International Journal of Agricultural Technology 2020 Vol. 16(2): 505-516
Available online http://www.ijat-aatsea.com
ISSN 2630-0192 (Online)

The smallholder farmers' perceptions of climate variability impact on rice production and the case of adaptation strategies in Banteay Meanchey, (BMC), Cambodia

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Thangrak, V., Somboonsuke, B., Sdoodee, S., Darnsawasdi, R. and Voe, P. (2020). The smallholder farmers' perceptions of climate variability impact on rice productions and the case of adaptation strategies from Banteay Meanchey, (BMC), Cambodia. International Journal of Agricultural Technology 16(2): 505-516.

Abstract Rice production is very vulnerable to climatic shocks and stresses which have negatively impact on its productivity. This makes the perceptions of farmer's to be a key in combating climate change and mitigating its impacts on rice production. The smallholder farmers' perceptions of climate change impact factors on rice production in Banteay Meanchey province, Cambodia was studied. Mixed methods including quantitative and qualitative approaches were employed. Primary data were explained the farmers perception using a structured questionnaire through household survey from January to March 2018. A total of 204 respondent of smallholder farmers in 5 districts in Banteay Meanchey province of Cambodia served as samples were clearly clarified information. The major findings revealed that the perceived impacts of climate change on rice production that resulted to severe to moderate. The increase in pest infestations were realized as the most elevated impact factor of climate change and followed respectively by increased frequency of drought occurrences and rising intensity of floods. Socio-economic characteristics of the respondent: age, educational level, farming experience, as well as training had significantly influenced in their perceptions towards climate change impacts on rice production. The study identified important issues for the policy makers and other development practitioners to address and recommend suitable programs for climate change adaptation.

Keywords: Adaptation, Climate variability, Smallholder farms

Introduction

Climate change has already seriously impacted on many agricultural areas worldwide (Fosu-Mensah *et al.,* 2012, Mendoza *et al.,* 2014,Touch *et al*., 2016b). There is a growing consensus that the impact of climate change has high negative effects on the agriculture sector both in developed and developing countries (Bandara and Cai, 2014; Schellnhuber *et al.,* 2013;

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Parry *et al.*, 2004; Khanal *et al.*, 2018). However, significant agricultural impact factors have two consequences, positive and negative, depending on the applicable climate zone, (Kawasaki and Herath, 2011). Climate variability is a global concern since it can unfavourably affect elements of various systems and sectors that threaten human wellbeing. The fifth assessment report of the Intergovernmental Panel on Climate Change (IPCC, 2013) provided clear evidence of changes in climate due to human activities (Somboonsuke *et al.*, 2018). While climate induced yield loss in agriculture is becoming a serious concern, other studies argued that agriculture might benefit from future climate change provided suitable adaptation measures are implemented (Di Falco and Veronesi, 2014; Dixon *et al.*, 2003; Khanal *et al.*, 2018). Many studies indicated that even the moderatd increase in temperatures will have negative impacts on the major cereal crops including rice, maize and wheat in developing countries whose economies rely heavily on agriculture (Morton, 2007). Agriculture is highly sensitive to climate variability and climate change. Ray *et al.* (2015) confirmed that at least 60% of global crop yield losses (i.e. maize, soybean, rice, and wheat) were explained by climate variability. Climate impacts are greater in developing countries as these economies are heavily reliant on agriculture (Morton, 2007, Touch *et al.*, 2016c). A study by Yusuf and Francisco (2009) showed that Cambodia is one of the countries in South-East Asia which is most vulnerable to climate change. Banteay Meanchey Province is located in the Northwest corner of Cambodia, bordering with Thailand, Oddar Meanchey, Siem Reap and Battambang Province. Its economy is based on agriculture, tourism and handicraft (Phon *et al.*, 2012). North-west (NW) Cambodia is an important production area for upland crops such as cassava, maize, mongbean, peanut and soybeans. Agriculture is the economic back bone for the rainfed uplands of NW Cambodia where more than 80% of family's income is from crop production (Brown and Johnstone, 2012; Touch *et al.*, 2016a). The objectives were aimed to determine the farmers' perceptions of climate variability impact on rice productions, and proposed a set of adaptation strategies for rice farming for development in Banteay Mean Chey Province, Cambodia.

