

Farmers' Adaptive Capacity towards the Impacts of Global Warming: A Review

Mas Ernawati Hamdan¹, Norsida Man¹, Sulaiman Md Yassin², Jeffrey Lawrence D'Silva² & HayrolAzril
Mohamed Shaffril²

¹ Faculty of Agriculture, Universiti Putra Malaysia, Malaysia

² Institute for Social Science Studies, Universiti Putra Malaysia, Malaysia

Correspondence: Norsida Man, Faculty of Agriculture, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia. Tel: 60-3-8947-1852. E-mail: masernah@gmail.com

Received: June 5, 2013 Accepted: July 16, 2013 Online Published: September 29, 2013

doi:10.5539/ass.v9n13p177

URL: <http://dx.doi.org/10.5539/ass.v9n13p177>

Abstract

Global warming has been detected in Malaysia, and is predicted to worsen in the future. Agriculture is highly dependent on weather stability, and warmer climates are expected to cause formidable challenges to industry. This paper focuses on the impacts of rising temperatures on the environment and farmers' socio-economic situations. Data were obtained through a literature review and document analyses. It can be concluded that rising temperatures have had direct effects on agricultural products, which then affects the income and productivity of farmers. Furthermore, rising temperatures have been found to affect farmers' health and obstruct their social routines, while causing a shortage in terms of food supply. A brief discussion on the need for adaptation is also highlighted, and hopefully this will assist concerned parties to develop adaptation strategies that are in line with farmers' needs and abilities.

Keywords: global warming, farmers, agriculture, environment change

1. Introduction

Agriculture relies greatly on weather stability, and rising temperatures are forecasted to cause problems within industry. Past studies (Elsgaard et al., 2012; Mitchell et al., 2008; Vesselin & Josef, 2005) have considered the challenges brought about by the global warming phenomenon for a number of agricultural branches (e.g. aquaculture, crops, grain crops). Global warming threatens not only the environment but also communities - particularly those who depend on the environment for their livelihood (e.g. farmers & fishermen), as the phenomenon has been found to impinge on their socio-economic aspects (Lacey, 2012; Gonzalez & Sauliere, 2011; Hannah et al., 2008). In a situation where the climate keeps changing, ignoring options for adaptation is unwise. Indeed, strengthening farmers' adaptive capacity towards global warming is vital, as it will assist concerned parties to develop strategies that can enhance their preparation and readiness towards the impacts of rising temperatures, while simultaneously supporting the sustainability of agriculture-dependent industries. The main focus of this study is on farmers' adaptation towards one of the elements of climate change- global warming; it discusses issues pertaining to the impacts of global warming on the agriculture industry, as well as farmers' socio-economic aspects, and the need for farmers' adaptation.

2. Global Warming in Malaysia

People all over the world are exposed to rising temperatures. This is commonly known as global warming, and is caused by greenhouse gases (e.g. carbon dioxide, nitrous oxide, methane) trapping heat and light from the sun in the earth's atmosphere, which then results in rising temperatures. A study by Nelson and Serafin (1996) on Malaysia's changing climate patterns predicted that by 2096, local temperatures will increase by between 1.5 and 4.5°C, while a study by the Intergovernmental Panel on Climate Change (IPCC) (2007) predicted that Malaysia's temperatures will increase by 0.6 to 4.5°C by 2060. In line with these studies, Wai et al. (2005) suggested rising temperatures of between 0.99 and 3.44°C per 100 years in several areas in Peninsular Malaysia, while Kwan et al. (2011) found that several areas in Malaysia, such as Bayan Lepas and Ipoh, are facing warmer days, while areas such as Malacca and Miri are facing warmer nights. The findings presented show that Malaysia certainly is getting warmer, and this raises concerns, particularly for those who depend on weather stability (e.g. farmers,

fishermen) to conduct their social and economic routines.

3. The Impacts of Global Warming on Agricultural Sectors

Malaysia is a vulnerable country, since both agricultural sustainability and related livelihood sustainability are under threat due to the adverse impacts of global warming. Malaysia has been placed as the 26th largest greenhouse gas emitter in the world, and with an increasing population, this emission rate is expected to grow. The emissions are predicted to change the climate; in 100 years, the world is expected to get warmer by 0.3°C to 4.5°C. A warmer world means that ice in both poles will melt faster than normal, which then will result in the sea level rising by about 95cm in the next century. Furthermore, a warmer world is expected to influence rainfall patterns, whereby the frequency of rain is expected to be markedly reduced or increased in several areas. These changes will affect the quantity and cultivation of certain crops, for instance depleting rubber, cocoa and palm oil (NRS, 2001). Table 1 indicates the evolution of the crop production in Malaysia, South East Asia and World from year 1970 to 2010. The data shows that all the crops exclude oil palm fruit, paddy rice, fruit exclude melons and vegetables and melons not uniformly decreased. According to Chamhuri and friends (2009) report, it seems that climate change may cause a small to moderate effect on the agricultural sector in Malaysia. However, regional effects could be significant, the crop yield significantly will vary considerably across different Malaysian regions.

