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Determination of Perception and Adaptive Capacity towards Climate Change among Paddy Farmers in State of Kelantan, Malaysia

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Abstract

Rapid changes in the climatic factors affect paddy farming in Malaysia. As Kelantan is the most vulnerable state to climate variations, its paddy production is negatively affected. Proper mitigation and adaptation approach can reduce paddy farmers' vulnerability to climate change. Hence, it is important to the paddy farmers to cope with climate change by having the right perception to ensure farmers take the right decisions on dealing with climate change. There are four objectives of this study which include estimating the trend of climate change in Kelantan using Mann-Kendall test, determining paddy farmers' perceptions towards climate change, measuring paddy farmers' adaptive capability using Analytic Hierarchy Process (AHP) and ascertaining associated factors of the adaptive capacity of paddy farmers using Binary Logistic Regression. Results showed that majority (85.9%) of paddy farmers in Kelantan perceived changes in climate but only 62.9% of paddy farmers were highly adaptive towards climate change. Finally, age, monthly income, and district were found to be significantly associated with paddy farmers' adaptive capacity towards climate change. Although, most paddy farmers in Kelantan were highly adaptive towards climate change, government and related agencies still need to take some efforts and initiatives to enhance the farmers' adaptation towards climate change.

Keywords: *adaptive capacity; perception; climate change; Analytic Hierarchy Process; Logistic Regression..*

1. Introduction

Climate change refers to the shift in the global weather phenomena which is commonly linked to an increase in global average temperatures. Malaysia, located in South Asia, is currently experiencing climate change, as evidenced by the increase in the number of warm nights in some parts of Malaysia by more than 90 % [1] with overall temperature is expected to have an increment between 0.6 °C and 4.5 °C by 2060 [2]. Countries in South Asia have been identified as having the highest proportion of sectors which are dangerously exposed to the changes in climate [3]. In Malaysia, climate change was found to pose high risk to the agricultural sector. Its crop yields were estimated to drop around 10% to 15% yearly [4] from the consequences of climatic change factors specifically in terms of rain invariability. Paddy farming as part of the main agricultural activities is sensitive to climate change, making paddy farmers as the most vulnerable and easily affected by climate change. As climate change is a natural cycle in the Earth' climate, there is nothing that can be done to stop climate change from happening. Even with the presence of advanced technology nowadays, the effect of climate change on mankind could not be stopped. Hence, the only possible way to handle climate change is to deal with it.

Adaptation has been identified as an effective measure to deal with climate change. Adaptive capacity is defined as the ability of paddy farmers to adapt to any changes in environment surrounding the farmers and varies according to various associated factors. The enhancement of adaptive capacity is an effective measure to facilitate the adaptation to climate change and variability especially for vulnerable groups such as small-scale paddy farmers in developing countries [3]. Having the right perception on climate change will lead the paddy farmers to take the right decisions in dealing with climate change. Only when paddy farmers have the right perception on climate change then government and related agricultural agencies can intervene to guide and assist farmers in dealing with the changes in climate change.

Malaysia experiences a wet and humid tropical climate throughout the year ([5-9]). According to [10], Kelantan was found to be the most vulnerable to climate variations among all states in Peninsular Malaysia, based on climate change vulnerability index, with a score of 0.7061 out of 1.0. It was exposed to several risks which include land elevation, water supply, telecommunications coverage, economic growth and health issues. This implies that paddy farmers in Kelantan are facing problems with the unpredictable climate. Due to the unstable and shifts in the climate of Kelantan, paddy farmers face many challenges so that they can be adaptive towards climate change and variability. Number of studies [11,12] was found to focus on the sustainability practices of paddy farmers in Kelantan, however none concentrates on investigating the perception and adaptive capacity of paddy farmers in Kelantan.

Hence, this study aims to estimate the trend of climate change in Kelantan, to determine the perception paddy farmers towards climate change in Kelantan, to measure the level of adaptive capacity of paddy farmers towards climate change in Kelantan, and to determine the factors associated with the adaptive capacity of paddy farmers towards climate change in Kelantan using combinations of several statistical techniques. In this study, the indicators of adaptive capacity were determined based on the framework of sustainable livelihood (SL). This framework searches for better understanding on the factors that affect poor people's livelihoods and the association with the factors [13]. Meanwhile, the items in adaptive capacity were adopted from [14,15].