Materials and Methods

Study area

The study was conducted in five (5) districts and eight (8) communes, in Banteay Mean Chey Province; North-west Cambodia (BMC-NW).The areas were: Phnom Srok (13 °52' 7"N, 103 °18' 4"E) , Preah Netr Preah (13 ° 37"N, 103 °15"E), Serei Saophoan (13 °35' 7"N, 102 °59"), Phma Pouk (13 ° 45' "N, 103°0'E) and Svay Chek (13 °40"N 103 °0'E) in BMC-NW (Figure 1). The main agricultural products grown include rice, cassava, banana and soybeans (Phon *et al.*, 2012). The study areas were a monsoon climate with

wet season between May to October (Touch *et al.*, 2017). The annual mean rainfall for BMC-NW is 1200 mm. Typically, farmers attempt to grow crop between July and November. The start of the cropping season varies depending on the start of rainfall. Acutely, the farmers generally sow crops after occasional rainstorms in late dry season.

The study selected 204 farmer households who are engaged in rice-based farming from the study area by using sampling methods (Table 1). The data was collected by interview schedules consisting of: i) socio-economic data of farm households, ii) impact of climate variability, iii) adaptation strategy and secondary data from the Provincial Department of Agriculture in Banteay Mean Chey province.

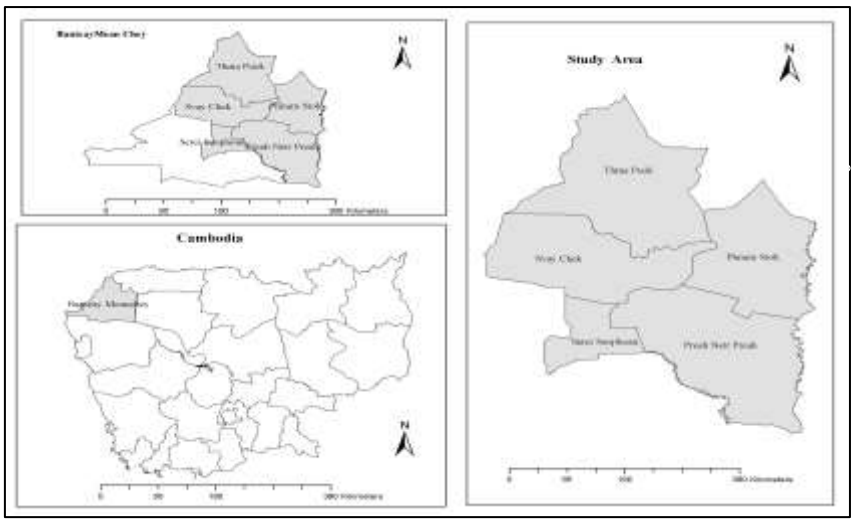

Figure 1. Map showing the study locations in Banteay Mean Chey province, Cambodia

Table 1. The locations and the number of households in this study

Banteay Mean Chey Province		
Distract	***Commune***	***Participant***
Phnom Srok	2	62
Svay Chek	1	52
Preanh Netr Preah	1	32
Serei Saophoan	2	33
Phma Pouk	2	25
Total	8	204

Sampling, data collection and analysis

The research sites were classified into 5 areas which were defined as climatically sensitive areas and considered at risk of being subjected to adverse climate variability.

The data analyses were conducted using various form of statistical measures. In measuring the level of information exposure, a Likert scale was used to determine smallholder farmers' perceptions on climate change impact on rice farming activating. For analysis of arithmetic mean, respondents were asked to express their perceptions on the impacts of climate variability on rice farming activities. So, a 5 Linkert scale was used to determine the level of impact for instance: [1] most impact, [2] high impact, [3] moderate impact, [4] less impact and [5] no impact. Then the weighted scale was used to interpolate i.e., (mean=2.26-3.00), (mean= 1.51-2.25), (mean= 0.76-1.15), (mean= 0.00-0.25) and representing the most, high, moderate and less impact levels respectively. (Somboonsuke *et al.*, 2018).

Results

Socio-economic characteristics of the smallholder farmers

The demographic and socio-economic characteristics of the smallholder farmers are shown in Table 2. The finding showed that most of the farmers aged above 50 years old, representing approximately 70% while the middle age represented about 22 %. About 55 and 23% of farmers went to secondary and primary school, respectively. A few farmers (3%) obtained high school education. However, illiterate farmers represent nearly 20%. Regarding marital status, the survey showed that most of the rice farmers were married (90.7%) while a few were single, widowed or divorced.

Majority of farmers were small-scale landholder approximately 89% of them held a small land including residential and farmland. Additionally, most of them were small-scale farmer. The study indicated approximately 66% of the farmers held a small rice cultivation area, but medium scale represented about 18% and 3% for large scale land. Most of them relied on rice cultivation. So, nearly all farmers (99.5 percent) depended on income from rice production.

