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Economic Impact of Climate Change on the Malaysian Palm Oil Production

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ABSTRACT

Climate change had become an important global environmental issue. Studies on different crops had evidenced that adverse impacts accrues to crop plants from climate variability. This could take the form of increase in temperature, flood or pest control challenges. This study has estimated the potential impact of climate change on palm oil production in Malaysia. The Ricardian model was applied to estimate the marginal impact of temperature and rainfall variations. The results show that climate change has significant nonlinear impact on net revenue. The total marginal increase in temperature and rainfall resulted in a declined of RM 40.55, RM 48.69 and RM 37.61 ha⁻¹ for Peninsular, Sabah and Sarawak, respectively. Meanwhile, by projection using regional climate modeling system, PRECIS, the palm oil is predicted to lose an average (RM ha⁻¹) amount of RM 344.12, RM 294.20 and RM 105.62 for Peninsula, Sabah and Sarawak, respectively in year 2099 Based on these results, the development of plant varieties tolerant to high temperatures and water low use is suggested to ease this impact.

Key words: Climate change, oil palm, Ricardian model, economic impact

INTRODUCTION

Climate change had nowadays constituted a serious global environmental threat. Scientists predict that the enhanced greenhouse effect could intensify climate variability. This phenomenon can cause severe weather, condition which might result in a natural disaster. The damage ensuing from climate change could result in invaluable losses to a community's resources such as human, material, economic as well as environmental adversities (UNEP, 2011). Agricultural activities have been most vulnerable due to climate change (IPCC, 2001). Consequently, changes in temperature and rainfall for instance, could significantly affect the yield of agricultural farms (Murad *et al.*, 2010). Sequel to the above, the decline in farm yield would impact unfavorably on earnings from agricultural output.

It is contended in existing studies that a rise in the incidences of heat stress, droughts and floods had far-reaching effect on agricultural productivity. The results of mean climate change, has negative economic impacts on the agricultural sector. Climate change will have agronomic impacts on crop yield which will consequently have economic effects on agricultural prices,

production, demand, trade, regional comparative advantage and producer and consumer welfare (Li *et al.*, 2011). For instance, a study by Vaghefi *et al.* (2011) has reported that a rise in temperature by 2°C on the Malaysian rice production consequences a reduction of 0.36 t ha⁻¹ which approximately causes economic loss of RM 162.531 million per year under such climate scenario.

The inherent risk in supply instability for export earnings on plantation crops as well as the threat to national food security constitutes the core of climate change concern in Malaysia. Any unfavorable climate will negatively affect agricultural growth (Murad *et al.*, 2010). Therefore, climate change phenomenon is an important issue that should be taken into account in maintaining the sustainability and productivity of agricultural crops. There are various measures for crop cultivation which could be employed to adapt to the current climate change event in order to minimize crop damage in the event of unexpected bad weather (Adger *et al.*, 2007). In order to identify how climate change could negatively impact the Malaysian socio-economy, it is necessary to understand the nature of climate variability. The description of the changing pattern of the climate could be understood by analyzing the pattern of daily temperature and rainfall for certain a period of years (Al-Amin *et al.*, 2011).

The objective of this study is threefold. Firstly, to access the historical impact of rainfall and temperature variability on palm oil production. Secondly, to estimate the marginal impact of change in the context of rainfall and temperature on palm oil production. Thirdly, to project the potential long-term future impact of climate variability on palm oil net revenue.

Oil palm is best suited to the humid climate in Malaysia where the rain occurs at night and the days are bright and sunny. For optimum yield, the minimum rainfall required is around 1,500 mm year⁻¹ with an absence of dry season and an evenly distributed sunshine exceeding 2000 h year⁻¹ (Basiron, 2007). A mean maximum temperature range between 29 to 33°C and minimum temperature between 22 to 24°C favor the highest oil palm bunch production (Corley and Tinker, 2003).

A high mean annual temperature that falls within the specified weather conditions required for the thriving of oil palm is favorable for higher fruit production. However if such high temperatures will lead to drought conditions, it is estimated that 208,000 ha of land or 12% of the present area would be considered as either marginal or unsuitable for oil palm cultivation. Lack of water can cause decreased production of female and male flowers. Besides, drought can also cause flower drop and reduce crop production (Corley and Tinker, 2003). Goh *et al.* (2002) reported that heavy intensity of rainfall can could result in decreased Fresh Fruit Bunch (FFB) yields, which will affect severity and frequency of moisture stress experienced by the palms. The harvest activities will be delayed and consequently the fruit of oil palm will rot if left for a long time.

