRACT. Due to its dependence on agro-climate condition, the rice-based farming system in Myinmu Township in Central Dry Zone (CDZ), Myanmar is one of the sectors that is vulnerable to weather variability. This study aimed to analyze the association of adaptation practices on production and income of rice farmers in Myinmu Township. One hundred fifty farmers were surveyed and key informant interviews were conducted to gather primary data. Results revealed that most farmers received agricultural and weather information from fellow farmers, extension agents from the Department of Agriculture, attendance to group meetings, and mass media channels such as radio and television. Adaptation practices were categorized into changing cultivated varieties and crops, changing farming systems, conserving rain water, improving irrigation systems, and engaging in non-farm activities. Factors associated with adaptation practices were type of agriculture (ecosystem), total cultivated area, total rice cultivated area, credit accessibility, attendance to training programs and access to inputs. Overall, results revealed an observable pattern of increased weather variability and minimal adaptation practices, which calls for a more vigorous extension intervention to promote practices that can minimize the impact of weather variability on farmers' production and income.

Keywords: *adaptation practices, sources of information, extension framework*

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INTRODUCTION

Global climate change is reshaping crop production and the farming communities (Sharma, 2015), which affects the availability of water for irrigation, amount of solar radiation for plant growth, and pest population (Dhaka, Chayal, & Poonia, 2010). It is predicted that climate change will trigger the increased occurrence of extreme weather events such as drought and flood, and, consequently, worsen the poverty situation in many rice-farming communities (ADAS UK Ltd. and University of Leeds, 2013).

Myanmar is among the most vulnerable to the impacts of weather variability as it has experienced rainfall scarcity, irregular rainfall, heat stress, drought, flooding, seawater intrusion, land degradation, desertification, deforestation, and other natural disasters (Kywe, Hom, Htwe, Hein, & Than, 2015). It has several variant climate zones such as Central Dry Zone (CDZ), Coastal, Hilly, and Delta regions. Annual rainfall intensity is far lower than normal average in Central Myanmar and this area also suffers from below average and uneven rainfall distribution, and high temperature of up to over 40°C during summer (Climate Change Management, 2010 as cited in The, 2012). In recent years, rainfall has become increasingly erratic with significant declines in total rainfall amount that led to reduced water availability for consumption and farming (Livelihoods and Food Security Trust Fund, 2014).

Mary and Majule (2009) argued that while climate change is global, adaptation is local and context-specific. The Intergovernmental Panel on Climate Change (IPCC) defines climate change adaptation (CCA) as "the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (Intergovernmental Panel on Climate Change, 2007, p. 6). Adger et al. (2007, p. 720), citing the Fourth Assessment Report of the IPCC, highlighted that CCA refers to "actual adjustments or changes in decision environments, which might ultimately enhance resilience or reduce vulnerability to observed or expected changes in climate."

Singh and Tyagi (2003), as cited in Billah (2013), reported that farmers with reasonable adaptive capacities had little constraints in adapting to climate change. If not handled properly, however, these constraints can potentially reduce productivity. Thus, this study contends that farmers need to have adaptive capacities, which the agricultural extension agency can help address. Central to this study, therefore, is the need to examine the role of extension in dealing with issues relating to weather variability adaptation in the rice-based farming system.

In Myanmar, agricultural extension is primarily responsible for providing educational activities, collecting agriculture-related data, enforcing standard weights and measures, procuring and distributing farm inputs such as high-quality seeds, fertilizers, and insecticides. However, adaptation to weather variability is a complex activity that requires more than addressing a component technology or providing component inputs.

Due to the importance of adaptive capacities and adaptation practices in addressing weather variability, this study aimed to discuss the sources of information on adaptation practices to weather change; determine the extension support received; examine the factors associated with farmers' adaptation practices; analyze the association of adaptation practices on production and income of rice farmers; and design an extension framework to promote rice farm adaptation strategies to weather variability.

METHODOLOGY

Theoretical Framework

Ramamasy and Baas (2007) defined climate as a statistical information, a synthesis of weather variation focusing on a specific interval. Climate is usually based on the weather in one locality averaged for at least 30 years. Climate change, on the other hand, refers to direct or indirect activities of humans, leading to changes in global atmosphere components and changes of natural climate variability observed over comparable time (United Nations Framework Convention on Climate Change, 2007). Climate change would lead to more extreme climate events, compromising crops, food security, shelter, and livelihoods (Intergovernmental Panel on Climate Change, 2007). An extreme weather event refers to meteorological conditions that are rare for a particular place and/or time, such as an intense storm or heat wave. An extreme climate event, on the other hand, is an unusual average over time of a number of weather events, for example heavy rainfall over a season (Pittock, 2003).

An effective way to address the impacts of weather variability is to integrate adaptation measures into sustainable development strategies to reduce the pressure on natural resources, improve environmental risk management, and increase the social well-being of the poor. Adaptation means the adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities (Intergovernmental Panel on Climate Change, 2001). Adaptation also refers to the process of adapting and the condition of being adapted. Societies have a long record of adapting to the impacts of weather and climate through a range of practices that include crop diversification, irrigation, water management, and disaster risk management (Adger et al., 2007).

Regarding human dimensions, Smit (1993) noted that adaptation involves adjustments to enhance the viability of social and economic activities and reduce their vulnerability to climate, including its current variability and extreme events as well as longer term climate change. Adaptation to climate change takes place through adjustments to reduce vulnerability or enhance resilience in response to observed or expected changes in climate and associated extreme weather events. Adaptation occurs in physical, ecological, and human systems. It involves changes in social and environmental processes, perceptions of climate risk, practices and functions to reduce potential damages or to realize new opportunities (Adger et al., 2007).

Some adaptation measures are undertaken by individuals, while others are planned and implemented by governments on behalf of societies, sometimes in anticipation of change but mostly in response to experienced climatic events, especially extremes (Adger, Huq, Brown, Conway, & Hulme, 2003; Kahn, 2003; Klein & Smith, 2003). There is a long record of practices to adapt to the impacts of weather as well as natural climate variability on seasonal to inter annual timescales – particularly to the El Niño-Southern Oscillation (ENSO). These include proactive measures such as crop and livelihood diversification, seasonal climate forecasting, community-based disaster risk reduction, famine warning systems, insurance, water storage, and supplementary irrigation (Mace, 2006).