Furthermore, almost 60% of the farmer have had experience on rice farming with less than 25 years, about 36% of them have experience ranging from 26 to 44 years, while about 6 % have had over 45 years' experience. Due to declining of rice productivity, it is therefore essential for the farmers to be introduced to new farming techniques to increase productivity. According to the data analysis about 13% of the rice farmers attended the training course on rice production technique and approximately 87 percent did not. So, a very few farmers attended the training course.

The analysis of the data also showed that majority of the respondents (78.4%) had moderate family labors under 5 persons, from 6 to 11persons about 13% and 12-20 persons about 9%. The result of the study also

revealed that about 31% of rice farmers had a total income of less than KHR 4000 which means that they are living below the national poverty line.

Table2. Demographic and socio-economic characteristics of the respondents

Item	Category	Frequency	Percentage	Mean	SD
Age (year)	Young (up to	15	7.4		
	Middle aged	46	22.5	2.63	0.619
	Old > 50	143	70.1		
Education level	No Education	39	19.1		
	Primary	112	54.9		
	Secondary	47	23.0	2.10	0.730
	Higher Education	6	2.9		
Marital status	Single	14	6.9		
	Married	185	90.7		
	Divorced	1	0.5	1.98	0.390
	Widow	4	2.0		
Total land holding size (ha)	Small	182	89.2		.464
	Medium	11	5.4	1.14	0.464
	Large	9	4.4		
Main income sources	Rice production	203	99.5		
	Animal husbandry	1	0.5	1.01	0.140
	Employed	0	0		
Farm rice size (ha)	Small	135	66.2		
	Medium	37	18.1	1.11	0.645
	Large	6	2.9		
Farming Experience (Years)	Low(<25)	118	57.8		
	Moderate (26-44)	74	36.3	1.48	0.608
	High (45>)	12	5.9		
Training course rice production (years)	Yes	26	12.7		
	No	177	86.8	1.88	0.343
Family labor (Person/ years)	<5	160	78.4		
	6-11	26	12.7	1.304	0.624
	12-20	18	8.8		
Total income (KHR' 000)	< 4000	65	31.9		
	4010-100000	38	18.6	2.151	0.888
	Above 11000	95	46.6		

[1]/ SD = Standard Deviation; Cambodia currency rail = KHR
[2]/ Source : interviews, 2018

The study was about the perception of the 204 farmers on climate change impart on rice production. The data were analyzed using the arithmetic mean. Respondents were asked to express their perception of the climate change impact on rice productions activities using a 5 Likert scale including most, high, moderate and less and no impact. The farmers highly

suffered from eight negative impacts of climate change on their rice production (Table 4). The climate change impacts that mostly affected rice production were: 1) reduce of crop areas, 2) pest/insects infestations has increased, 3) rice paddy field has changed and 4) loss of yield. There were four high impacts of climate change phenomena on rice production namely: 1) disease has increased, 2) reduction of soil and fertility, 3) change in method of rice planting, 4) reduction of varieties of rice because the new varieties of rice adapted to climate change impact were recommended.

Table 3. Smallholder farmers' perceptions of impact climate variability on rice productions (BMC)

Impact of climate variability	*Climate change impact*	
	Mean	Lever of impacts
1.Reduce of crop areas	2.48	Most
2.Pest/insects infestations has increased	2.45	Most
3. Rice paddy field has been change	2.40	Most
4. Loss of yield	2.34	Most
5 Disease has increased	2.17	High
6. Reduction of soil fertility	2.19	High
7.Rice planting has been changed to new methods	1.76	High
8. Reduction of varieties of rice	1.71	High

[1]/: Source : interviews, 2018

The correlation between eights factors with socioeconomic characteristics and farmers' perception

According to the null hypothesis (Ho) which was formulated to determine the association between the descriptive variables and the focus variable, i.e., perception to climate change impact on the rice production. Ho indicated that there is no association between descriptive and focus variables. Pearson Product Moment coefficient of correlation (r) was employed to explore the association, where a five percent level of probability was used to reject the Ho. A summary of the test is shown in (Table 4).