According to MMD (2009), the climate change experienced in Malaysia is driven by two main phenomena which are El-Nino and La-Nina. El-Nino denotes hot and dry weather while La-Nina is used to describe wet weather characterized by excessive rainfall. Since the last 30 years, the two strongest El-Nino that have occurred were experienced in the year 1982-1983 and 1997-1998. These scenarios could be observed in Fig. 1. This severe climate has effect on the yield of crop oil palm production. The impact of the El-Nino-driven drier weather can be noticed now with the development of lower oil-yielding male flowers and can extend until next year.

Recently, the Economics and Development Division of MPOB (2010) reports that palm oil production declined because the direct and indirect uncertainties of climate change. The CPO drops by 3.3% to 16.99 MT from 17.MT in 2009. Peninsular Malaysia and Sabah both registered declines of 6.1 and 2.5% from 9.5 and 5.3 MT, respectively. However, Sarawak's CPO production has

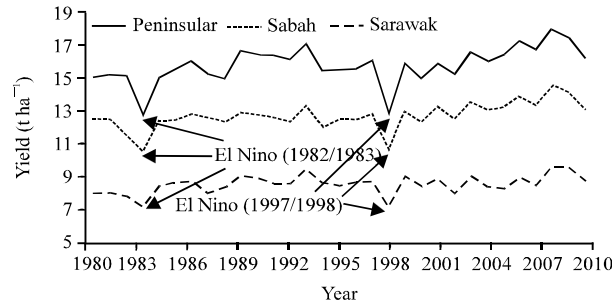


Fig. 1: Annually CPO production yield (total) by region (Tonne ha⁻¹) effected by El-Nino episodes

increased by 9.3% to 2.2 MT. MPOB reported that average FFB yield fell 6.1% while OER lowered by 0.2% in 2009. Peninsular Malaysia was the worst affected with average FFB yields declining by 7.5%, followed by Sabah 4.7% and Sarawak 2.6% (MPOB, 2010). So, the objective of the study is to estimate the potential impact of climate change on palm oil production in Malaysia.

MATERIALS AND METHODS

Model specification: In order to study and determine the sensitivity of oil palm production to CC, the Ricardian model which is currently employed under this study had been proven to be useful by a number of researchers (Mendelsohn *et al.*, 2001; Mendelsohn, 2007; Gbetibouo and Hassan, 2004; Seo *et al.*, 2005; Adger *et al.*, 2007). The Ricardian model estimates total net revenue that accrues to farms per hectares of cultivated land depending on climate and other explanatory variables such as price, quantity of goods and temperature (Seo *et al.*, 2005). This modeling approach to analyze the impact of climate on crop productivity is based on a set of CC scenarios to measure the impact of CC on the net revenue that accrue to farmers. Besides, it is employed to study the impact of climate change on agriculture (Adger *et al.*, 2007). Ricardian method assesses the performance of farm by quantifying impacts on agricultural productivity across the landscape revealing the effects of variation between different climate zones (Hassan, 2010). Below is the general formulation to calculate the net revenue:

$$NR = \sum Pi Qi(X, Y, Z) - \sum P \times X \quad (1)$$

where, NR is net revenue per hectare, Pi is the market price of crop i, Qi is output, X is a vector of purchased input, Z is the economic variables and Px is a vector of input prices. Y is a vector of climate variables. The study defines net revenue as the gross revenue less per hectare production cost. The dependent variable will be regressed on climate and other control variables. Following previous specification by Mendelsohn (2007), the standard Ricardian model relies on a quadratic formulation of climate. This study extends the specification by adding "area"; which refers to the area of cultivated land committed to the planting of oil palm. Thus we model both the basic model and an extended model as specified below:

- Model 1(without control variables):

$$NR = \beta_0 + \beta_1 \text{rain} + \beta_2 \text{rain}^2 + \beta_3 \text{temp} + \beta_4 \text{temp}^2 + \epsilon \quad (2)$$

- Model 2 (with control variables):

$$NR = \beta_0 + \beta_1 \text{rain} + \beta_2 \text{rain}^2 + \beta_3 \text{temp} + \beta_4 \text{temp}^2 + \text{area} + \epsilon \quad (3)$$

In the above model specifications (Model 1 and 2) for both Eq. 2 and 3, where rain is denoted as rainfall, temp is abbreviation for temperature and ϵ refers to the error term. Both linear and quadratic terms captured for rainfall and temperature are introduced. The introduction of quadratic terms (rain^2 and temp^2) stand for the nonlinear values of rainfall and temperature. These reflect the non-linear shape of response function between net revenues and climate. This study also extends the specification on Model 2 in Eq. 3 by adding area; which refers to the area of cultivated land committed to the planting of oil palm.