According to Mace (2006), technological adaptation can serve as potent means of adapting to climate variability and change. New technologies can be developed to adapt to weather variability, and the transfer of appropriate technologies to developing countries forms an important component of the UNFCCC. However, technologies are not a panacea. Adaptation options that are effective in one location may be ineffective in other places, or may create new vulnerabilities for other places or groups.

Conceptual Framework

The conceptual framework for this research is presented in Figure 1. Adaptation refers to farm and non-farm adjustments in relation to actual or expected changes in weather variability. The weather variability phenomenon investigated was determined based on the frequency of occurrence using the review of climate data for the past 30 years. Climate data showed that drought, flooding, and too high temperature were the most frequent weather events in the area of study. Employing any adaptation measure is hypothesized to be associated with socio-demographic characteristics of the farm household. The selected socio-demographic factors, which were based on review of literature, included household size, educational attainment, farm experience, type of ecosystem, total cultivated area, total cultivated area for rice, and credit access. Additionally, the choice of adaptation measures will also depend on access to information, training programs, and agricultural inputs from different institutions. These adaptation practices are hypothesized to be associated with production and income.

Research Sites

A field survey was conducted in Myinmu Township, Sagaing District, Sagaing Region in Central Dry Zone (CDZ) of Myanmar. The study area was located in Myinmu Township having a total population of 113,339 with 25,278 households. The respondents came from 10 purposively selected villages (Figure 2).

The general criteria in choosing these villages were the geographical stratification of Myinmu Township (Figure 2) and the extent of occurrences of extreme weather events. Occasionally, all 10 villages suffer from drought during the dry season and flood during the rainy season. Except for the villages of Kan Pyar, Kan Taw, and Pe Ku, some areas for crop cultivation in the other seven villages are affected by seasonal floods especially when Mu and Irrawaddy (Ayeyarwady) rivers overflow. This usually happens from June to October; peak

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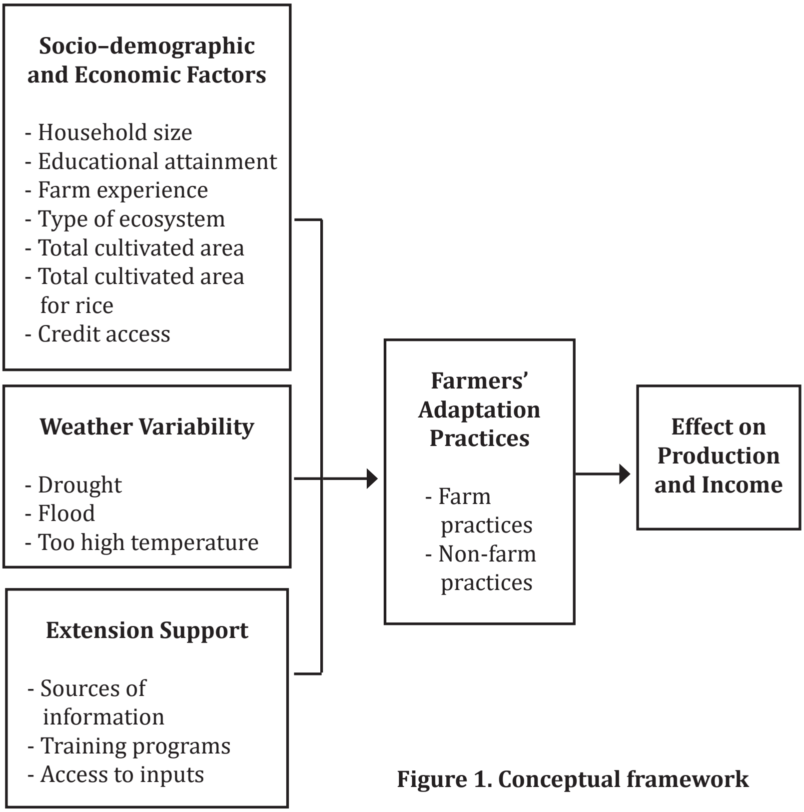


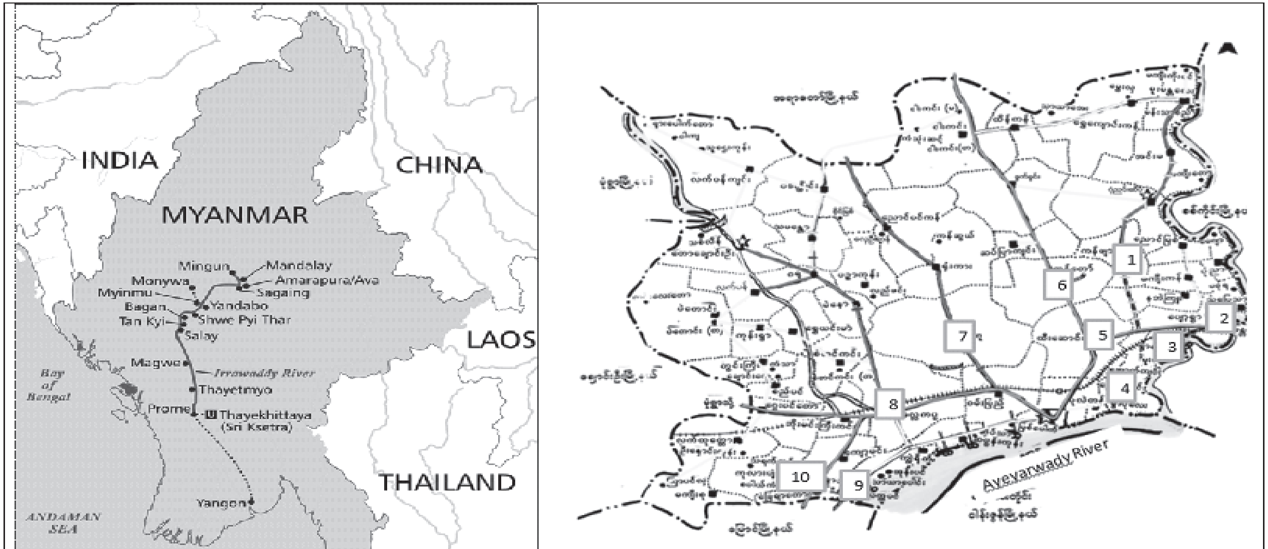
Figure 1. Conceptual framework

month is August. On the other hand, some cultivated areas in the villages of Kan Pyar, Kan Taw, and Pe Ku are flooded occasionally in rainy season because of poor engineering designs of embankments, dams, and canals.

