ISSN 1819-1894

Asian Journal of Agricultural Research

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OPEN ACCESS Asian Journal of Agricultural Research

ISSN 1819-1894
DOI: 10.3923/ajar.2017.120.127

Research Article
Determinants of Malaysian Farmers' Choice of Adaptation Strategies for Adapting to Climate Change in Kedah Malaysia

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Abstract

Background and Objective: In Malaysia, the climate is changing. So, the associated risks are expected to have serious impacts on agriculture and national food sufficiency level which in turn will affect the rural farmers for whom agriculture is the main source of income. The level of impacts will mainly depend on the awareness and the level of adaptation in response to the changing climate. It was thus important to analyze which factors may affect the decision of the farmers whether they adapt with the climate change in order to implement appropriate policy measures for the sake of the affected farmers. The objective of the study was to examine the perception of the farmers towards climate change and the factors that influence farmers' choice of adaptation measures to climate change. **Materials and Methods:** In this study conducted a survey of 300 farmers in Kedah Malaysia to accomplish the objectives of the study. A logit model was used to identify the factors that influence farmers' choice of adaptation measures to climate change. Data analysis was conducted using Statistical Package for the Social Science. **Results:** It was found that access to extension, income, knowledge about climate change, household size and farm size affect the decision to adapt any adaptation strategies or not. **Conclusion:** It is suggested that social adaptation should be intensified by focusing on farmers' climate change knowledge, support of the extension officers for developing alternative skills, involvement of the farmers in climate change adaptation planning and enhancement of the farmers' access to credit. These adaptation strategies can be a basis for policy makers, managers and local leaders to produce adaptation strategies that are in line with the farmers' needs, abilities and interests.

Key words: Determinants, perception, logistic regression model, adaptation strategies, social adaptation

Citation: Rafia Afroz and Rulia Akhtar, 2017. Determinants of Malaysian farmers' choice of adaptation strategies for adapting to climate change in Kedah Malaysia. Asian J. Agric. Res., 11: 120-127.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

In Malaysia, the government is considering the rice as one of the commodities in achieving the national self-sufficiency level. In 2014, the country produced 75% and imported 25% of the total rice supplied[1,2] Nevertheless, rice production was affected by climatic factors such as rainfall and temperature. It was reported that rice production is affected by climate changes such as geographic changes, unavailability of water for irrigation purposes and the loss of land due to the rising sea level[3]. It was found that a 1% increase in temperature leads to 3.44% decrease in the current rice production and 0.03% decrease in rice production in the following season and a 1% increase in rainfall leads to 0.12% decrease in the current rice production and 0.21% decrease of rice production in the following season. Since rice production is affected, it decreases the productivity and increases the production cost of the farmers[4]. Consequently, this situation was reducing the income of the farmers, increasing their poverty level and seasonal unemployment rate[5,6]. The most vulnerable poor states in Malaysia are Sabah (23%), Terengganu (15.4%), Kelantan (10.6%), Sarawak (7.5%), Kedah (7%), Perlis (6.3%) and Perak (4.9%), where the projected temperature and rainfall changes were very high[7,8]. Therefore, in order to support the farmers and increase productivity as well as to increase the income of farmers, need to know how the farmers were adapting with the climate change. In recent years, farmers, researchers and policy makers were more concerned about the adaptation to climate change[9]. Adaptation in agriculture was defined as how the perception of the farmers was translated into agricultural decision process. It also indicates a set of actions that the farmers need to take in order to maintain the capacity to cope with the climate change[10,11]. It was reported that adaptation strategies were the actions that can reduce the effects of environmental changes and take advantages of opportunities for the benefit of the society[12]. Adaptation strategies were essential to predict the trend of climate change and to analyze how climate change and how its impacts are perceived, experienced and responded by the farmers.

The main policy of the Malaysian government on rice production was to maintain basic needs from 1955 to several years after the country attained independence. To achieve the goal of self-sufficiency level (SSL), the government has established eight rice basins in the country. MADA is one of the main rice basins (Fig. 1) as this area has contributed more than 40% of rice production to the country's self-sufficiency level[13]. In 2010, the government allocated 41.383 million RM to the MADA to carry out the development and maintenance of irrigation infrastructure in MADA (Malaysia, 2010). To date, MADA is the largest direct contributor to rice in the country ensuring food safety (Table 1).

