The Impact of Climate Change Disaster to the Socio-economic of Paddy Farmer in Malaysia

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Abstract
The uncertain climate nowadays has devastated the agricultural sector, particularly the rice sector and has become a natural disaster to paddy farmer. In fact, climate change has influenced the socio-economic status of farmers by decreasing crop yields. The aim of this study is to examine the impact of climate change such as precipitation, on the net income of farmers. With the assistance of the questionnaire for data collection, a quantitative approach will be adopted. Descriptive statistics will be carried out to explore the socio-demography of respondents. The Ricardian method will be used to analyse the impact on farmers' net incomes of changes in the level of precipitation. The marginal impact analysis was carried out to investigate the effect of an infinitesimal change in rainfall.

The study found that the relationship between household income and weather variables between the two seasons is nonlinear. Net revenue decreased in the low season as rainfall increased. In the absence of an adaptation model, net revenue fell to RM3/hectare due to climate change. With the adaptation model, net revenue would be a loss of RM1/hectare.

Keywords: Natural Disaster, Climate Change, Socio-economic, Paddy Farmer.

Introduction

Paddy is one of the ASEAN priorities included in the national food security agenda. The impact of climate uncertainties has affected food production and the socio-economic of paddy farmers in recent decades[13]. Global food safety and living standards are expected to have effects of climate change especially in the agricultural sector[5]. Previous studies in Southeast Asia have shown that climate change affects rice production in the region. Increases in rainfall and solar radiation above maximum and minimal levels will decrease rice production in East Java at least 1% per year[11].

Rice is Malaysia's main diet and contributes significantly to the incomes in the farming community. At present, rice autonomy levels in Malaysia are about 70% as global changes affect rice crop production, which will continue to affect rice crops' autonomy in Malaysia[19]. Roughly 0.3 million rice farmers are found in Malaysia, 40% of which are full-time farmers. The farm is less than 1 ha, which is expected to account for 65 per cent of the total rice farmers. This record of agricultural size per hectare has shown a negative trend in the recent use of rice crops. The total number of rice plants is 426,260 hectares and the average yield per hectare is 3.5 tonnes[6].

Singh et al[18] reported the real agricultural yields of Malaysia ranging from 3 to 5 tonnes with potential yields of 7.2 tonnes. Unfathomable variations in Kelantan and Kedah precipitation have triggered flooding and drought during the paddy manufacturing seasons.

In the event of climate change, paddy production will decline as the accumulation of water decreases the availability of water. This influences the soil fertility and distribution of pests[17]. Heavy rainfall correlated influxes are one of most hydrological phenomena[14]. Kelantan was struck by high floods in 2014[4].

Figure 1 shows the increase in annual precipitation in Kelantan. This shows that Malaysia, Kelantan and Kedah are not excluded from climate change impacts and vulnerabilities. Malaysia is temperate mainly year round with temperatures ranging between 21°C and 31°C in lowlands during the dry (year-round and south-eastern monsoon seasons from September to March.

Consequently, climate change has an immense impact on vulnerable populations such as livelihood farmers. According to Chamhuri et al[8], one of the most susceptible to climate change is the most impoverished states such as Kelantan, Terengganu, Perlis and Kedah.

At present, the unpredictable climate affects agriculture and socio-economic growth of farmers as they are interconnected[1]. Al-Amin et al[3] highlighted the strong interconnection between the climate change situation in Malaysia and rice agriculture. The dire impact of climate change on Malaysia's agriculture is a decline in productivity, food security vulnerabilities, an increase in air and water temperatures, a decrease in plant capacity and energy resources resulting in high economic costs, regional distribution restrictions and altered crop production due to changes in precipitation, temperature and carbon concentrate.

Furthermore, Malaysia also lacks credible results and scientific studies on climate change and socio-economic problems. Again, there is no mechanism to train the vulnerable population including farmers for tackling and responding to climate change implications and disaster in Malaysia[2].