2. Method of analysis

2.1. Study Site, Respondents, and Method of Gathering Data

This study was conducted in Kelantan, covering five different districts i.e. Bachok, Kota Bharu, Pasir Mas, Pasir Puteh, and Tumpat. Areas under these districts were involved in paddy plantation activities under the management of Kemubu Agricultural Development Authority (KADA). Meanwhile, two types of data consisting of primary data and secondary data, were used in this study. The collection of primary data involved two groups of respondents. The first group consisted of a panel of three experts on paddy farming, purposively chosen to provide ratings on the relative importance of the different indicators of adaptive capacity. The ratings were elicited using the pairwise comparison questionnaire. These experts' ratings were then used to generate the weights of each indicator using Analytic Hierarchy Process (AHP). Then, the second group of respondents, consisting of 383 paddy farmers in Kelantan were selected using stratified random sampling. Under a cross-sectional survey, information on the paddy farmers' perception and adaptive capacity towards climate change were obtained through interviews. Meanwhile, the secondary data involving climatic records of rainfall and temperature in Kelantan were obtained from Malaysian Meteorological Department, covering period in 1972 to 2017 based on three weather stations; Gong Kedak, Kota Bharu, and Kuala Krai. These data were used to estimate the trend of climate of Kelantan.

2.2 Estimation of Trend using Mann-Kendall (M-K) Test

The trend of climate change in Kelantan was analyzed based on climatic records of rainfall and temperature from 1970 to 2017 using data from three weather stations. In particular, Mann-Kendall (M-K) Trend Test was used to test the null hypothesis H_0 of observations x_i follows no trend versus the alternative hypothesis H_1, of where observations x_i follow an increasing or decreasing monotonic trend. The M-K test statistic, S is calculated based on the following formula:

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} sign\left(x_j - x_k\right) \quad (1)$$

A set of time series x_k, is ordered based on $k = 1, 2, \ldots, \mathrm{n}$. Then, each data point is compared with data point x_k, referred as the reference point, so that:

$$Sign\left(x_j - x_k\right) = \begin{cases} 1 & if \quad x_j - x_k > 0 \\ 0 & if \quad x_j - x_k = 0 \\ -1 & if \quad x_j - x_k < 0 \end{cases}$$

When the data size, $n \geq 8$, the statistic, S is assumed to follow normal distribution with

$$E(S) = 0 \quad (2)$$

and

$$Var(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{q} t_p \left(t_p - 1\right)\left(2t_p + 5\right) \right] \quad (3)$$

Where q is defined as the number of tied groups and t_p is the number of point values in the p^{th} group. Meanwhile, the Z variable, i.e. the standardized normal variable, is computed based on the values of S and $Var(S)$ as follows:

$$Z = \begin{cases} \dfrac{S-1}{\sqrt{Var(S)}} & if \quad S > 0 \\ 0 & if \quad S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & if \quad S < 1 \end{cases} \quad (4)$$

Positive Z implies that there is an upward trend and vice-versa. Further statistical test is needed to confirm whether the upward or downward monotone trend is significant or not. A two-tailed test involves rejection of H_0 when $|Z|$ is larger than $Z_{1-\frac{\alpha}{2}}$ at α level of significance.

2.2.1 The Sen's Estimator of Slope

It is quite common that some seen trends are found not to be statistically significant even though it is expected [16]. In this study, linear trend analysis i.e. Sen's slope method is applied to measure the trend's magnitude. The computation of the slope (Q_i) for all data pairs is based on [17] defined as follows:

$$Q_i = \frac{x_j - x_k}{j - k} \quad for \quad i = 1, 2, 3, \ldots, N \quad (5)$$

Let x_j and x_k be data points at time j and k (where j>k). Meanwhile, let the median for all N values referring to Q_i is denoted as Sen's slope's estimator, and the value was defined as:

$$Q_i = T_{N+\frac{1}{2}}, \text{ when N is odd} \quad (6)$$

$$Q_i = \frac{1}{2}\left(T_{\frac{N}{2}} + T_{\frac{N+2}{2}} \right), \text{ when N is even} \quad (7)$$

If Q_i has a positive sign then it indicates an upward or increasing trend but if Q_i displays negative sign then it shows that there is a downward or decreasing trend in the time series.