After estimating the model above, simulations were undertaken using different climate scenarios to determine how palm oil production will be effected under the scenario. The sign of the linear term indicate the unidirectional impact of the independent variable, the quadratic term reflects the non-linear shape of the net revenue of the climate response function. When the quadratic term is positive, the net revenue function is U-shaped and when the quadratic term is negative the function is hill-shaped. The expected marginal impact of a single climate variable on the land value and farm net revenue evaluated at mean is:

$$E[d(NR)] = \frac{b_{1,i} + 2 * b_{2,i} * E[f_i]}{d(f_i)} \quad (4)$$

where, Following Kurukulasuriya *et al.* (2006) the specification in Eq. 4 is used to calculate the marginal impact on Net Revenue (NR) for each rainfall and temperature climate variables (f_i). Marginal impact calculations determine how palm oil production will be affected by a 1°C rise in temperature and a 1 mm increase in rainfall. The advantage of this approach is that the method includes direct effect of climate on yield on crops and control variables as adaptation response.

Control variable: The control variables were introduced to control for extraneous factors. It is important to clarify the reason for including the control variables. The control independent variables represent one of the non-climate features that influence the net revenue (per hectare). Sanghi and Mendelsohn (2008) reported that control variable is useful for the purpose of controlling the influence of missing data (variable). In this study, as the net revenue per hectare is expected to be influenced by factors other than climatic variables, we have included one control variable which is oil palm area planted.

Data: Oil palm raw data on net revenue and its determinant were collected from Malaysian oil palm statistics reported by Economics and Development Division of the Malaysian Palm Oil Board (MPOB). Three regions were selected for oil palm cultivation, which are Peninsular, Sabah and Sarawak (Fig. 2). Average annual temperature and rainfall from 1980 to 2010 were obtained from MMD (2009).

Statistical analysis: The data for this study covers Malaysia's three main regions of the Peninsular, Sabah and Sarawak. Annual time-series data spanning 31 years (1980-2010) was used



Fig. 2: Oil palm estate distribution in Malaysia, Centre of Remote Imaging, Sensing and Processing (CRISP), Singapore 2010

to analyze the impact of climate change in each of the aforementioned regions. Using E-views software, a Ricardian model was estimated based on Ordinary Least Squares (OLS) regression method for each region. The motivation for employing the Ricardian method was informed by its popular use to estimate economic impact of climate change in agricultural sector since the fairly recent past. The regression results support the presence of climate impact as evidenced by Eq. 2 (Model 1) and Eq. 3 (Model 2). Interpretations of results have been done through an examination of both the signs and magnitudes of estimated parameters. Sequel to this, the estimation of the marginal impact value based on fluctuations in temperature (per^oC) and rainfall (per mm) was made possible.

RESULTS AND DISCUSSION

Estimated model: This study had estimated a basic model (Model 1) and a variant model (Model 2) by including the area of cultivated land as a control variable. The essence is to consider beyond climate factors, the effects of related but non-climate factors. The basic model only considers climate factors and their quadratic terms as the most essential independent variables. Meanwhile the extended model (Model 2) examines how the inclusion of the non-climate factor (planted or cultivated area) might impact the dependent variable (net revenue) as well as the statistical significance of the climate variables. The climate variables considered (temperature and rainfall) were each squared, resulting in a quadratic (non-linear) model. This was done to reflect the non-linear shape of response function between net revenues and climate.