Although, the contribution of the MADA demonstrates high significance but this success story has to deal with a variety of constraints such as natural disasters, diseases and so on. Recently, rice production in this area was affected by natural disasters. A total of 48,693 h of fields have been affected by the floods that occurred between 2005 and 2010, affecting a total of 32,794 paddy farmers[15]. This has an impact on the production of rice and SSL and affects the infrastructure of the farm in the area. Therefore, to achieve SSL in rice production in MADA, extensive government interventions were granted as a very crucial factor[16] specially in case of their adaptation strategies. In Malaysia, it was found that farmers have following adaptation practices to cope with the climatic change but they were not adequate and satisfactory[4]. They are following the adaptation strategies based only on their ideas or reactions. As a result, they were not able to properly cope with the climate changes[6]. For this reason, rice farmers were exposed to different climatic risks and have a low adaptive capacity[17].

In Malaysia, there is lack of studies related to climate change farmers' perceptions of climate change and adaptation. Many studies report impacts of climate change[18-20], some of them discuss about agricultural vulnerability and climate change[2,4,21] as well as adaptation and barriers[2,20]. Nevertheless they did not discuss what factors affect the farmers' decision to adapt with the climate change. So, there was urgent need to carry out studies on farmers' perception of climate change and the factors that affects their

Table 1: Paddy production in MADA in Malaysia

Year	Country's paddy production (m. t)	Paddy production in Muda irrigation area (m. t)	Subsistence level of commodity of paddy (%)	Contribution of Muda irrigation area to SSL (%)
1985	1257970	724078	72	41.71
1990	1377339	724883	79	41.38
1995	1372584	862094	76	47.96
2000	1342370	760928	70	39.60
2005	1455440	880370	81	48.75
2010	1642000	909050	71	39.53

Source: MADA[14]

Fig. 1: Location of MADA
Source: Ibrahim[1]

decision about their adaptation. Hence, the objective of this study was to analyze which factors can affect the decision of the farmers to adapt with the climate change in Muda Agricultural Development Authority (MADA) in Kedah.

MATERIALS AND METHODS

Econometric approach: It was evident that both probit and logit model are well-established approaches in the literature of adoption of technology and adaptation to climate change[22-25]. In this study, logit model was used to investigate whether the farmer has adopted any strategy to cope with the climate change. If the farmer has adopted any strategy, it was counted as 1 and 0 otherwise. This study hypothesizes that farmers who adapt currently perceive a change in temperature or a change in rainfall. On the other hand, also hypothesized that non-adapting farmers do so because of barriers based on individual experiences. Therefore, in this study, each farmer's decision to adapt is a dummy variable defined as follows:

$$Y_1 = \begin{cases} 1 \text{ if the farmer adapts to cope with climate change} \\ 0 \text{ if the farmer does not adapt to cope with climate change} \end{cases}$$

If p_i is defined as the probability of adaptation of the farmer, then $(1-p_i)$ is defined as the probability of no adaptation of the farmer. So, $\frac{p_i}{1-p_i}$ is the odds ratio in favor of adaptation that is the ratio of the probability that a farmer will adapt to climate change to the probability that it will not adapt. The logistic regression model shows that the log of the odds ratio is not only linear in but also linear in parameters, as shown in Eq. 1.

Table 2: Description of the independent variables

Variables	Description
Access to extension	If a farmer is in contact with extension officers, workshops, seminars or other sources of information. If yes 1, otherwise 0
Age	Age in years
Education	Highest level of schooling attained by the farmers. 1 = none, 2 = primary, 3 = secondary, 4 = college. 1 if educated and 0 otherwise
Off-farm income	If the farmers has other sources of income besides farming activities, if yes, 1 otherwise 0
Knowledge about climate change	If the farmer knows impacts of climate change. If yes 1, otherwise 0
Farm size	In hectares
Farming experience	In years

$$L_i = In\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 x_i \quad (1)$$

where, L_i is the log of odds ratio, β_0, β_1 are the parameters and are the independent variables. The independent variables are presented in Table 2.

Methods: In this study used a stratified simple random sampling technique. Using stratified proportionate sampling technique, stratified the whole study area into 27 PPK strata based on homogenous group with approximately 55,000 farmers. It was reasonably difficult to cover whole strata due to time and budget constraint. Hence, using simple random sampling, we selected 7 strata (7 PPK) for this study. Simple random sampling technique has equal chance to be selected in the samples. Before the final survey, a pilot survey was conducted among 20 farmers selected from Kedah in January, 2016 to modify the questionnaire based on the comments from the farmers. After modification of the questionnaire, the final survey was conducted in Kedah in July, 2016.