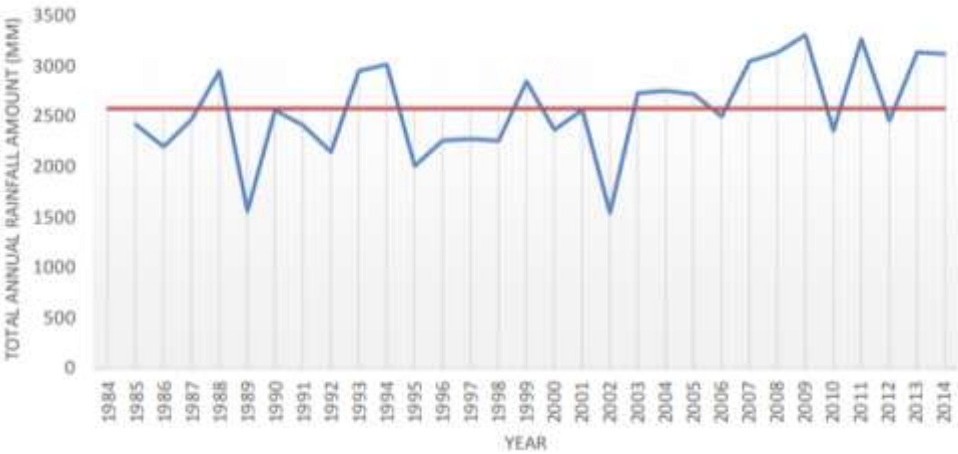

Fig. 1: Total Annual Rainfall in Kelantan from 1984-2014[14]