Respondents of the Study

The total number of sampled households was calculated using the Yamane's (1973) formula. With a 25,278 households and 10 percent margin of error, a total of 100 sample size was computed.

While the computation suggested 100 respondents, the researchers opted to increase the number of respondents to 150. Hence, 15 respondents per village were selected using simple random sampling.



Source: DOA, Myinmu Township

Study Areas:

1. Kan Pyar Village	3. Mu Wa Ywar Htaung Village	5. Htee Saung Village	7. Pe Ku Village	9. Let Ka Pin Village
2. Pyawt Village	4. Nyaung Yin Village	6.Kan Taw Village	8. Allakapa Village	10.Chay Yar Taw Village

Figure 2. Myanmar relative to its neighboring countries (left); Myinmu Township highlighting the 10 villages covered by the study (right) (Department of Agriculture, 2017)

Data Gathering Instrument in Research

Field survey was conducted from June to July 2017. Primary data were obtained through survey and interviews. The survey questionnaire included socio-demographic and socio-economic characteristics of farmers, major impacts of weather variability over the past 5 and 10 years, perceived impacts of weather variability on crop production, adaptation of farming practices in response to climate change, constraints faced by farmers in adapting to weather variability, and extension support received. Primary data were collected from rice growing farmers, while secondary data were gathered from the Department of Agriculture (DOA) and the Department of Meteorology and Hydrology (DMH) in Myinmu Township and from published and unpublished documents from other government agencies, journals, books, and other references. Focus group discussions (FGDs) and key informant interviews (KIIs) were also conducted in 10 villages. The discussions revolved around resources available in the community, perceptions of climate change and weather variability, experiences and knowledge on weather variability, adaptation measures, adaptation constraints, agricultural extension services, and forms of institutional support.

Statistical Analysis

The data collected were coded and analyzed using Microsoft Excel version 16.0, Statistical Package for Social Sciences (SPSS) version 20.0, and STATA Version 14.1. STATA is a command and menu-driven statistical package designed for data management, data visualization, and statistical analyses (Stata Corp, 2019). SPSS is a popular and widely used package to code data within both academic and business circles as it is a versatile package that allows many different types of analyses, data transformations, and interpretation of results from a large sample size (Arkkelin, 2014).

Descriptive statistics such as frequency, percentage, mean, and standard deviation were used to describe the local patterns of rainfall variability and other variables. Correlation analyses among variables were performed to determine if association exists among variables. Spearman correlation analysis was employed to determine if monotonic association exists between variables measured such as some socio-demographic variables (education level, household size, farming experiences, total cultivated area and total cultivated area for rice) and adaptation practices in at least ordinal scale (Gibbons & Chakraborti, 2003). On the other hand, Chi-square Test of Independence was used to determine if association exists between two categorical variables such as crop production and family income and adaptation practices.

RESULTS AND DISCUSSIONS

Major Impacts of Weather Variability over the Past 5 and 10 Years

Table 1 shows the impact of weather variability over the past 5 and 10 years. Respondents reported increased occurrence of drought (69%) and high temperature (88%) in the past 5 years. In the past 10 years, almost the same trend was reported: There were observed increases in the occurrence of drought (70%) and high temperature (84%). Aside from the observations reported above, key informant interviews revealed that drought and high temperature occurred more frequently during the periods covered.

Perceived Impacts of Weather Variability on Crop Production

Agricultural production is among the major economic activities in the study area given that farmers' livelihoods depend on upland (rainfed) and lowland (irrigated) rice farming. Table 2 shows the impacts of weather variability on crop production as reported by the respondents. Drought and too high temperature led to water shortage that eventually resulted in yield reduction and soil degradation. Delayed monsoon rain, on the other hand, reduced the area for cultivation for monsoon crops. Moreover, floods lowered crop quality and caused yield loss.

Pest and disease infestation was the most serious problem in the study area followed by weed infestation due to weather variability. Nearly half (47%) of respondents indicated that their crop production was strongly affected by infestation of pest and diseases, while more than one-third (37%) noted that their crops were strongly affected by weeds. Less than one-fourth (20%) of the respondents indicated that their crop production was affected by water shortage.

In terms of crop quality reduction, only 15 percent of the respondents reported that they suffered strongly while the majority

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Table 1. Major impacts of weather variability over the past 5 and 10 years (n=150)

IMPACTS	PAST 5 YEARS						PAST 10 YEARS					
	DROUGHT		TOO HIGH TEMPERATURE		FLOOD		DROUGHT		TOO HIGH TEMPERATURE		FLOOD	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Increase	103	68.7	132	88.0	27	18.0	105	70.0	126	84.0	19	12.6
Decrease	11	7.3	3	2.0	20	13.3	10	6.7	2	1.3	19	12.6
Irregular	19	12.7	9	6.0	33	22.0	14	9.3	14	9.3	40	26.5
No change	17	11.3	6	4.0	70	46.7	21	14.0	8	5.3	73	48.3

Table 2. Perceived impacts of weather variability on crop production (n=150)

IMPACTS OF CLIMATE VARIABI-LITY	INCREASE PEST AND DISEASE		INCREASE WEED INFESTA-TION		WATER SHORTAGE		RE-DUCTION IN CROP QUALITY		REDUCED PLANTING AREA		CROP YIELD RE-DUCTION	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Very little	7	4.7	13	8.7	73	48.7	47	31.3	129	86.0	61	40.7
Little	19	12.7	22	14.7	18	12.0	46	30.7	19	12.7	59	39.3
Moderate	46	30.7	52	34.7	22	14.7	33	22.0	1	0.7	20	13.3
Strong	70	46.7	55	36.7	30	20.0	22	14.7	0	0	4	2.7
Very strong	8	5.3	8	5.3	7	4.7	2	1.3	1	0.7	6	4.0

suffered "little" or "minor reduction." Most (86%) of the respondents reported that they reduced their planting area, which they considered as a minor impact of weather variability. While most farmers encountered problems relating to pests, diseases, and weeds, nearly half (41%) of them reported that crop yield reduction was insignificant.

The results of the FGD offer an explanation to the minor yield reduction experienced by farmers despite being strongly affected by weather extremes. It was found that there were several sources of irrigation in the study area such as a reservoir, tube well, and the River Water Pumping Station. A farmer from Pyawt said:

> *"We used chemical insecticides and/or herbicides to manage insect pests and weeds, respectively. When we were confronted by water shortage because of drought during the planting period, we sourced water from the River Water Pumping Station. If there are difficulties getting water from that Station, we used a pumping system to irrigate water in the field by digging a tube well."*

Farmer's Communication Exposure

Sources of information on farmers' adaptation practices. Extension field staff members used a variety of activities and methods in disseminating to farmers new agricultural technologies and farming adaptation practices. Information sources relating to adaptation practices are presented in Table 3.