Sample size: In order to obtain appropriate sample size from the population, since the number of population is known in this study, the following formula can be used to calculate the appropriate sample size:

$$n = \frac{N}{\left(1+Ne^2\right)}$$

Where:

N = Desired sample

N = The population size, in this case the total number of farmers is 55,000

E = Level of precision or sampling error (sampling error in this study is 5%)

Thus, sample size is equal to;

$$n = \frac{N}{1+Ne^2} = \frac{55,000}{1+55,000*(0.05)^2} = 400$$

By taking the formula, n which is the desired sample size for this study is set at the amount of 400. It is calculated with 95% confidence level and 5% error level.

Statistical analysis: Maximum likelihood method was used to estimate the parameters of the logit model. In this study, data analysis was analyzed using Statistical Package for the Social Science (SPSS) version 16. Probability was used (0.95%) to decide the level of significance.

RESULTS

Farmers' perception on climate change: To explore the farmers' perception of climatic parameters over last 15-20 years, the respondents were asked for any observed changes in temperature, rainfall, drought and frequency of flood over the last 15-20 years. The results of the study reveal that majority of the surveyed farmers perceived increasing temperature and decreasing rainfall. It was found the same results in another study[26]. The results also reveal that almost all of the farmers perceived that frequency of drought and flood has increased over the last 15-20 years, respectively as shown in Table 3.

Farmers' perception on the causes of climate change: To explore the farmers' understanding of possible causes of climate change, several possible reasons for climate change were stated in the questionnaire. The results indicate that 35% of the farmers perceived nature as the main causes of climate change while only 2% of farmers do not know the causes of climate change as shown in Fig. 2.

Adaptation strategies to climate change: In this study, the farmers who claimed to have observed changes in climate

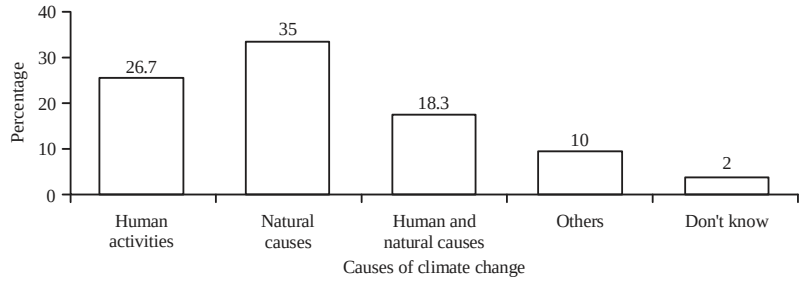

Fig. 2: Perceived causes of climate change

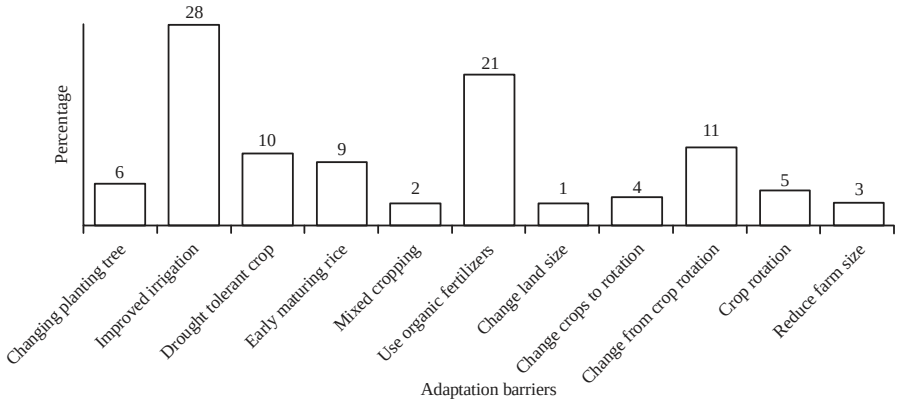

Fig. 3: Adaptations practices by farmers

Changing planting trees (6), improved irrigation (28), drought tolerant crop (10), early maturing rice (9), mixed cropping (2), use organic fertilizers (21), change land size (1), change crops to rotation (4), change from crop rotation (11), crop rotation (5), reduce farm size (3)

Table 3: Farmers perceptions of climatic parameters over last 15-20 years

	Percentage of respondents			
Farmer's perception of CC	Temperature	Rainfall	Drought	Flood
Increased	76.3	10.2	85	97.3
Decreased	15.0	85.4	5.3	0.0
Not Changed	5.30	3.40	8.5	0.0
Don't know	3.40	1.00	1.2	2.7

Table 4: Logit regression of determinants of adaptation to climate change

Variables	Coefficient	Standard error	z-value	Significance
Access to extension	0.33	0.067	2.59	0.009
Age	0.520	0.645	0.81	0.420
Education	0.623	0.443	1.41	0.160
Off-farm income	0.114	0.047	2.43	0.006
Knowledge about climate change	0.064	1.351	3.00	0.003
Farm size	0.569	0.157	3.62	0.000
Farming experience	-0.909	0.321	-2.83	0.005
Likelihood ratio	0.630			
Pseudo R-square	0.386			

were asked whether they adapted any strategies. Consequently, those who responded that they have adapted to climate change reported different adaptation strategies such as changing planting trees, improved irrigation, drought tolerant crop, early maturing rice, mixed cropping, organic fertilizers, change land size, change crop rotation and farm size (Fig. 3). The improved irrigation was the most commonly used method, whereas change land size was the least practiced among the major adaptation methods identified by the farmers in the study area.