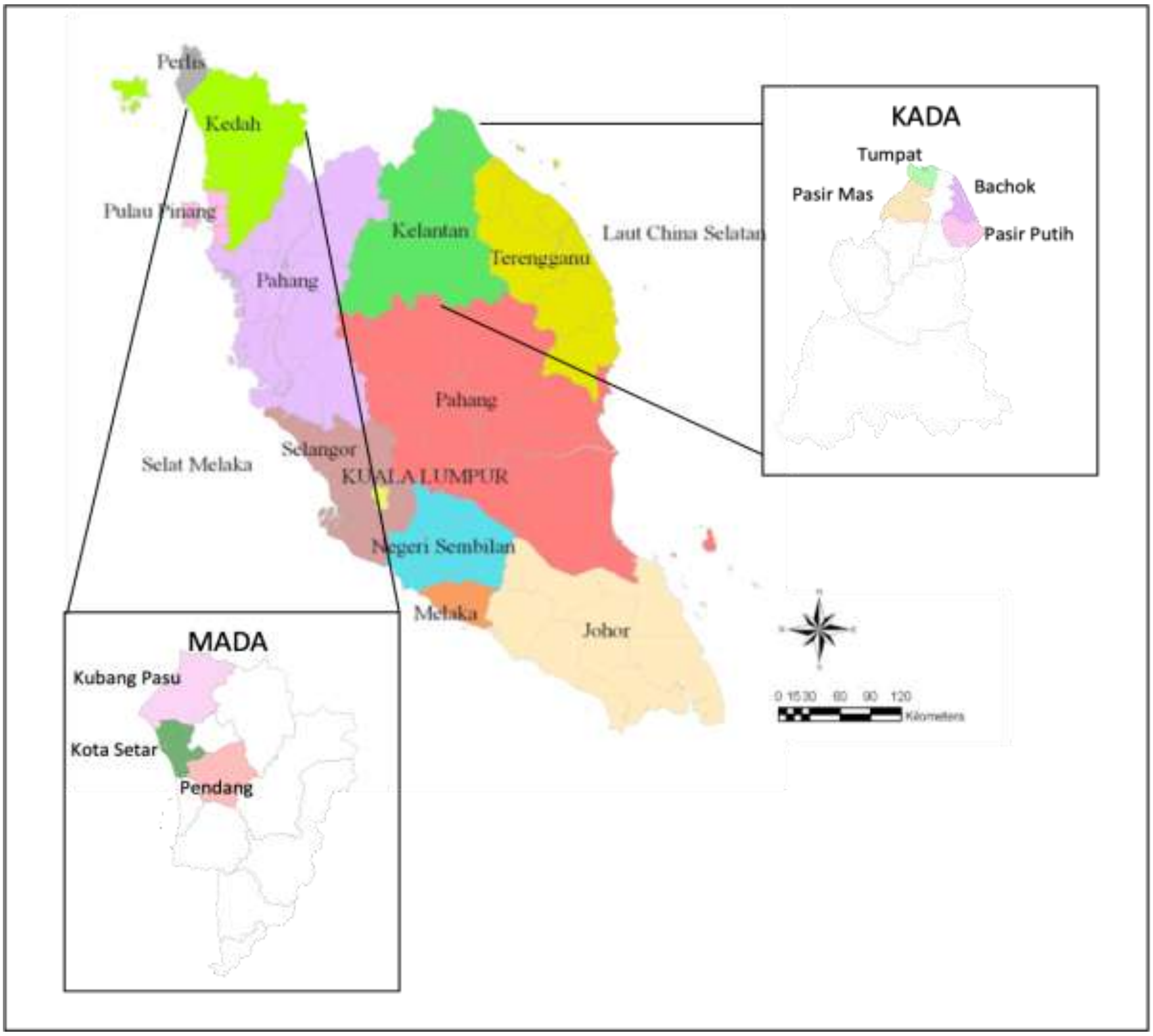

Fig. 2: Study Area

This study will explore paddy farmers' socio-demographic. This knowledge is beneficial for policymakers to devise mitigation strategies and plans for adapting farmers' resistance to the effects of climate change including floods. This study would also explore climate change impacts by focusing on changes in precipitation levels with socio-economic net revenue variables. The impact of precipitation variations on rice productivity is measured in various paddy fields in Kelantan and Kedah using the Ricardian method as a statistical tool. As we know, climate change is likely and in today's literature, its impact is clear[12]. We should also strive to explore possible vulnerability preparation strategies.

This study aims primarily at the examination of the effects of fluctuating Kelantan and Kedah precipitation levels during peak and off-season rice production as a result of climate change. In other words, shifts in precipitation affect the study region's water supplies on paddy production and paddy farmers' net income. Thus, the net income of paddy farmers is measured and the marginal influence of environmental variables on the net income is determined. This statistical study could assist policymakers in taking steps to counter possible future changes in Malaysia's rice production and climate fluctuations.

Methodology

Data Collection and Study Area: This study will investigate the knowledge and awareness of farmers on the impact of climate change on crop production. The questionnaire will be developed and distributed to the paddy farmers in Kelantan, Kemubu Agriculture Development Authority (KADA) and Kedah, Muda Agriculture Development Authority (MADA) where the most paddy field areas are located in Peninsular of Malaysia (Figure 2). There are approximately 7000 families that are still active in paddy cultivation at KADA and MADA respectively[1]. A total of 642 samples participated through random sampling method for both study area. Selection of these areas as the study site is based on the vulnerability to flooding every year.

Besides that, the data of climatic variables such as rainfall of study area was collected from the Institute of Climate Change, University Kebangsaan Malaysia (UKM). The rainfall data includes the monthly mean temperature total monthly precipitation in the 2010–2017 periods of 1 meteorological station of each region.

Average climatic data were calculated according to seasons based on classification: the rainy season from May to October and a dry season from November to April of next year. The critical summary statistics of all the variables used in the estimation is given in table 1.

Data analysis: Descriptive research will be carried out to determine farmers' knowledge of the effect on climate change crops on their socioeconomic status and farmers' knowledge. Inferential analyses like the Ricardian Model can also be used to analyse the impact of climate variables on farmers' net incomes. The Ricardian is the model used for cross-sectional analysis of crop production. This cross-sectional approach will explore the disparity between farms and show that each farmer is vulnerable to climate change.