Under interpersonal channel, most (72%) of the respondents reported that they accessed information from their co-farmers regularly. Similarly, more than half (55%) of the farmers said that they accessed information from agricultural extension agents (AEA) from DOA on a regular basis. In sum, the farmer-farmer mode of accessing information appears to be the most effective among the sources of interpersonal information.

Group meetings were a regular source of information for more than one-third (37%) of the farmer-respondents. One finding that should be highlighted under the Group category is that a large majority (95%) of the farmer-respondents reported that they have never accessed information through the farmers field school (FFS).

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Table 3. Percent distribution of accessibility of information sources (n=150)

SOURCES OF INFORMATION	REGULARLY		OCCASIONALLY		RARELY		NEVER	
	No.	%	No.	%	No.	%	No.	%
Interpersonal[a]								
AEA from DOA	83	55.3	38	25.3	7	4.7	22	14.7
AEA from NGOs/INGOs	21	14.0	33	22.0	15	10.0	81	54.0
AEA from company	29	19.3	70	46.7	9	6.0	42	28.0
Farmer to Farmer	108	72.0	26	17.3	3	2.0	13	8.7
Group[a]								
Group meeting	55	36.7	56	37.3	7	4.7	32	21.3
Demonstration meeting	23	15.3	34	22.7	15	10.0	78	52.0
Field day	19	12.7	24	16.0	8	5.3	99	66.0
Farmers field school	-	-	2	1.3	5	3.3	143	95.3
Training course	12	8.0	19	12.7	9	6.0	110	73.3
Mass Media[a]								
Radio	85	56.7	33	22.0	6	4.0	26	17.3
Television	77	51.3	34	22.7	5	3.3	34	22.7
Print media	33	22.0	42	28.0	10	6.7	65	43.3

[a]Multiple response
Legend:
AEA: agricultural extension agents
DOA: Department of Agriculture
INGOs: International NGOs
NGOs: Non-government organizations

Interestingly, most (73%) of them also said that they have never accessed information from training courses.

Radio (57%) and TV (51%) were accessed regularly by farmers. Nearly half (43%) of the farmer-respondents have never accessed information from the print media.

Table 4. Percent distribution of communication channel preferences

MOST PREFERRED CHANNEL	NO. (n=150)	%
Interpersonal		
AEA from DOA	30	20.0
AEA from NGO/INGOs	14	9.3
AEA from company	2	1.3
Farmer to farmer	10	6.7
Group		
Group meeting	28	18.7
Demonstration meeting	7	4.7
Field day	10	6.7
Farmers field school	2	1.3
Training course	9	6.0
Mass Media		
Radio	18	12.0
Television	10	6.7
Printed media	10	6.7

Farmers' communication channels. It was also in the interest of this study to ask for the farmer-respondents' most preferred sources of information by farmer-respondents. Summarized in Table 4, the findings are useful in informing communication plans relating to promoting adaptation practices. The AEA from DOA were mentioned by almost one-fourth (20%) of the respondents as the most preferred channel because they can ask directly and be able to clarify things immediately. Group meetings occupied the second position in the most preferred channels (19%), while radio came in third (12%). Farmers said that they prefer to get information from radio because they can easily listen to the weather and agricultural information being broadcasted. They can also carry it anywhere and listen to it.

Overall, interpersonal sources, particularly the AEA, were the most preferred. Okwu and Daudu (2011) noted that extension agents are preferred sources of information because they can outrightly respond to the technical issues raised by farmers. Mass media, especially the print media, is least preferred owing to the high number of farmers who only finished basic education.

Factors Associated with Adaptation Practices to Weather Variability

Association between the farmers' adaptation practices and socio-demographic and economic variables. Spearman correlation analysis was performed on selected socio-demographic and socio-economic variables concerning the respondents' 18 adaptation measures identified by farmers in the study sites (Table 5). The aim was to verify if association exists between these adaptation measures and the socio-demographic and socio-economic variables of farmers. Estimated Spearman rank-correlation coefficients and Chi-square test statistics are shown in Table 5.

Adaptation practices were categorized into changing cultivate varieties, changing farming system, rain water conservation, improving irrigation system, and non-farm adaptation activities. These adaptation practices were initially shortlisted from the list of adaptation farming practices gathered from review of literature and from interviews with the extension workers and key informant leaders.

Results revealed that type of ecosystem, total cultivated area, total cultivated area for rice, and credit availability were associated with some adaptation practices. Based on the analysis, there was an association between the frequency of intercropping and total cultivated area at 5 percent level of significance. With a reverse coding of 1 as practicing and 4 as not practicing, results showed that as the total cultivated area increases, the farmers are more likely to practice intercropping. In addition, there was also an association between the practice of crop rotation and total cultivated area for rice. As the total cultivated area for rice increases, the farmers are less likely to practice crop rotation. It appears that as farmers have larger farms, the propensity to adopt intercropping increases.

However, when the farm area is planted with rice alone, they prefer to plant rice all throughout the year. Ecosystem types were significantly associated with digging pond/well and with the use of pumps for irrigation at 1 percent level of significance. Pragmatically speaking, the chance that farmers who do not have access to irrigation would dig a well or use water pumps to address this issue is high. It can be inferred that total area cultivated for rice affected the decision to use a drainage system to manage water efficiently to ensure optimum crop growth. Lastly, credit availability was significantly associated with practicing crop diversification. This is understandable given that

Table 5. Measures of association between adaptation practices and different socio-demographic and socio-economic characteristics