2.3 Measuring Adaptive Capacity using Analytic Hierarchy Process (AHP)

Analytical Hierarchy Process (AHP) is a multi-criteria decision-making method that models the complexity of decision problem, incorporating both quantitative and qualitative factors [18]. AHP develops scores where these values can be used to rank each decision based on the agreement between the alternative and the criteria of the decision maker. Specifically, AHP is utilized to assess how each indicator of adaptive capacity (human resources, physical resources, financial resources, information, and livelihood diversity) contributes to the overall adaptive capacity levels as perceived by the key informants.

2.3.1 Pairwise Comparison Matrix

A pairwise comparison matrix for the relative importance between each pair of alternatives was developed. A group of panels which consisted of five experts, chosen purposively were asked to provide ratings on the relative importance of the different adaptive capacity indicators and sub-indicators of adaptive capacity. The ratings were derived by using the pairwise comparisons questionnaire scale, which comes from the AHP method. Table 1 provides the value of pairwise comparisons based on Saaty's AHP fundamental scale.

Table 1. Saaty's AHP Scale for Pairwise Comparisons

Numerical Values	Verbal Scale	Explanation
1	Equal importance of both elements	Two elements contribute equally
3	Moderate importance of one element over the other	Experience and judgment favor one element over another
5	Strong importance of one element over the other	An element is strongly favored
7	Very strong importance of one element over the other	An element is strongly dominant
9	Extreme importance of one element over the other	An element is favored by at least and order of magnitude
2,4,6,8	Intermediate values	Used to compromise between two judgments

2.3.2 Computation of Adaptive Capacity Index

A numerical value that is the weighted performance score is utilized to form the basis of the decision on the selection [19]. A multiplicative model was used to develop the adaptive capacity scores for each paddy farmer, calculated as:

$$AC = a_1 HR + a_2 PR + a_3 FR + a_4 I + a_5 LD \quad (8)$$

Where:

AC is the adaptive capacity scores for paddy farmer

$\alpha_1, \alpha_2, \ldots, \alpha_5$ is the weightage for each respective indicator of AC

HR is the indicator score for human resources
PR is the indicator score for physical resources
FR is the indicator score financial resources
I is the indicator score for information
LD is the indicator score for livelihood diversity

The weighted indicators, based on Equation 7, for human resources (HR), physical resources (PR), financial resources (FR), information (I), and livelihood diversity (LD) were calculated based on the formulas [20] as follows:

$$HRI = w \cdot HR_1 + w \cdot HR_2 + w \cdot HR_3 \quad (9)$$

$$PRI = w \cdot PR_1 + w \cdot PR_2 + w \cdot PR_3 + w \cdot PR_4 \quad (10)$$

$$FRI = w \cdot FR_1 + w \cdot FR_2 + w \cdot FR_3 \quad (11)$$

$$II = w \cdot I_1 + w \cdot I_2 + w \cdot I_3 + w \cdot I_4 \quad (12)$$

$$LDI = w \cdot LD_1 + w \cdot LD_2 + w \cdot LD_3 \quad (13)$$

The indicator scores together with their corresponding weights were linearly combined to come up with one single index score ranging from zero to one to reflect the level of adaptive capacity.

2.3.4 Classification of Adaptive Capacity's Scores

The final step involved classifying the sores into three different levels of adaptive capacity which are low, moderate, and high. Table 2 shows the three categories of adaptive capacity which are based on the range levels referred from the previous study [21].