Table 1
Summary Statistics of variables used in the Ricardian Model

Variables	Mean	Std. Deviation	Minimum	Maximum
Crop Net-revenues (RM)	24776.23	43045.41	1100	770000
Average rainfall low season (1) for 5 years (mm)	145.46	169.87	0.19	1160.25
Average rainfall low season (1) for 5 years $(mm)^2$	21160.24		0.036	1346180.06
Average rainfall peak season (2) for 5 years (mm)	265.85	161.72	20.5	932.39
Average rainfall peak season (2) for 5 years $(mm)^2$	70676.01		420.25	869351.11
Ages (Years)	50.58	12.05	19	63
Gender of Household Head (female=0, male=1)	0.94	0.23	0	1
Education Head of Household (0=unschooling, 1=primary, 2=secondary, 3=Certificate, 4=Diploma, 5=Degree and above)	2.06	0.98	0	5
Household Highest Education (0=unschooling, 1=primary, 2=secondary, 3=Certificate, 4=Diploma, 5=Degree and above)	3.24	1.43	0	5
No of Household (person)	5.12	1.84	2	10
No of Working Household (person)	2.05	1.06	0	6
Area of rice field (Ha)	7.36	9.93	0.29	150
Working hours (hours)	5.12	1.63	2	8
Knowledge on climate change (0/1)	0.75	0.43	0	1
Awareness on climate change (0/1)	0.85	0.35	0	1

This approach is usually used to assess the economic impacts of climate change and to identify adaptation steps for farmers[17]. David Ricardo (1772-1823) used the Ricardian system for the first time. This method has been used by several continents like America, Europe, Africa and Asia to determine the effect of climate change on agriculture. Previous studies have shown that net agricultural sales are environment, soil and economy. This approach is also based on the theory that land value is productive of the land net. This idea is illustrated in the following equation:

$$LV = \sum P_i, Q_i\ (X, C, S, G, H) - \sum P_x X \quad (1)$$

where LV is the land value, P_i is the price of crop i, Q_i is the quantity of crop production i, X is a vector of purchased inputs (except the soil), C is a vector of climate variables, H is a vector of water flow, S is a vector of soil variables, G is a vector of socio-economic variables and P_x is a vectors of input prices.

In theoretical profit, this study assumes that farm households always strive to optimise their profit based on the terms that the inputs change and choose crops, type of production or income to maximise net income, which depends exclusively on exogenous variables. The households' input demand function depends on the market price of the input while the market price of the output is expected to be influenced by weather, climate and other factors. Market prices of output and input in the Ricardo model are expected to be market values. This is a critical study hypothesis. If rejected, the study is invalidated because the model's estimation is irrelevant. The standard Ricardian model depends on a quadratic climate formulation. Consequently, the net value of the land can be expressed as follows:

$$V = \beta_0 + \beta_1 C + \beta_2 C^2 + \beta_3 S + \beta_4 G + \beta_5 H + \mu_i \quad (2)$$

where V is land value, C is a vector of climate variables, S is set of soil variables, G is set of household's socio-economic variables, H is set of water flow, the β coefficient of the variables and μ is an error term.

For this study, the Ricardo model will be developed from equation 2. Variations in rainfall analysed in off season and peak season were observed and this study uses more interaction variables between average precipitations of two seasons to examine their combined impact on net income.

$$V_{net} = \beta_0 + \beta_1 Ro + \beta_2 Ro^2 + \beta_3 Rp + \beta_4 Rp^2 + \sum_{j=1}^{n} cjGj + \mu_i \quad (3)$$

where V_{net} is farmland net revenue, R is respectively the mean rainfall while o represents off season and p represents peak season, G_j is a set of socio-economic characteristics of the household while β_i, a_i and c_j are coefficients of the variables, β_0 is a constant term and μ is an error term.