Table 1 presents the result from the regression with net revenue value as dependent variable. Rainfall as well as its squared effect is 5% level of statistically significant for Peninsula region in both Models (Model 1 and 2) but statistical evidence does not support the impact of temperature on net revenue. Both Models reveal that the relationship between rainfall and net revenue is U-shaped (non-linear). In addition, adjusted R² value shows that Model 2 (with a magnitude of 0.743) is better than Model 1 (which has a smaller value of 0.729). According to MMD (2009),

Table 1: Determinants of net revenue per hectare in Peninsular

Independent variable	Model 1			Model 2		
	Coefficient	t-stat	Sig.	Coefficient	t-stat	Sig.
Constant (c)	1165027	-1.3166		-1.00E+06	-1.023	
Rainfall Peninsular	-127.637	-2.0320	**	-259.24	-1.837	***
Rainfall Peninsular square	0.398	1.9724	**	0.775	1.763	***
Temperature Peninsular	87886.200	1.3189		97604.60	1.024	
Temperature Peninsular square	-1647.130	-1.3082		-1811.80	-1.015	
Planted area (area)				0.00446	1.759	**
Adjusted R ²	0.729			0.743		***

***Significant at 10, 5 and 10% level

Table 2: Determinants of net revenue per hectare (Sabah)

Independent variable	Model 1			Model 2		
	Coefficient	t-stat	Sig.	Coefficient	t-stat	Sig.
Constant	-40035.930	-2.671	**	-26268.590	-1.957	*
Rainfall Sabah	0.720	2.485	**	0.444	2.266	**
Rainfall Sabah square	-0.001	-2.111	**	-0.001	-2.224	**
Temperature Sabah	2958.474	2.718	**	2049.089	2.100	**
Temperature Sabah square	-54.349	-2.747	**	-38.304	-2.163	**
Planted area (area)				-0.001	-4.929	***
Adjusted R ²	0.514			0.777		***

***Significant at 10, 5 and 10% level

heavy rainfall is experienced during wet season, from about November to March. This is induced by the east winds from the South China Sea to the east coast of the Peninsular. Meanwhile, the south-west wind blows from the west Sumatra Peninsular. Records show that heavy rains that cause floods occur within months of each year in the monsoon season. This caused the flooding to occur in some places which take few days to recede. During flooding periods, fertilization as well as harvesting activities is hindered reducing outputs. This result, is coherent with a previous finding by Goh *et al.* (2002), who studied oil palm grown in coastal alluvial soils in peninsular Malaysia. They suggested that the warmer climate itself does have significant influence on production.

Meanwhile, from the result in Table 2, both climate indicators of rainfall and temperature as well as both squared effects in both models, were found to have 5% level of statistically significant impact on net revenue in Sabah region. In addition, R² shows that much improved Model 2 (0.777) than Model 1 (0.514). Meanwhile, Model 2 shows that the control variable (planted area) also impacts on net revenue. However, a per cent increase in cultivated area/ha reduces net revenue by a small amount of 0.1%. This is because flooding which result from rain variation reduces farm output by delaying fertilization and harvesting. An often cited example in support of this is the 1996 Greg storm event. Another example is that of Hilda tropical storm, which brought heavy rain to Sabah in year 1999 (MMD, 2009). This rain caused terrific floods and landslides. This havoc was exacerbated by the geographical positioning of Sabah region which exposed it to winds from the neighboring country, namely, South China and Philippine. The wind typically brings heavy rains and storms flooding several days, especially in low areas (MMD, 2009). The report also portrays

Table 3: Determinants of net revenue per hectare (Sarawak)

Independent variable	Model 1			Model 2		
	Coefficient	t-stat	Sig.	Coefficient	t-stat	Sig.
Constant	23480.38	3.324	***	23204.65	3.219	***
Rainfall Sarawak	0.478	1.295		0.403	1.001	
Rainfall Sarawak square	-0.000269	-1.594		-0.00024	-1.256	
Temperature Sarawak	-1712.06	-3.259	***	-1693.82	-3.157	***
Temperature Sarawak square	31.238	3.207	***	30.958	3.112	***
Planted area (area)				0.000053	1.059	**
Adjusted R ²	0.387			0.38		***

***Significant at 10, 5 and 10% level

that the El-Nino and La-Nina events have greater influence on rainfall reduction in East Malaysia (especially in Sabah) compared to peninsular Malaysia. This evidence while rainfall and temperature are important indicators which affect palm oil net revenue in Sabah.