Table 2. Category Level of Adaptive Capacity

Degree of AC	Ranges of Indices for AC
Low Adaptive Capacity	0.00 – 0.32
Moderate Adaptive Capacity	0.33 – 0.66
High Adaptive Capacity	0.67 – 1.00

2.4 Fitting Binary Logistic Regression to Determine the Factors Associated with Paddy Farmers' Adaptive Capacity

This study applied binary logistic regression, to determine the factors that could be associated with the level of paddy farmers' adaptive capacity towards climate change. The choice of this model is based on the desired result "Adaptive Capacity" has two possible outcomes coded as 0 for moderate level and 1 for high level. The proposed model was:

$$\begin{aligned} \text{logit}(p(x)) &= \log\left(\frac{P(y=1)}{1-P(y=1)}\right) \\ &= a + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 \end{aligned} \quad (14)$$

where:

$P(y=1)$ = probability of a farmer is highly adaptive

β_i = contribution rates from each variable

x_i = variables associated with adaptive capacity of farmer

$i = 1, 2, 3, 4, 5$

3. Results and Discussions

3.1 Determination of Trend in Climate Variability

The Mann-Kendall (M-K) statistical test was used to determine the trend of climate variability in Kelantan in terms of rainfall and temperature based on three weather stations. These weather stations were chosen to represent Kelantan's climate as more than 30 years of data were recorded at these stations. The time period of the study is considered long enough to study the changes in climate [22]. Furthermore, this test also needs the time series to be assumed serially independent as the presence of autocorrelation in the time series may affect the accuracy of the estimation of the trend. Before applying M-K test, the presence of auto-correlation was examined using:

a) Correlogram of Autocorrelation (ACF) plot and Partial Autocorrelation (PAF) plot; autocorrelation exists if the vertical spikes do not lie between the straight horizontal dotted blue lines in the plot.
b) Durbin-Watson test; autocorrelation exists of the p-value for Durbin-Watson test is equal or greater than 0.05.

The presence of autocorrelation was detected in temperature across the years from 1972 to 2017. Therefore Cochrane-Orcutt transformation procedure was applied on the data to remedy the problem. Hence, only after the autocorrelation was removed, the trend was analyzed. Table 3 shows the summary of trend analysis of Kelantan's climate, for both rainfall and temperature based on M-K test.

Table 3. Trend Estimation of Kelantan's Climate

Component	Station	Tau (p-value)	Trend	Slope	Direction of Trend
Rainfall	Gong Kedak	0.587 (<0.001)	Exist	3.729	Increasing
	Kota Bharu	0.099 (0.324)	Do not exist	-	-
	Kuala Krai	0.267 (0.008)	Exist	3.293	Increasing
Temperature	Gong Kedak	1.000 (<0.001)	Exist	0.005	Increasing
	Kota Bharu	1.000 (<0.001)	Exist	0.019	Increasing
	Kuala Krai	1.000 (<0.001)	Exist	0.028	Increasing

The results showed that there were existences of positive trends for rainfall in Gong Kedak and Kuala Krai but no significant trend of rainfall existed in Kota Bharu. Meanwhile, there was an existence of trend for temperature across all three weather stations. The trend for temperature in all three stations shows positive trend. Overall, it can be concluded that there were changes in the trend of rainfall and temperature in Kelantan over the years.

3.2 Perception of Paddy Farmers towards Climate Change

Perception of paddy farmers refers to how the farmers view the climate variability [23]. The indicators used to reflect the farmers' perception are based on study done by [24] and [25]. Table 4 displays the distribution of the perception of paddy farmers. It was found that 85.9% of the paddy farmers perceived climate's changes, while only 14.1% of the farmers did not perceive changes in climate change. Therefore, it can be said that majority of paddy farmers in Kelantan did perceive changes in climate. These results are in line with the trend analysis of climatic records of rainfall and temperature from 1970 until 2017, where there exists trend in climate change for both rainfall and temperature. It is only relevant to measure the paddy farmers' adaptive capacity only if the farmers perceived changes in Kelantan's climate. Since the obtained result indicates that majority of paddy farmers in Kelantan perceived changes in climate, it is appropriate for the level of adaptive capacity of paddy farmers to be measured.

Table 4. Distribution of Paddy Farmers' Perception

Perception	Frequency	Percentage (%)
Do Not Perceive Changes	54	14.1
Perceive Changes	329	85.9
Total	383	100.0

3.3 Weights of Adaptive Capacity

Based on experts' opinion, priority importance of each indicator and sub-indicator of adaptive capacity was evaluated. These criteria were used to determine the level of adaptive capacity for each paddy farmer. The weight for the indicators and sub-indicators is shown in Figure 1.