Table 4. Correlation between descriptive and focus items

Socio-economic item	Correlation co-efficient®	Tabulated value of r	
		0.05	0.01
Age (X1)	0.1*		
Education level (X2)	-0.399 *		
Marital status(X3)	0.166*		`
Total income (X4)	0.042		
Farming Experience (Years) (X5)	0.400**	0.400	0.00
Training course (X6)	0.039		
Total land holding size (X7)	0.042		

[1]/: Correlation is significant at the 0.05 level (2-tailed), correlation is significant at the 0.01 level (2-tailed).

[2]/ :Source : interviews, 2018

Result indicates that three variables such as farming experience (X5), training course(X6) and education level (X2) as well as X6, X2 comprised the model and they together (R2 = 0.25) explained 25 percent variation in the farmer's perception to climate change impact on rice production (Table 5). The first variable entered into the model was years of the farming experience (R2= 0.16), which made the highest contribution of 16% explaining the focus variable. The second variable that was entered into the model was educational level and training course which were found to contribute 9% explaining the variation of the focus variable. The third variable which was training course contributed 9% explaining variation in the focus variable.

Table 5. The summary of the stepwise multiple regression analysis(n=204)

Model	R Square	Adjusted R Square	R Square Change	F Change	Sig.
Constant +X5	0.16	0.1	0.16	38.45	0.00
Constan+tX2+ X2+X6	0.25	0.24	0.09	25.65	0.00

(Constant 1), Farming experience(X5)
(Constant 2), Training Course(X6), Education level(X2)

It found that four of seven descriptive variables : age, education level, marital status, farming experience were significant and positively associated with smallholder farmers' perception using stepwise multiple regression analysis. Individual contribution of the explanatory variable to the variation on smallholder farmer's perception to climate change impact on rice production was observed. A stepwise multiple regression analysis was employed to understand individual continuation of the explanatory variable to the variation of smallholder farmers' perception to climate change impact on rice production.

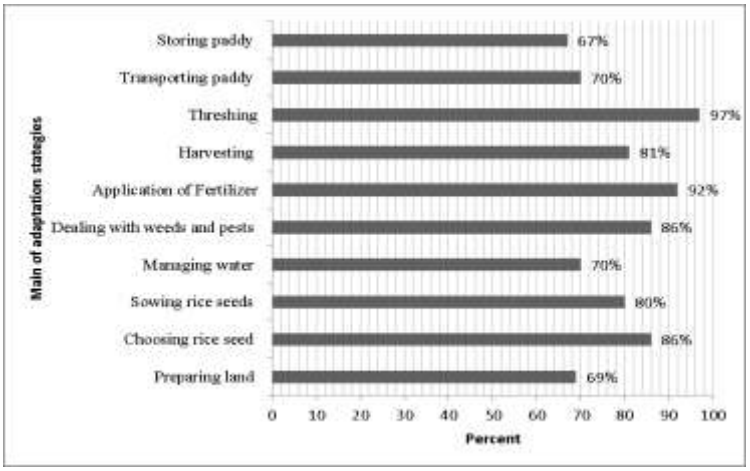

Figure 2. Adaptation strategies for smallholder farmers' perceptions of impact climate. Variability on Rice productions (BMC); Source: interviews, 2018

The information based on farmer's experience on what key actions has to be taken in response to perceived trends in climate variability and climate change is presented in Figure 2. Changing rice crop species was seen as the most common practice in response to adverse climatic effects. However, it was not clear how farmers separated climate impacts from other factors such as labour shortages and price in making the decision to change crop species. In addition, adjusting sowing date was also a popular practice among the respondents in the region. However, a majority of the respondents took no action to adapt their cropping practices in response to the adverse climate effects.

It is useful to discover adaptation strategies in order to obtain an understanding of rice crop adaptive capacity. More emphasis should be done on rice with supplementary irrigation, short duration rice varieties, changing planting and harvesting dates, the conversion of paddy land into mango orchards', agro-forestry, using different crop varieties, the cultivation of various pulse and the cultivation of jute and wheat. Irrigation is the most commonly used method (75%). Other main adaptive choices include changing the planting date and providing supplementary irrigation practice. Secondary adaptation strategies being adopted by farmers was also important to advert climate change impacts. The adoption of these adaptation strategies implies that the farmers in the study areas are well-equipped.