ADAPTATION PRACTICES	EDUCATION LEVEL	HOUSEHOLD SIZE	FARMING EXPERIENCES	TYPE OF ECOSYSTEM	TOTAL CULTIVATED AREA	TOTAL CULTIVATED AREA FOR RICE	CREDIT AVAILABILITY
	rs	rs	rs	χ_c^2	rs	rs	χ_c^2
Changing cultivated varieties							
Drought-tolerant varieties	-0.0123	-0.0458	0.1423	0.313	-0.1271	-0.1032	0.354
Short-duration varieties	0.0844	0.1008	-0.0262	10.122	-0.0231	0.0058	2.276
Changing crops	-0.0046	0.0375	-0.0648	2.830	-0.0071	0.0268	2.589
Changing farming system							
Changing planting time	0.0231	-0.0392	-0.0493	10.922	0.0607	-0.0417	3.188
Changing planting method	-0.0295	-0.0728	-0.0527	3.910	0.0280	-0.1243	1.353
Practicing crop rotation	-0.0451	0.0243	0.1246	7.942	-0.1572	0.1754*	1.03
Practicing intercropping	-0.1066	-0.0703	0.1147	2.354	-0.1916*	0.0499	1.25
Practicing crop diversification	-0.0275	-0.0932	0.0586	5.446	-0.1380	-0.0511	9.78*
Homestead gardening	-0.1340	-0.0435	0.0404	6.581	-0.1030	-0.0008	4.801
Vegetable cultivation	-0.0910	-0.1447	0.0954	7.364	-0.0867	0.0528	0.192

*Significant at 0.05 level of significance
** Significant at 0.01 level of significance

Table 5. Continued

ADAPTATION PRACTICES	EDUCATION LEVEL	HOUSEHOLD SIZE	FARMING EXPERIENCES	TYPE OF ECO-SYSTEM	TOTAL CULTIVATED AREA	TOTAL CULTIVATED AREA FOR RICE	CREDIT AVAILABILITY
	rs	rs	rs	χ_c^2	rs	rs	χ_c^2
Rain water conservation							
Digging pond/well	-0.1200	0.0809	0.1535	12.209*	-0.0253	0.1200	2.865
Mulching with crop residue	0.1047	-0.0487	-0.0001	5.811	0.1046	-0.1157	0.241
Improving irrigation system							
Use of pumps for irrigation	-0.1221	0.1234	0.0370	20.638**	0.0150	0.1450	1.842
Use of drainage system	-0.0362	0.0728	-0.0504	4.419	0.0511	-0.1346	6.184
Non-farm activities							
Duck rearing	0.0369	-0.1469	-0.1428	5.810	0.0399	-0.0370	0.049
Engaging in trading activities	-0.1254	0.0666	0.1411	0.640	0.1392	-0.0002	0.014
Changing work (transportation)	-0.0059	-0.0951	-0.0225	5.649	0.1196	0.0243	0.273
Migration	-0.0422	-0.1072	-0.0767	5.800	0.0305	-0.0740	0.80

*Significant at 0.05 level of significance
** significant at 0.01 level of significance

farmers would need credit to buy inputs such as high-quality seeds and fertilizers. Yirga and Hassan (2010) noted that access to credit of a household indicates the availability of funds that will enable adoption of adaptive strategies.

Association between farmers' adaptation practices and information sources. The result of the Spearman rank correlation analysis shows the association between the adaptation practices and various information sources (Table 6). There was sufficient evidence that there existed a very weak positive monotonic association between using drought-tolerant varieties and getting information from demonstration at 5 percent level of significance. With a reverse coding of 1 as practicing and 4 as not practicing for adaptation practices and a reverse coding of 1 as regular source of information and 4 as not at all for source of information as farmers participate in demonstrations, they are more likely to use drought-tolerant varieties. In sum, it shows that the various sources of information were associated with famers' decision regarding changing cultivated varieties/crops in their farm as a response to weather variability.

As regards the changing of planting method, there was sufficient evidence that there existed a positive monotonic association with some information sources (AEA from non-government organizations [NGOs] or International NGOs [INGOs], demonstration, field days, group meetings, training course, and printed media) at 1 percent level of significance and 5 percent level of significance, respectively. This means that as farmers tend to use these as sources of information, they are more likely to change planting method. The strengths of associations ranged from very weak to moderate associations. Among the sources of information, attendance to demonstration had a moderate association with changing of planting method.

Results of the analysis further showed that there was a very weak positive monotonic association between mulching the soil with crop residue and AEA from NGOs/INGOs, group meetings, field days, and training course as sources of information at 5 percent level of significance. This means that as farmers tend to use these as sources of information, they are more likely to mulch the soil with crop residue.

The analysis also showed that there was sufficient evidence that there existed a positive monotonic association between using the drainage system and getting information from training course

Table 6. Summary of relationships between some adaptation practices and information sources

ADAPTATION PRACTICES	SOURCES OF INFORMATION												
	Interpersonal				Group					Mass Media			
	1	2	3	4	5	6	7	8	9	10	11	12	13
Changing cultivated varieties													
Drought-tolerant varieties	-0.0274	-0.0267	0.0323	-0.1520	0.0863	0.1655*	0.0489	0.1091	0.1169	-0.0249	0.0922	0.1079	0.0553
Short-duration varieties	-0.0147	-0.0112	-0.0110	-0.1277	0.0738	0.1402	0.1342	-0.0581	0.0171	-0.0411	-0.0193	0.0046	-0.0218
Changing crops	-0.0653	0.0812	-0.0919	0.0719	0.0246	0.0820	0.0653	0.0314	0.0545	-0.0363	-0.0915	-0.1774*	0.0764
Changing farming system													
Changing planting time	0.0808	0.0574	0.1143	0.0990	0.0273	0.1290	0.1345	0.0843	-0.0079	0.0274	0.0656	-0.0612	-0.0352
Changing planting method	0.0595	0.2164**	0.0786	-0.0059	0.1898*	0.4263**	0.3420**	0.0625	0.1891*	0.0589	0.0764	0.0386	0.1615*
Practicing crop rotation	-0.1572	0.0016	-0.0417	0.0015	-0.0943	0.0014	-0.0895	0.0814	0.0009	-0.0455	0.0504	0.0124	-0.0108
Practicing intercropping	-0.0522	0.0352	-0.0759	-0.0131	-0.0250	0.0146	-0.0012	0.0118	0.0889	-0.0813	0.0280	-0.0380	-0.0619
Practicing crop diversification	-0.0428	-0.0663	-0.0313	0.0164	-0.0007	0.0158	-0.0120	-0.0326	0.1050	-0.1305	-0.0612	-0.1238	-0.0067
Homestead gardening	-0.0360	0.0657	-0.1566	0.0515	-0.1193	-0.0842	-0.1496	-0.0608	0.1244	-0.0448	0.0866	0.0936	0.1030
Vegetable cultivation	0.1102	0.0713	-0.0772	-0.0169	-0.0464	-0.0612	-0.0554	-0.0052	0.0300	-0.0585	-0.0009	0.0144	0.0389
Rain water conservation													
Digging pond/well	-0.1577	0.0362	0.0489	0.0817	-0.1276	-0.0098	-0.0849	0.0384	-0.0704	0.0202	0.1499	0.1135	0.1218
Mulching with crop residue	0.1062	0.1863*	-0.0313	0.0324	0.1801*	0.1500	0.1819*	-0.0375	0.1858*	0.0186	-0.0468	0.0618	0.0978
Improving irrigation system													
Use of pumps for irrigation	-0.0151	0.0850	-0.0171	0.0161	0.0028	-0.0790	0.0532	0.0469	-0.0375	-0.0277	0.1017	-0.0013	0.1021
Use of drainage system	0.1105	0.0583	0.0121	0.0872	0.1308	0.0998	0.0531	0.1158	0.1611*	0.0226	-0.0484	0.0104	0.2280*
Non-farm activities													
Duck rearing	0.0903	-0.0790	0.0867	0.0745	0.1274	0.0863	0.1681*	-0.0489	0.0201	0.0263	-0.0338	-0.0013	-0.1017
Engaging in trading activities	0.0999	0.0051	0.1025	-0.0418	0.0568	0.1443	0.1148	0.2479**	0.0857	0.0096	0.0261	0.0958	0.1137
Changing work (transportation)	0.0018	-0.0081	0.0524	0.1255	0.1087	0.0319	0.0989	-0.0404	0.0637	0.0706	0.0273	-0.1382	-0.0224
Migration	-0.0265	-0.1044	0.0180	-0.0459	0.0764	0.0347	-0.0669	-0.0600	0.0141	0.0791	0.0954	0.0572	0.1618*