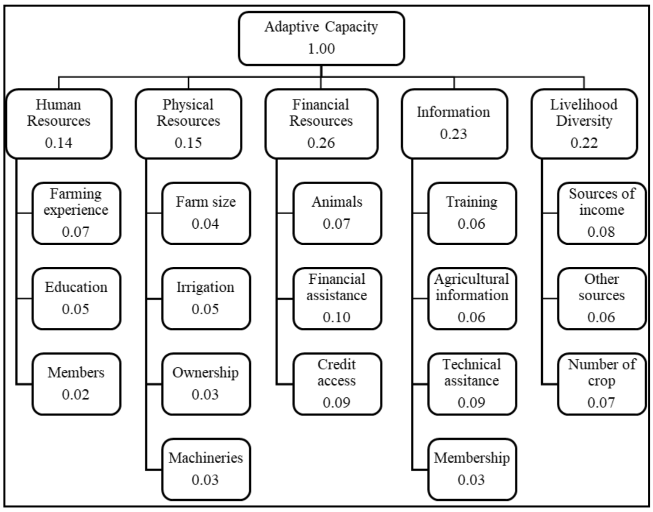

Fig 1. Weights of Adaptive Capacity

Based on the experts' opinion, the most important indicator for adaptive capacity is financial resources. Financial resources scored the largest weight from experts as the experts believed that adaptation towards climate change requires monetary expenditures. Furthermore, higher financial resources make possible the acquirement of physical and information resources. Information was ranked second as experts believed that accurate and enough knowledge is important for farmers to come up with effective adaptation strategies. These weights are then multiplied with respective answers chosen by farmers to obtain the score of adaptive capacity for each farmer.

3.4 Levels of Adaptive Capacity

The scores obtained were standardized to remove potential issues related to using indicators measured at different scales in order to categorize farmers into respective level of adaptive capacity, based on the standardized scores obtained. The categorization of farmers into respective level of adaptive capacity was based on the cut-off value as indicated in Table 2.

After the categorization, it was found that paddy farmers in Kelantan are either moderately or highly adaptive towards climate change. Table 5 shows the frequency and percentage of farmers by levels of adaptive capacity. It can be shown that 37.9% of the paddy farmers are moderately adaptive towards climate change with the average score of 0.59 while 62.1% of the paddy farmers are highly adaptive towards climate change with the average score of 0.77.

Table 5. Distribution of Paddy Farmers by Levels of AC

Level of Adaptive Capacity	Ranges of Indices for Adaptive Capacity	Frequency	Percentage (%)	Average Adaptive Capacity Scores
Moderate	0.00 – 0.32	145	37.9	0.59
High	0.33 – 0.66	238	62.1	0.77
Total	0.67 – 1.00	383	100.0	

3.5 Determination of the Factors Associated with Paddy Farmers using Binary Logistic Regression

Before developing the model, the assumptions were initially tested for any presence of outlier and multicollinearity. It was found that there is no presence of outlier and multicollinearity. Hence, Binary Logistic regression was performed. Initially, analysis using binary logistic regression to determine the significant factor that associates significantly with paddy farmers' adaptive capacity towards climate change was performed by including all the predictor variables which are gender of paddy farmers (gender), age of paddy farmers (age), marital status of paddy farmers (marital status), monthly income of paddy farmers (income), and the district in which paddy farmers reside (district). After the significant predictor variables that associates significantly with paddy farmers' adaptive capacity was determined, the analysis using binary logistic regression was performed again by including only the significant predictor variables. Table 6 shows the summary of predictive model on factors associated with the adaptive capacity of paddy farmers (including only significant predictor variables).