The independent variables include the linear and quadratic terms of rainfall and socio-economic variables. Household net revenue is taken as dependent variable. From the equation 3, we can evaluate the marginal impact value of climatic variables (rainfall) on the household revenue. If the change increases net income, it will beneficial and if it decreases net income, it will be harmful.

From eq. (3), we can derive the marginal impact of a dry season rainfall (R_d) on household revenue evaluated at the mean as follows:

$$MI_{Rd} = \left[\frac{dV}{dR_d}\right] = [\beta_1 + 2\beta_2 Rd] \quad (4)$$

The change in welfare measured impact of climate change. ΔMI can be expressed as follows:

$$\Delta MI_{Rd} = MI_{Rd+1} - MI_{Rd} \quad (5)$$

Combining eqs. (4) and (5) and assuming other factors as constant, ΔMI_{Td} can be measured as follows:

$$\Delta MI_{Rd} = [\beta_1 + 2\beta_2 (Rd_{rb+1})] - [\beta_1 + 2\beta_2 Rd_{tb}] \quad (6)$$

If the change increases net income, it will be beneficial and if it decreases net income, it will be harmful.

Results and Discussion

Respondent's Profile: Table 2 shows the socio-demographic distribution of paddy farmers in the study area. These results indicate a majority (94%) of paddy farmers in Malaysia are male with age ranging between 19 and over 60 years. The most significant number of farmers was from the age group over 50 years. Most of the farmers (>50%) are senior.

The second, largest group of farmers (>30%) was between 20 years and 49 years. Therefore, it could be concluded from this result that the population of rice farmers in the study area is senior. This age distribution could give a problem on the adoption of new techniques of production.

Besides that, the finding of this study shows the educational status of the farmers. It is reported that more than 50% had secondary education with the farming experience for more than 10 years.

However, the monthly income of the majority of respondents is below RM2000 which is under B40 category. Besides, this finding is parallel with the monthly saving of majority respondent which is less than RM100.

Results indicate that more than 60% of the farmers have a farm size of fewer than 6 hectares. 32% of farmers have 1.0–2.0 hectares and 22% have 2.0 to 3.0 hectares of land. Most farmers in the study area are small-scale farmers as 33% reported farm sizes of less than 1 hectare. It is the reason that most of the respondents only spend 3-6 hours daily working in the paddy field.