Discussion

It was found that majority of the respondents in the study area were in the middle age group. Middle aged and old farmers were found to have more experience and aware of climate change and its impacts on crop production (Ishaya and Abaje, 2008). It was noticed that the majority of respondents did not have formal schooling. Education helps farmers to access diversified information sources that enables them to have better perception on climate change impacts (Habiba *et al.,* 2014). Larger farm size influences the farmers to access more information regarding climate change impacts and technology adoption (Daberkow and McBride, 2003). However, it was found that more than half of the respondents (60 percent) had only 0.21-0.47 ha of land. Farmers with more farming experience are likely to be more aware and to have better understanding about climate change and farm related decision making. In addition, family income is also found to be a key factor in farming decisions (Habiba *et al.,* 2014). Information sources can play a great role in farm management decision of any type. Access to enough training enables farmers to understand climate change and its impact on crop production along with necessary farm adjustments.

These findings may be as a result of that the smallholder farmers were usually subsistence farmers, they rather like to work in their farms and could perceive that participation in organization could be time and resource consuming. It can be seen that the study area had experienced moderate to severe impacts of climate change on crop production. Increased temperature, uneven and off season rainfall has led to drought occurrences. Agriculture in this study area is mostly rice based along with vegetables and some fruit crops. Therefore, climate change could directly influence crop production due to its nature. Majority of the farmer participants reported that they cannot timely transplant rice because of unavailability of irrigation system, thus they have to bear a significant amount of cost in getting irrigation water for crop production.

From the perception index, we can see that increased pest infestation was the most significant impact of climate change on crop production. Hot and humid weather is congenial for pest outbreaks. The study area was typically a drought prone area, where increased temperature could result to pest infestation. Akanda and Howlader (2015) reported that increased temperature and diseases was due to climate change in their study. The continuous less and uneven rainfall could result to increased intensity of droughts in the study area. Due to low and erratic rainfall, it was difficult to rely on surface water during the peak growing season when droughts come in. Islam and Hossen (2016) reported thatd ecreased source of water is the most perceived impact of climate change. Drought frequency, due to insufficient rainfall, and increased evaporation lead to complete crop failure (Liu *et al.,* 2010). Crop production system directly depends on climatic condition (Sikder and Xiaoying, 2014), and hence, little changes in the climatic pattern can have severe impact on crop production. Sikder and Xiaoying (2014) stated that warming caused by climate change lowers crop production. Due to climate induced increase in temperature, untimely precipitation, droughts, floods and salinity can adversely affect rice production (Rimi *et al.,* 2009). This clearly implies that low rainfall during the rainy season could be responsible for this findings. In recent years, there is no rainfall even during the rainy season, consequently, canals and lakes remained dry. Ghosh *et al.* (2015) reported a decrease in rainfall in their study explaining the drought phenomena.

The findings demonstrated that old aged farmers were likely to perceive climate change impacts on crop production more efficiently. This could be due to the fact that aged farmers through their experience could predict their farms and take necessary decisions to address the problems. Huda *et al.* (2016) found significant and positive correlation between age of the farmers and agricultural adaptation strategies to climate change. Mardy *et al.* (2018) reported similar finding in their study. Education helps a person to be more aware, knowledgeable and broaden their outlook about farming and other issues. With the increase in year of schooling, an

individual becomes able to realize the impacts and consequences of climate change. Islam and Hossen (2016) and Akanda and Howlader (2015) also found that education is positively and significantly associated with farmers' perception in their respective study. Mardy *et al.* (2018) reported a significant and positive association between education and adaptation to climate change. Access to various information sources helps a person to be smart and wise. They can come across and consult different farm related issues that help them undertake suitable adjustments. Through participation in different training programs individual can access information about crop production and the impact of climate change.

Using Stepwise regression implies that with increased educational level, the smallholder farmers' perception increases. Farmers with high level of formal schooling possess significant knowledge about their farms and farm problems as they can have access to a wider range of information sources (Uddin *et al.,* 2014). Increased farming experience of the smallholder farmers enhances their level of perception. Farmers with high farming experience can predict their farms and related issues. They also become able to address farm problems regarding climate change and make suitable adjustments. The finding also shows that training exposure enhances famers' ability to perceive the impact of climate change on crop production. Farmers in the training programmes learn the know-how and do-how of certain farm activities. Farmers with high training exposure are likely to have more ability to manage their farms as well as to predict climate change impacts on crop production.

Acknowledgment

The author would like to offer particular thanks to Her Royal Highness Princess Maha Chakri Sirindhorn scholarship which supported this study. Also, advisor Prof. Dr Buncha Somboonsuke, head, Department of Agricultural Development and co-advisors Asst Prof. Darnsawasdi and Asst. Prof. Dr. Sdoodee, Department of Plant Science, Faculty of Natural Resources, Prince of Songkhla University.

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(Received: 26 June 2019, accepted: 20 February 2020)