Table 6. Summary for Predictive Model on Factors Associated with Paddy Farmers' Adaptive Capacity

Variable	B	S.E.	Wald	df	Sig.	Exp(B)
Age	0.021	0.009	4.842	1	0.028*	1.021
Income			13.785	4	0.008*	
Income (1)	0.146	0.262	0.313	1	0.576	1.158
Income (2)	0.754	0.372	4.121	1	0.042*	2.126
Income (3)	1.579	0.593	7.095	1	0.008*	4.852
Income (4)	1.816	0.833	4.752	1	0.029*	6.148
District			23.168	4	<0.001*	
District (1)	-0.411	0.375	1.201	1	0.273	0.663
District (2)	0.501	0.349	2.063	1	0.151	1.650
District (3)	0.534	0.379	1.980	1	0.159	1.705
District (4)	1.534	0.458	11.204	1	0.001*	4.637
Constant	-1.25	0.631	3.927	1	0.048	0.287

*Significant at 0.05

It was observed that the significant associated variables with the level of adaptive capacity among paddy farmers towards climate change in Kelantan include age of paddy farmers (age), monthly income of paddy farmers (income), and the district in which paddy farmers reside (district). Since the variables income and district were categorical, dummy variables were created for these variables. The reference variable for income was the monthly income between RM0 to RM2000 while the reference variable for district was Tumpat. Age of paddy farmers had a positive relationship with the level of adaptive capacity (1.021). The implication is that for every one year' increases in the age of paddy farmers, the likelihood that the paddy farmers to be highly adaptive was 2.1 percent more as compared to moderately adaptive towards climate change in Kelantan.

Table 6 also shows that there is a positive relationship between paddy farmers whose monthly incomes are between RM2000 and RM3000 and their level of adaptive capacity (0.754). Paddy farmers whose monthly income is between than RM1000 and RM2000 are 2.1 times more likely to be highly adaptive towards climate change compares to paddy farmers whose incomes are lower than RM2000. Furthermore, there is also a positive relationship between paddy farmers whose monthly income lies between RM2000 to RM3000 and their level of adaptive capacity (1.579). Paddy farmers whose monthly income lies between RM3000 and RM4000 are 1.6 times more likely to be highly adaptive towards climate change compares to paddy farmers whose incomes are less than RM1000. Lastly, paddy farmers whose monthly income is above RM4000 are 6.2 times more likely to be highly adaptive towards climate change compares to paddy farmers whose incomes are less than RM1000.

Further results from Table 6 also indicate the districts in which paddy farmers reside have positive relationship with the level of adaptive capacity towards climate change in Kelantan (1.534). Paddy farmers that reside in Pasir Puteh are 4.637 times more likely to be highly adaptive towards climate change compares to paddy farmers who live in Tumpat. This is expected as Tumpat has the highest percentages of the urban hard-core poor residences as compared to other districts in Kelantan [26].

4. Conclusion

Paddy farmers in five districts of Kelantan; Bachok, Kota Bharu, Pasir Mas, Pasir Puteh, and Tumpat were asked if they had observed any changes in temperature and rainfall in Kelantan. The result indicates that 85.9% of the paddy farmers perceived variations in rainfall and temperature. These results are in line with the climatic data records of rainfall and temperature in Kelantan. The statistical analysis of rainfall from 1970 to 2017 in three weather stations; Gong Kedak, Kota Bharu, and Kuala Krai had shown the existence of trend in Kelantan's climate. The existence of trend in Kelantan's climate of rainfall and temperature are significant. This is due to the trend of temperature is increasing from year after year. The same goes to rainfall, as it signifies an increasing trend in Kelantan's rainfall. To find out that paddy farmers in Kelantan do perceives changes in Kelantan's climate make it possible to measure the level of adaptive capacity of paddy farmers towards climate change.
Although more than half of the paddy farmers in Kelantan are highly adaptive towards climate change, paddy farmers in different district of Kelantan adapt to climate change differently. In addition, the analysis using binary logistic regression highlighted age of paddy farmers, monthly income of paddy farmers, and the district in which paddy farmers reside as the factors that associated with the level of adaptive capacity significantly. These findings are in line with the previous studies ([15], [21], [25]). Furthermore, the findings could assist KADA and agricultural authorities in Kelantan to take appropriate measures in ensuring paddy farmers in Kelantan to be highly adaptive towards the changes in climate. It is also recommended that further studies to be pursued on other factors that can facilitate adaptive capacity of paddy farmers.

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