Determinants of adaptation: The results of the logit model on the determinants of adaptation strategies of the farmers are presented in Table 4. Found out that access to extension,

income, knowledge about climate change, household size and farm size affect significantly and positively affect the decision to adapt any adaptation strategies or not. Furthermore, it was found that age and education also have positive impact on the likelihood of the farmers to adapt with climate change but they were not significant variables.

DISCUSSION

The results of the study reveal that 76.3% of the surveyed farmers observe the increase in the temperature over the last 15-20 years. 61.7% of the farmers perceived that climate change occurs due to natural and human causes. Although majority of the farmers perceived about the increased temperature, not all of them were adapting to climate change. In this study, it was found that among 300 farmers, 215 farmers were adapting to climate change. The most common adaptation practices adapted by farmers were improved irrigation. Greater use of irrigation was mainly due to the contribution of MADA, who makes irrigation available for rice production in this area. These adaptation measures are similar to other findings in the climate change adaptation literature[2,6,20].

The results of the regression analysis show that access to extension, income, knowledge about climate change, household size and farm size affect the decision to adapt any adaptation strategies or not. The results of the study indicate that the farmers who have access to extension are more likely to adapt to climate change. This result was expected because extension officers can inform about climate change and also at the same time, they can advise them how to mitigate the impact of climate change on rice production. Some studies also reported same findings[9,27,28,29]. Furthermore, also find that farmers who have off-farm income are more likely to adapt to climate changes. This study indicates that if the farmers want to do adaptation, they need to adopt innovation and adjust the farm management which requires capital. This finding was consistent with the study of Knowler and Bradshaw[30] and Arunrat *et al.*[23], who find that high income families are more likely to adapt because they have more access to credit. This research shows that farmers who have knowledge about climate change were more likely to adopt means of mitigating and adapting to climate change. These findings are in agreement with other researchers[31,32]. Looking into farm size, find that large farm owners were more likely to adapt climate change. This can be attributed to large fixed cost and the fact that small farm owners were not able to adapt to climate change because of huge amount of fixed and production costs associated with the technology. This study findings were in agreement with another study[33] that there is a critical limit on farm size that prohibits small farm owners from adapting. In this study also find that farmers who have more farming experience are more likely to adapt climate change. This was expected because experienced farmers have much knowledge and also information on changes in climatic conditions and the best crop management and livestock practices to adapt[29,34].

CONCLUSION

Although majority of the farmers perceived about the increased temperature and decreased rainfall but not all of them are adapting to climate change. The most common adaptation practices adapted by farmers are improved irrigation system and use organic fertilizers. Furthermore, the study found several barriers associated with adaptation practices such as high cost of farm input, unpredictable weather, insufficient water resources, uncertainties of weather information etc. From the logistic regression model, it is found that access to extension, income, knowledge about climate change, household size and farm size affect the decision to adapt any adaptation strategies or not.

SIGNIFICANCE STATEMENTS

In Malaysia, there is no study carried out yet about barrier to adaptation and adaptive capacity in this area. Thus, this study will fill up the gap in the selected area. The research findings could help the government and policy planners by offering important inputs for policy direction in reviewing and analyzing the possible impact of existing policies on farmers in the agriculture sector. This specifically would help the farmers to minimize the shock due to adaptation constraints towards climate change and increase the level of awareness, adaptation behavior towards climate change. The findings of this study would also assist policy makers to formulate better adaptation behavior polices through the Malaysian farmers. This study helps to analyze the possible barriers impeding the capacity of the farmers to adapt and assisting them to adapt to climate change more efficiently and effectively. In terms of national level, this study helps the authority in policy making in order to respond to natural disaster risks. Apart from policy making, it also becomes a useful tool in creating food security, as paddy is one of the main staple in Malaysia. The econometric model also may help the farmers to obtain a more stable yield which may lead to increased income and also indirectly increasing the economic growth and competitiveness with other paddy producing nations.

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