For rice production, the yield response to cultivars, location and management practice. The impact of climate change on this crops has been subjected to many scientific researches due to its important on human being. The average potential yield of rice varies is about 10 tons/ha in the tropics and over 13 tons /ha in temperate region (Al-Amin & Siwar, 2008). The actual farm yields in Malaysia vary from 3-5 tons /ha, (i.e. potential yield in Malaysia per ha is 7.2 tons (Singh et al., 1996)). Based on experimental data obtained elsewhere, the rice crop, in general responds positively (until certain limit) to an increase in atmospheric CO₂ concentration. In addition, rice grain yields might decline by 9 to 10% for each 1 degree Celsius rise (Baharuddin, 2007).

Oil palm is listed as one of main crop produced in our country. In 2012, Malaysia known as the world's second largest producer of palm oil where it produced 18.79 million tonnes of crude palm oil on roughly 5,000,000 hectares (19,000 sq mi) of land. Baharuddin, 2009 said that even though theoretically they will have higher growth of oil palm tree as rainfall increases, an excessive amount negatively affects the crop yield. In southern Malaysia, the production of crude palm oil has reduced to 1.1 million metric ton or 26.3% in December 2006.

Table 1. Evolution of the crop production in Malaysia and South-Eastern Asia and world

Production (Thousands of tonnes)	1970	1980	1990	2000	2010	SE-Asia (%)	World (%)
Cocoa beans	3.2	35.4	247.0	70.2	18.9	3.6	0.7
Coconuts	1291.0	1188.0	1134.0	734.4	550.14	1.4	0.9
Natural rubber	1269.3	1530.0	1291.5	928.0	899.0	12.9	10.1
Oil palm fruit	2155.0	12800.0	31000.0	56600.0	87825.0	47.1	40.4
Pepper	31.6	31.6	31.2	25.1	18.7	11.4	5.7
Rice, paddy	1681.4	2044.6	1885.0	2141.0	2464.8	1.3	0.3
Fruit exclude Melons	865.3	938.1	1109.5	1182.0	1073.9	2.7	0.2
Vegetables and Melons	279.5	322.8	362.2	523.3	1207.4	2.0	0.1

Source: Adapted from FAOSTAT

Table 2. Predicted effects of climate change on agriculture by 2050

Climate element	Expected Changes by 2050	Confidence prediction	in	Effects on agriculture
CO ₂	Increase from 360 to 450-600 ppm	Very high		Good for crops; increased photosynthesis; reduced water use
Sea level rise	Rise by 10-15cm, increased in south and offset in north by natural subsistence	Very high		Loss of land, coastal erosion, flooding, salt intrusion
Temperature	Rise of 1-2°C. Increase in the recurrence of hot waves	High		Change in seasons
Precipitation	Seasonal changes by -10%	Low		Lodging, soil erosion

Source: Adapted from Mad Nasir and Ahmad (2009)

In a study by Bazaaz (1996), it was claimed that a warmer world will contribute to losses in grain weight, while Butler (2007) claimed that the new temperatures will not be suitable to grow grain crops. Rosenweig and Hillel (1995) looked into another impact of global warming - drought - whereby a longer duration of drought will increase pressure on water supplies. A study done by Mad Nasir and Ahmad (2009) on climate change and agricultural development has concluded the predicted effects of climate change on agriculture by 2050 (Table 2). As such impacts of global warming on the agriculture industry are potentially disastrous, farmers and policy makers have started to think of ways to delay and absorb the impacts. A number of adaptation strategies have already been recommended, while scientists around the world have widened their research scope by investigating crop and disease patterns in a number of vegetables, such as potatoes, tomatoes, cabbage and spinach, onions and garlic (Bazaaz, 1996; NRS, 2001).

3.1 Impacts of Global Warming on the Economic Dynamics of Farmers

According to Siwar et al. (2009), a warmer world will have both direct and indirect impacts on the economic dynamics of farmers. A warmer world will result in crop damage, reduce farmers' productivity, and increase their costs, which will then minimize their income, increase poverty levels, and cause seasonal unemployment rates to increase. Alam et al. (2012) conducted a study with regards to paddy production and the changing climate, within which it was found that more than two-thirds of farmers agree that paddy production is not very profitable due to climate instability. Mitchell (2008) suggested that global warming creates problems such as droughts, insect outbreaks, wildfires, land degradation, crop damage, decreased water qualities and shortages in water supplies. Farmers have a high dependency on environmental stability, and the impacts of global warming are expected to pose problems with regards to their agricultural outputs, food and livelihood, human capital and welfare. Both risks and uncertainties are commonly related to seasonality and farming practice, and farmers with weaker adaptation abilities are expected to face problems in running their agriculture activities (Table 1).