In the peculiar case of Sarawak region, statistical evidence supports the impact of temperature on net revenue as both the level and quadratic terms are found to be 1% level of statistically significant at reducing palm oil revenue. The relationship between temperature and revenue is inverted U-shaped. In the case of the control variable, although there is statistical evidence that cultivated area of land increases palm oil revenue, the magnitude is small since one per cent increase in cultivated area/ha will increase revenue only by 0.0053%. Despite this impact of temperature on palm oil revenue, the study finds no relationship between rainfall variations and palm oil revenue. Moreover, R² seems like unchanged by given Model 2 (0.387) compare to Model 1 (0.380). This is understandable since relatively, Sarawak is geographically sheltered from east winds, especially from Philippine which usually result in storm clouds that consequently cause heavy rain. This explains why heavy rains that cause terrific floods are rarely encountered in this region. In addition, low moisture caused by high temperatures in the dry season in Sarawak has affected the volume of oil palm fruits grown.

Overall, in all regions as shown in Table 1-3, climate variability indicated by either rainfall or temperature or both, are found to impact negatively on palm oil revenue. Model fits are better in Model 2 compared to Model as the values of adjusted R² improved after adding the control variable and it is found to be statistically significantly in all regions.

Nonetheless, the magnitude of the coefficients representing the impact of cultivated area on palm oil revenue is practically insignificant because the values are very small and hence, negligible.

This suggests that the control variable has relatively smaller impact on oil palm net revenue when compared to the climate variables. Moreover, the result is consistent with the report by Mahmood *et al.* (2007) that the price factor is a significant variable explaining area changes which have significant positive coefficient relation of lagged acreage. Future research could focus on other control variables which might have more spectacular impact on oil palm production in the face of climate change.

Marginal impact analysis for net revenue model: The marginal impact analysis was done to assess temperature and rainfall impacts on net revenue per hectare of oil palm production. Table 4 shows the marginal effect of climate change on net revenue (RM/hectare). Particularly shown by Model 1, the marginal effect of rainfall for every 1 mm increase will reduce net revenue

Table 4: Marginal effect of temperature and rainfall on net revenue per hectare

Model	Peninsular		Sabah		Sarawak	
	1	2	1	2	1	2
Rainfall	5.24	-8.12	-4.59	-4.87	-1.60	-1.45
Temperature	-44.52	-23.21	-45.60	-42.31	-37.70	-34.47

Table 5: Average estimated net revenue (RM ha⁻¹) under PRECIS climate scenario

Year	Peninsular	Sabah	Sarawak
2029	-341.29	-127.43	-51.80
2059	-362.33	-192.28	-68.19
2099	-344.12	-294.20	-105.62

by RM 4.59 and RM 1.60 for Sabah and Sarawak, respectively. Meanwhile average peninsular region gains increase in net revenue for every increase per 1 mm rain by RM 5.24. On the other hand, the marginal effect of temperature on net revenue presented by Model 1 shows that, for every 1°C increase, revenue reduces by RM 44.52, RM 45.60 and RM 37.70 for Peninsular, Sabah and Sarawak, respectively. Based on the total average value from results obtained in both Model 1 and 2, the highest impact of climate (temperature and rainfall) variability on palm oil revenue is obtained in Sabah Region. Meanwhile the least effect is observed in Sarawak region.

Future climate impacts: This study had projected the impact of climate change on oil palm production net revenue (RM/ha) by applying PRECIS Regional Climate Modeling System on oil palm production. The study simulated the impact of future climate change scenarios by using estimated coefficients for net revenue function. We estimate the consequences of climate change scenario for the years; 2029, 2059 and 2099 shown by result in Table 5. By projection using regional climate modeling system, PRECIS, palm oil is predicted to lose an average (RM/hectare) amount of RM 341.29, RM 127.43 and RM 51.80 for Peninsula, Sabah and Sarawak, respectively in year 2029. This means that Peninsular shows highest affect compared to Sabah which is the lowest affect of future predicted climate change. The predicted loss in net revenue rises over the years if no adaptation and mitigation strategies are taken. The essence of this excise is to examine the role climate change might play in the future.

CONCLUSION

The study attempted to investigate the economic impacts of climate change on oil palm production in three regions, namely Peninsular, Sabah and Sarawak. The study applies modified Ricardian method to estimate the effect of climate change on oil palm production net revenue in Malaysia. Based on the objectives of this study, the relevant conclusion is summarized as follow; firstly, increase in rainfall and high temperature will negatively impact on palm oil production. As such net revenue from oil palm production will reduce annually. Besides, in the impact of climate variability on output will be more apparent in the future if adaptation measures are not taken. This study thus, suggests that adaptation and mitigation strategies are taken in order to minimize the adverse effects of climate change on oil palm production.