**Significant at 0.05 level of significance*
*** Significant at 0.01 level of significance*

Sources of Information:
1 - AEA form DOA
2 - AEA from INGOs, NGOs
3 - AEA from Agro chemical company
4 - Farmer to farmer
5 - Group meeting
6 - Demonstration
7 - Field day
8 - Farmers field school
9 - Training course
10 – Radio
11 – Television
12 – Farmers Channel
13 – Printed Media

and printed media at 5 percent level of significance. This means that as farmers tend to use these as sources of information, they are more likely to use the drainage system.

Meanwhile, non-farm activities such as duck rearing and getting information from field days had a significant positive very weak monotonic relationship at 5 percent level of significance. This means that as farmers tend to use field day as source of information, they are more likely to employ duck rearing. In addition, engaging in trading activities and getting information from FFS had a significant positive weak monotonic association at 1 percent level of significance. This means that participating in FFS affected farmers' decision to engage in non-farm activities as a way to cope with the adverse impacts of weather variability.

In sum, results cogently showed that the various sources of information are associated with famers' decision regarding changing cultivated varieties/crops, changing farming system, conserving rain water, and engaging in non-farm activities in their farm as responses to weather variability. Overall, information sources such as AEA from INGOs, NGOs, group meetings, demonstrating meetings, field days, FFS, training course, and printed media were associated with the decision to employ most of the adaptation practices.

Attendance to training programs and access to inputs. Knowledge of different agricultural information and technologies is important in adapting to weather variability. Farmers obtained information on these matters by attending training programs provided by public and private institutions. Among the training providers were the DOA, Agricultural Mechanization Department (AMD), and INGOs (e.g., World Hunger Health). Some of the topics relating to adaptation that were covered include the use of certified seeds and access to credit and farm machinery. The descriptive statistics for information and knowledge to adopt the adaptation practices to climate variability such as attendance to agriculture-related training programs and access to inputs provided by different organizations are shown in Table 7.

Most (67%) of the respondents reported that they have never attended any training program provided by the public sector through DOA, while about a third (33%) reported to have attended related training programs specific to the promotion of adaptation practices to weather variability. On the other hand, this may imply that only a

Table 7. Forms of access to institutional support

CHARACTERISTICS	NO. (n=150)	%
Attendance to training programs		
Yes	50	33.3
No	100	66.7
Access to inputs		
With access	48	32.0
Without access	102	68.0

few farmers showed interest to improve their knowledge and skills as regards adaptation practices to climate change. None of the farmers surveyed reported that they have attended a training on understanding the technical aspects of weather variability.

There were several input providers in the research site. For instance, there were public and private organizations that provided seeds to farmers through DOA. The AMD provided access to farm machines through custom hiring services or by selling them with different payment terms. Maung (2014) reported that the chance is high for farmers to adapt to weather variability by adjusting their farming practices if they were to seek institutional support. However, 68 percent of the respondents reported that they have no access to the inputs cited above.

Association of farmers' adaptation practices and attendance to training programs. Correlational analyses were conducted to identify the factors that are associated with the decisions of farmers in employing certain adaptation practices (Table 8). There was sufficient evidence that there existed an association between the training attendance provided by private or public sector through DOA and the mulching with crop residue at 1 percent level, p value = 0.010. Considering the raw data, the association means that a large number of farmers who do not attend training provided by private or public sector through DOA also do not practice mulching with crop residue. In addition, there was sufficient evidence that there was an association between the training attendance provided by private or public sector through DOA and the farmers' use of drainage system at 5 percent level of significance, p value= 0.033. The association means that a large number of farmers who do not attend training provided

Table 8. Measures of association among attendance of training program, access to input, and some adaptation practices

ADAPTATION PRACTICES	ATTENDANCE T0 TRAINING PROGRAMS		ACCESS TO INPUTS	
	χ_c^2	p-value	χ_c^2	p-value
Drought resistant varieties	7.4073	0.060	6.2515	0.100
Short duration varieties	1.6549	0.647	4.4038	0.221
Changing crops	2.4236	0.489	5.9766	0.113
Changing planting time	0.2226	0.974	5.7647	0.124
Changing planting method	2.7896	0.425	5.9625	0.113
Practicing crop rotation	3.7389	0.291	11.2462**	0.003
Practicing intercropping	2.6542	0.265	5.4403	0.066
Practicing crop diversification	1.8968	0.594	3.8770	0.275
Homestead gardening	6.1798	0.103	0.9552	0.812
Vegetable cultivation	1.0348	0.793	2.3481	0.503
Digging pond/well	5.5705	0.062	1.3269	0.515
Mulching with crop residue	11.3282**	0.010	1.7171	0.633
Use of pumps for irrigation	0.1160	0.944	0.7315	0.694
Use of drainage system	8.7355*	0.033	2.2497	0.522
Duck/poultry rearing	0.4888	0.783	2.4790	0.253
Engaging in trading activities	2.5511	0.279	1.0442	0.593
Changing work (transportation)	4.1970	0.241	8.7606*	0.033
Migration	2.2861	0.319	2.5051	0.286

*Significant at 0.05 level of significance
**Significant at 0.01 level of significance

by private or public sector through DOA also do not use the drainage system. On the other hand, no significant relationship was established between training attendance and other adaptation practices to weather variability. An initiative of the Food Security and Agriculture Thematic Group (2010), as cited in Maung, Pulhin, Espaldon, and Lalican (2016), reported that the Dry Zone is an area where the technical knowledge, organizational capacity, and skills among the rural population are still poorly developed to promote community resilience for food security in Myanmar.