Table 2
Socio-demographic Characteristic of Respondents

Demographic		Frequency (%)		
		Kemubu Agriculture Development Authority (KADA)	Muda Agriculture Development Authority (MADA)	Total
Gender of Household	Male	380 (94.8)	224 (92.9)	604
	Female	21 (5.2)	17 (7.1)	38
Age	<20 years old	4 (1)	1 (0.4)	5
	20-29 years old	46 (11.5)	13 (5.4)	59
	30-39 years old	42 (10.5)	31 (12.9)	73
	40-49 years old	70 (17.5)	54 (22.4)	124
	50-59 years old	132 (32.9)	57(23.7)	189
	>60 years old	107 (26.7)	85 (35.3)	192
Ethnic	Malay	392 (97.8)	237 (98.3)	629
	Chinese	0 (0)	4 (1.7)	4
	Siamese	9 (2.2)	0 (0)	9
Marital Status	Married	351 (87.6)	221 (91.8)	572
	Single	43 (10.7)	10 (4.1)	53
	Widowed	7 (1.7)	10 (4.1)	17
No. of Household	<2 persons	49 (12.2)	54 (22.4)	103
	3-4 persons	122 (30.4)	65 (27)	187
	5-6 persons	102 (25.4)	54 (22.4)	156
	>6 persons	128 (31.9)	68 (28.3)	196
No. of Household Working	0	0 (0)	16 (6.6)	16
	1 person	157 (39.2)	66 (27.4)	223
	2 persons	128 (31.9)	102 (42.3)	230
	3 persons	56 (14)	27 (11.2)	83
	>4 persons	60 (15)	30 (12.4)	90
Paddy Field area	<5 ha	174 (43.4)	214 (88.8)	388
	6-10 ha	119 (29.7)	20 (8.3)	139
	11-15 ha	46 (11.5)	3 (1.2)	49
	16-20 ha	35 (8.7)	0 (0.0)	35
	>21 ha	27 (6.7)	4 (1.7)	31
Experience in paddy farming	<5 years	87 (21.7)	49 (20.3)	136
	6-10 years	75 (18.7)	31 (12.9)	106
	11-15 years	66 (16.5)	22 (9.1)	88
	>16 years	173 (43.1)	139 (57.7)	312
Education (head of household)	Primary School	89 (22.2)	47 (19.5)	136
	Secondary School	229 (57.1)	143 (59.3)	372
	Certificate/STPM/STAM	49 (12.2)	23 (9.5)	72
	Diploma	12 (3)	3 (1.2)	15
	Bachelor/Master/Doctorate	8 (2)	25 (10.4)	33
	Unschooling	14 (3.5)	0 (0.0)	14
Highest Education in Household	Primary School	0 (0)	1 (0.4)	1
	Secondary School	164 (68.6)	75 (31.4)	239
	Certificate/STPM/STAM	54 (13.5)	24 (10)	78
	Diploma	51 (12.7)	45 (18.7)	96
	Bachelor/Master/Doctorate	132 (32.8)	96 (39.8)	228
Monthly Income	<RM600	76 (19)	23 (9.5)	99
	RM601—RM1000	174 (43.4)	88 (36.5)	262
	RM1001-RM2000	93 (23.2)	64 (26.6)	157
	RM2001-RM3000	27 (6.7)	30 (12.4)	57
	RM3001-RM4000	21 (5.2)	20 (8.3)	41

	>RM4000	10 (2.5)	16 (6.6)	26
Monthly Saving	<RM50	162 (40.4)	119 (49.4)	281
	RM51-RM100	56 (14)	23 (9.5)	79
	RM101-RM200	54 (13.5)	34 (14.1)	88
	RM201-RM300	56 (14)	20 (8.3)	76
	RM301-RM400	24 (6)	13 (5.4)	37
	>RM401	49 (12.2)	32 (13.3)	81
Working Hour daily	<2 hours	22 (5.5)	28 (11.6)	50
	3-4 hours	139 (34.7)	126 (52.3)	265
	5-6 hours	188 (46.9)	54 (22.4)	242
	> 7 hours	52 (13)	33 (13.7)	85

Table 3
Regression Result

Variable	Model without adaptation	Model with adaptation
Average rainfall low season (1) for 5 years (mm)	- 0.078 (- 2.53)**	- 50.82 (- 2.09)**
Average rainfall low season (1) for 5 years (mm) ^{2}	6.67 (10.46)***	2.18 (3.54)**
Average rainfall peak season (2) for 5 years (mm)	- 0.41 (-2.13)**	- 0.32 (-1.45)*
Average rainfall peak season (2) for 5 years (mm)^2	0.26 (20.45)***	0.17 (8.48)***
Age		-2414.13 (-2.71)**
Education (Head of Household)		1037.04 (0.53)*
Highest Education of Household		248.08 (1.92)*
Working Hours/ Day		2216.45 (2.08)**
Area of paddy field		15110.43 (9.78)***
Knowledge on Climate change		801.60 (1.20)*
Awareness on Climate Change Impact		2615.15 (2.53)**
N	642	642
Pseudo R^2	0.160	0.223

*significant at 10% level
**significant at 5% level
***significant at 1% level

Results and Discussion

Regression Model: For this study, two main sets of modified Ricardian models were applied. Both models have variable and differential parameters. The model is defined as adaptable and adaptable. The first model depends only on integrated physical factors such as climate variables without adaptation. In the next model, there is an additional variable consisting of two sets of climates and socio-economic variable regressors. The retrogrades are used to justify farmers' net income. The socio-economic variable consists of age, education, household education, working hours, the paddy field, climate change knowledge and climate change awareness.