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REFERENCES

- Adger, W.N., S. Agrawala, O. France, M.M. Qader and M. Canada, 2007. Assessment of Adaptation Practices, Options, Constraints and Capacity. In: *Climate Change 2007: Impacts, Adaptation and Vulnerability*, Parry, M.L., O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson (Eds.). Cambridge University Press, Cambridge, UK., pp: 717-743.
- Al-Amin, W. Leal, A.H. Jaafar and A.Z Ghani, 2011. Assessing the impacts of climate change in the Malaysian agriculture sector and its influences in investment decision. *Middle East J. Sci. Res.*, 7: 225-234.
- Basiron, Y., 2007. Palm oil production through sustainable plantations. *Eur. J. Lipid Sci. Technol.*, 109: 289-295.
- Corley, R.H.V. and P.B. Tinker, 2003. *The Palm Oil*. 4th Edn., Blackwell Publishing, Oxford, UK.
- Gbetibouo, G.A. and R.M. Hassan, 2004. Measuring the economic impact of climate change on major south African field crop: A Ricardian approach. Department of Agriculture Economic, University of Pretoria, South Africa, pp: 144-152.
- Goh, K.J., K.K. Kee, P.S. Chew, H.H. Gan, Y.C. Heng and H.C.P. Ng, 2002. Concept of site yield potential and its applications in oil palm plantations. *Malaysian Oil Sci. Technol.*, 11: 57-63.
- Hassan, R.M., 2010. Implication of climate change for agricultural sector performance in Africa: Policy challenges and research Agenda. *J. Africa Econ.*, 19: ii77-ii105.
- IPCC, 2001. Synthesis report summary for policymakers. Third Assessment Report, An Assessment of the Intergovernmental Panel on Climate Change.
- Kurukulasuriya, P., R. Mendelsohn, R. Hassan, J. Benhin and T. Deressa *et al.*, 2006. Will African agriculture survive climate change. *World Bank Econ. Rev.*, 20: 376-388.
- Li, X., T. Takahashi, N. Suzuki and H.M. Kaiser, 2011. The impact of climate change on maize yields in the United States and China. *Agricult. Syst.*, 104: 348-353.
- MMD, 2009. Climate change scenarios for Malaysian 2001-2090. Malaysian Metrological Department, Scientific Report. http://www.met.gov.my/index.php?option=com_contentandtask=view&id=1650&Itemid=1589
- MPOB, 2010. Overview of the Malaysian oil palm industry. Report. http://bepi.mpob.gov.my/images/document/Overview202010_final.pdf
- Mahmood, M.A., A.D. Sheikh and M. Kashif, 2007. Acreage supply response of rice in Punjab, Pakistan. *J. Agricult. Res.*, 45: 231-236.
- Mendelsohn, R., A. Dinar and A. Sanghi, 2001. The effect of development on the climate sensitivity of agriculture. *Environ. Dev. Econ.*, 6: 85-101.
- Mendelsohn, R., 2007. Measuring climate impacts with cross-sectional analysis. *Clim. Change*, 81: 1-7.
- Murad, W., R.I. Molla, M.B. Mokhtar and A. Raquib, 2010. Climate change and agricultural growth: An examination of the link in Malaysia. *Int. J. Climate Change Strateg. Manag.*, 2: 403-417.
- Sanghi, A. and R. Mendelsohn, 2008. The impact of global warming on farmer in Brazil and India. *Global Environ. Change*, 18: 655-665.
- Seo, S.N.N., R. Mendelsohn and M. Munasinghe, 2005. Climate change and agriculture in Sri Lanka: A Ricardian valuation. *Environ. Dev. Econ.*, 10: 581-596.
- UNEP, 2011. *Global Environment Outlook 3: Past, Present and Future Perspectives*. Earthscan Publication, London.
- Vaghefi, N., M.N. Shamsudin, A. Makmom and M. Bagheri, 2011. The economic impacts of climate change on the rice production in Malaysia. *Int. J. Agric. Res.*, 6: 67-74.