There was also sufficient evidence that association between access to agricultural inputs provided by either private or public sector and practicing crop rotation existed at 1 percent level of significance. This means that if farmers will have more access to agricultural inputs, their chance to adapt to weather variability is high. Moreover, there was sufficient evidence that an association between access to agricultural inputs provided by either private or public sector and changing work existed at 5 percent level of significance. The association means that a large number of farmers who do not have access to inputs also do not use the drainage system.

Perceived Effects of Farmers' Adaptation Practices on Agricultural Production and Family Income

An association existed between crop production and adaptation practices (i.e., changing planting method, practicing crop rotation, cultivating vegetables, and rearing duck) at 0.01 percent level of significance (Table 9). This means that the farmers in the study area reduced the adverse impacts of weather variability on their crop production by adapting these practices. This association can be proven by the result in Table 2 showing that nearly half (41%) of the farmers perceived that the weather variability reduced only slightly their crop yield. Meanwhile, a significant association existed between crop production and the adaptation practices involving changing crops, practicing intercropping, and practicing crop diversification. The data pointed out that the factors affecting crop production were those adaptation practices that engage farmers in activities such as animal raising, crop diversification, and crop management improvement.

The chi-square test showed a significant association between family income and short-duration varieties. The use of short-duration varieties, in general, is recommended as an adaptive practice to weather variability as it somehow enables the farmers to avoid the losses brought about by weather extremes such as drought and flood. Similarly, significant relationships were obtained between family income and the use of drought-tolerant varieties and migration. This means that use of drought-tolerant varieties and migration affected family income. Overall, it can be deduced that only these three adaptation practices were the factors that affected family income.

Table 9. Association between crop production and family income, and farmers' adaptation practices

ADAPTATION PRACTICES	CROP PRODUCTION		FAMILY INCOME	
	χ_c^2	p-value	χ_c^2	p-value
Drought resistant varieties	13.1	0.3	17.58*	0.04
Short duration varieties	19.38	0.08	22.19**	0.10
Changing crops	20.67*	0.05	13.44	0.14
Changing planting time	17.74	0.12	6.91	0.65
Changing planting method	38.45**	0.01	9.17	0.42
Practicing crop rotation	41.98**	0.00	9.78	0.37
Practicing intercropping	18.29*	0.02	7.31	0.29
Practicing crop diversification	28.09*	0.03	3.22	0.99
Homestead gardening	9.43	0.66	5.86	0.75
Vegetable cultivation	38.84**	0.00	5.11	0.83
Digging pond/well	13.3	0.10	7.59	0.27
Mulching with crop residue	5.51	0.94	12.91	0.22
Use of pumps for irrigation	11.41	0.18	8.29	0.694
Use of drainage system	7.04	0.86	14.21	0.12
Duck/poultry rearing	20.76**	0.01	2.93	0.82
Engaging in trading activities	5.21	0.74	9.88	0.13
Changing work (transportation)	14.15	0.29	15.04	0.09
Migration	7.93	0.79	20.10*	0.02

*Significant at 0.05 level of significance
**Significant at 0.01 level of significance

Proposed Extension Framework in Promoting Adaptation Strategies to Weather Variability in Rice-based Farming Systems

The framework shown in Figure 3 was designed to promote adaptation strategies to weather variability in a rice-based farming system. It should be noted that most farmers adopt only selected adaptation farming practices such as crop rotation and use of short-duration varieties. Given the ongoing and projected weather variability,

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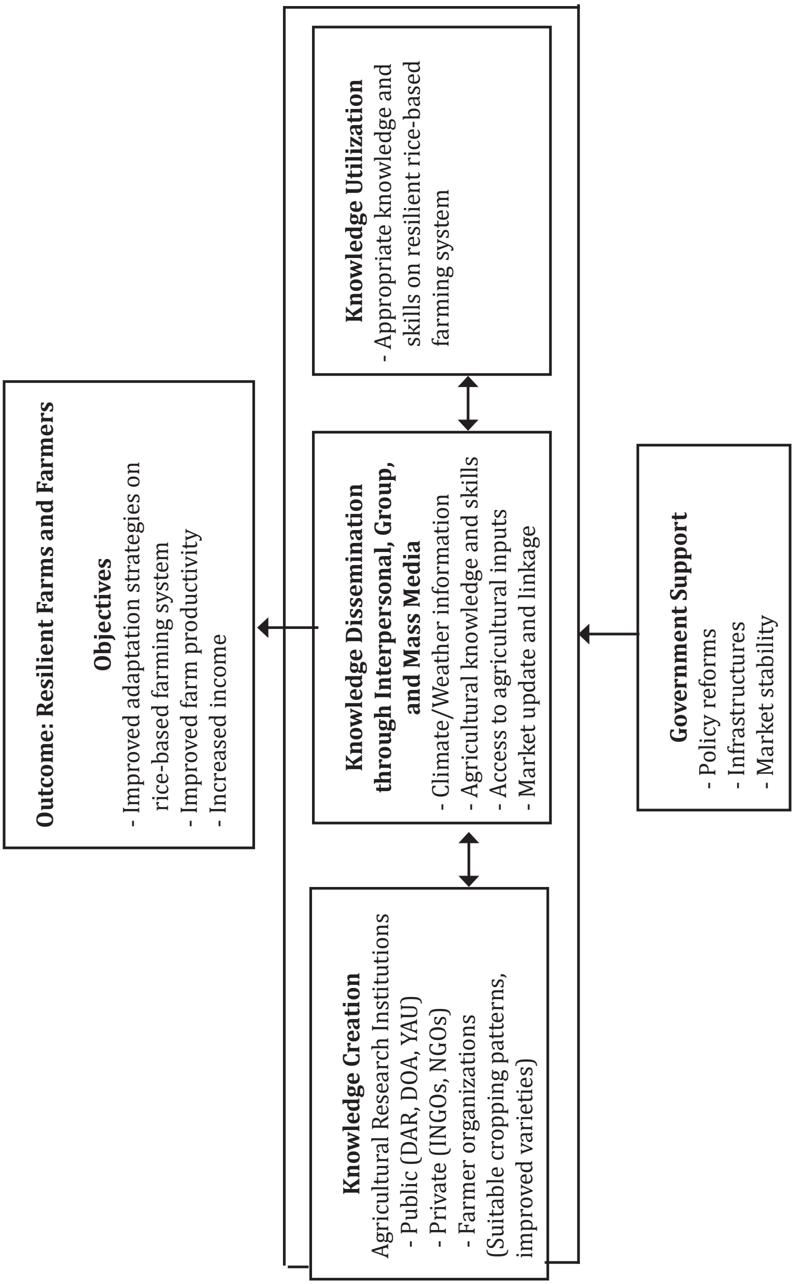