The agricultural income of specific farmers can be accessed by taking into account the adaptations of farmers. As noted above, both Ricardian models were estimated with and without adaptation. According to Huong et al[13], cross-sectional data combination and conventional regression (OLS) can overcome issues like variance, multi-coloniality, external value impact and autocorrelation that distort the estimated results. In the particular model, many explanatory variables have been multi-linear and this problem, in general, is not entirely annulled[7]. Table 3 records the regression estimates of the two models. The pseudo R2 is the interpretation level of the model. The Pseudo R2 without models was 16% and the adaptation model was 22.3%. The resulting value is slightly the same as in Benhin[7] studies as 16.99% in Mano and Nhemachena[16] studied as 18.71% and in Huong et al[13] studied as 18.37%.

All the climate factors showed a negative coefficient, both average rainfall in the low season and high season, according to the results. The average rainfall without adaptation in low season is -2.53 while the adaptation is -2.09. In peak season, more significant numbers were recorded -2.13 without adaptation and with adaptation as -1.45. Based on the average rainfall generated in both seasons, the model without adaptation produced a more significant result than the adaptation model.

Besides climatic factors, the coefficient generated in the result from the model also presented the socio-economic factors. All of the variables showed a positive coefficient (0.53, 1.92, 2.08, 9.78, 1.20, 2.53) except age (-2.71). The positive number indicated that all of them significantly affect farmer's income as expected.

Table 4
Marginal Impact of Climate on Paddy Farmer net Revenue per hectare

	Paddy Season	Model without Adaptation	Model with adaptation
Impact of Rainfall	Low Season (Hujan)	-3.45**	-1.02
	Peak Season (Panas)	-1.51**	-1.25

**significant at 5% level

Marginal Impacts of Climate Change on Paddy Farmer revenue: A marginal impact analysis was carried out to monitor the effect of an infinitesimal change in precipitation on the net income of households. The marginal temperature impacts were calculated based on the average low season and peak season temperatures. The marginal rainfall impact was also calculated on the average annual precipitation of the sample during the low season and peak season (Table 4).

Increased precipitation during the low and peak seasons significantly reduces household net income in both models. Increased marginal rainfall in low and peak seasons decreases household net sales respectively by RM 3.45 and RM 1.51 in model without adaptation. It also reduces net income in adaptation models, although the level of reduction is not significant.

The trend towards changes in precipitation was also identified in this study as a similar trend in research across the globe[9,10,15]. In the marginal analysis, the interpretations of signs and magnitudes of impacts are further explained. During the peak season, a slightly higher precipitation temperature increases germination because it is the cultivation season.

During low season, slightly high precipitation may promote diseases and insect pests[9]. The reduction in household net income during the low season is due to the already high rains during this season while further precipitation is causing extreme weather conditions such as heavy rainfall and flooding.

Conclusion

The Ricardian analysis shows the impact and problem of climate change on the farmers in two main paddy fields of Malaysia (MADA and KADA). In general, based on significant values, the rainfall together with the socio-economic situation represented the climatic factor and is expected to have substantial effects on farmers' net incomes. The impact of climate change might be a disaster for the paddy farmer.

Therefore, either Government or NGO should consider developing and implementing the paddy adaptation system to enhance cultivation and to educate farmers well with modern implementation. Besides, the adaptation model should adopt the concept of Disaster Risk Reduction (DRR) to focus on structural changes in crops, development of new plant varieties adapted to the climate conditions of the region, planting drought-tolerant plants, educating farmers, reinforcing financial services and implementing agricultural diversification.

Acknowledgement

Special thanks go to Universiti Malaysia Kelantan and Institute Climate Change, Universiti Kebangsaan Malaysia for providing technical support and adequate financial assistance facilities under UKM-Yayasan Sime Darby Research grant (R/YSD/A08.00/00793A/002/2018/ 000543).

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(Received 03rd January 2021, accepted 09th March 2021)