Figure 3. Extension framework for improving adaptation strategies in rice- based farming systems

it is imperative that farmers become more knowledgeable and skillful in applying adaptation practices.

The framework is guided by a knowledge management systems thinking approach, which contends that there should be a synergistic relationship between researchers, extension workers, and farmers in attaining a resilient rice-based farming systems. Hence, the following principles are forwarded:

Synergism among research, extension workers, and farmers. Without new knowledge on appropriate technologies and practices, pushing for resilient agriculture would be a difficult task. It is along this line that research, extension, and farmer-groups should work closely together. The key task is to identify problems, solutions, and processes in effectively disseminating information.

Public agricultural research institutions such as Department of Agricultural Research (DAR), DOA, and Yezin Agricultural University (YAU); private sectors such as INGOs and NGOs; policymakers; and farmers themselves can come together to craft a research agenda about practices that promote farmer resiliency.

As documented in this study, farmers need technologies such as those that relate to optimizing water resources and farm diversification which demands more water use. The government research centers can fund researches, investigate local adaptation practices, and set up farm demonstrations on best cropping combinations.

Along this line, farmers need assistance on input investments such as credit, seeds, and fertilizer after the onslaught of extreme weather events. Research on willingness to pay for crop insurance and mechanisms to deliver crop insurance should be a priority of the research agency.

Pluralism in extension. In promoting adaptation practices, the government, private sector, and farmer organizations need to work collaboratively. In this study, it was found that farmers prefer interpersonal interaction the most; hence, those involved and have the capacity to work with farmers should be guided by a framework that banks on cooperation and dissemination of appropriate information. Both public and private sectors should also work together in conducting on-farm research using participatory approaches such as FFS. Additionally, local authorities and extension agents may consider conducting farmer-based participatory demonstration trials and field visits, as these activities can enhance knowledge sharing among farmers.

Use of various media for dissemination of weather forecasts and seasonal calendars per district. Farmers need to have updated information regarding weather and weather disturbances. Although the DMH regularly delivers climate information such as Daily Weather Forecast, Seasonal Weather Forecast, Sea Route Forecast, Special Weather Forecast depending on duration, as well as other weather disturbances report through mass media such as radio, television, newspapers, Facebook, and their website (www. dmh.gov.mm), most farmers in the study area did not notice these information sources because of lack of access to mass media. This is despite the fact that DMH also disseminates the important meteorological and hydrological information 24-36 hours before the natural disasters. Because of these reasons, extension workers need to closely coordinate with the weather bureau and researchers to get weather forecasts. The flow of information, therefore, should include extension workers. Moreover, it is suggested that seasonal calendars and other possible adaptation strategies be mapped out by various stakeholders. Developing communication plans that effectively mobilize media channels will ensure that important information relating to adaptation practices will reach the intended audience.

Continuous skills training on technologies and adaptation practices to promote resilient farms. Researchers and extension agents need to be updated on regarding new technologies, techniques, and practices in promoting resilient farms. Thus, it is important that they be trained on relevant topics such as on agro-ecology, climate change, soil degradation, policy reforms in agriculture, postproduction facilities, and provision of crop insurance.

Promotion of diversified farm-based income. A resilient farm means that it can support farmers' needs; thus, it should be diversified. Farm diversification, which is already being practiced by a number of farmers, should be studied further and promoted, especially since there are many opportunities to promote the care for livestock. In addition, given the market-based orientation of farmers, it is necessary to do more research on export crops to serve as alternative sources of income for farmers.

Provision of appropriate support. In promoting farmer resiliency, it is important for the government to identify critical support areas such as upgrade of irrigation systems, construction of reservoir, and provision of facilities for agricultural information (Puriawanti & Koji ASAI, 2016). Resource-poor farmers need access to inputs, reliable infrastructure, accurate market information, and supportive policy environment. Given the limited funding, it is important that the government identifies priority support systems and infrastructure such as those relating to improved water management systems for drought-prone areas. The allocation of fund support to farmers in terms of seeds as well as assistance in leveling and harrowing the field after an extreme weather event or natural disaster should be a policy. Thus, provision of crop insurance should be a policy worth considering.

As it stands, it appears that there is a plethora of challenges that must be hurdled in promoting adaptation strategies to weather variability in rice-based farming systems. The proposed extension framework is expected to give some direction toward addressing those challenges. The coming together of key players and the provision of much needed support in particular can help enhance farmer resiliency in rice-based farming communities.

CONCLUSIONS AND RECOMMENDATIONS

Farmers acknowledged that increased occurrence of drought and high temperature are the most observable weather variability. The factors associated with the decision to adopt adaptation practices were type of agriculture, total cultivated area, total cultivated area for rice, and credit availability. Farmers accessed information from farmer to farmer regularly, but they prefer to get information straight from AEA since they can outrightly clarify confusing issues.

Moreover, the decision to adopt most of adaptation practices were associated with various information sources such as AEA from INGOs, NGOs, group meetings, attendance to demonstration, field days, FFS, training course, and printed media. Some adaptation practices such as changing crops; changing planting method; practicing intercropping, crop diversification, and crop rotation; cultivating vegetables; and rearing ducks were significantly associated to production. Family income was affected by the use of drought-resistant and short-duration varieties, and migration.

A more vigorous extension campaign to promote adaptation practices is thus necessary. To promote adaptation strategies to weather variability in a rice-based farming system, there is a need for a suitable extension program to promote adaptation to weather variability.

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