3.2 Social

Global warming has been found to obstruct people from conducting social routines as well, such as recreational activities and sports (Tucker & Gilliland, 2007; Morris & Wall, 2009). As the global temperature continues to increase, it will eventually limit the outdoor activities of many individuals. McDonald (2006) found that an increase in temperature can obstruct elements of sustainable development, such as structures, critical facilities and natural resources, as these elements are vulnerable towards the impacts of global warming. Moreover, as global warming has contributed towards shortages in terms of food supply, it will pose problems relating to diets within communities, and this includes farmers. As also pointed out by Mitchell et al. (2008), disasters arising from global warming will pose a number of problems to society and their settlement. First, global warming will reduce people's quality of life with regards to housing, particularly for those without cooling devices; second, shortages will arise in water supplies for communities and for industry; and third, the demand for heating devices will decrease while demand for cooling devices will increase, which will affect the air quality in the relevant areas. Extreme events such as floods, drought and wild fires have been highlighted as impacts of global warming, and it has also been proven to pose risks to human life. According to the World Resources Institute (WRI) (2007), the altered environment has resulted in a significant increase in deaths caused by extreme events. Extreme temperatures, for example, have caused a total of 5,671 deaths in 27 years (1990-2006), compared to only 110 in

the period 1900-1989. In addition, Lemman et al. (2008) and the Climate Change Science Program (2008) highlighted a number of possible impacts of global warming and other elements related to the changing climate on farmers' socio-economic aspects (Table 1).

Table 3. Potential socio-economic impacts associated with climate change

Access to Goods and Services	
Land	Loss of land along the coastline and riparian areas for a multiplicity of purposes (e.g. housing, agriculture, recreation). Increased costs of land preparation to prevent flooding along coastline and riparian areas.
Water	Threat of reduced access to potable water due to saline intrusion of freshwater aquifers. Threat of reduced access to potable water due to contamination of water supplies and disruption of treatment works and supply infrastructure. Risk of sewer overflows.
Food	Loss of riparian and coastal land area suitable for agriculture. Reduced availability and increased cost of agricultural (animal, dairy and vegetable) products due to wet weather and flooding. Reduced availability of fish/shellfish due to lower water quality.
Housing	Damage and loss of buildings and property during floods and storms. Increased cost of housing in coastal areas. Employment and business opportunities in sustainable construction and design.
Energy	Disruption to electricity supplies during weather events. Outages of production lines for manufacturing.
Employment and education	Loss of business, skills and jobs relating to agriculture and tourism due to business failure and/or costs to businesses from storm events, etc. Loss of pupil/teaching days due to storm damage to educational buildings.
Leisure and recreation	Disruption of sports events and recreational activities. Reduced access to leisure, cultural facilities and historic buildings and sites.
Landscapes and nature	Damage and reduced access to ecosystems, historic and cultural landscapes, green spaces and gardens.
Transport and mobility	Disruption of transport and communication networks.
Business and finance	Increased costs for establishing and maintaining business facilities and operations insensitive areas. Increased costs of insurance.
Adaptive Capacity	
Social inclusion/cohesion	Dislocation from family and community through evacuation. Disadvantaged and elderly people are particularly at risk. Community conflict over resource allocations. Increases in the sense of community in the face of common risks.
Participation in climate change adaptation measures	Exclusion and/or non-participation of vulnerable groups.

Source: Adapted from climate change and its effects on humans; state of the gulf of Maine report (2010)

3.3 Health

Global warming will also create bad smog, and more “bad air days”, which result in discomfort relating to irritated eyes, noses, and lungs. Furthermore, people with respiratory diseases such as asthma are already having difficulties coping with the impacts of global warming. In addition to these respiratory-related problems, rising temperatures are expected to increase the number of dehydration, malnutrition, and heat stress cases. A number of potential direct and indirect health effects from the changing climate are presented in Table 2.

Table 4. Mediating processes, and direct and indirect potential effects on health of changes in temperature and weather

Mediating process	Health outcome
<i>Direct effects</i>	
Exposure to extreme temperature	Increase in the number of illness and deaths caused by extreme heat and cold
Increase in the number or strength of extreme weather events	Deaths, injuries, psychological disorders; damage to public health infrastructure
<i>Indirect effects</i>	
Disturbances of ecological systems; increased activities of vectors and infectious parasites	Changes in geographical ranges and incidence of vector-borne disease
Changed local ecology of water-borne and food-borne infective agents	Increased number of diarrhoeal and other infectious diseases
Reduced food production (especially crops) resulting from the changing climate and associated pests and diseases	Malnutrition and hunger, and consequent impairment of child growth and development
Sea level rise, resulting in the need for the population to be transferred to a safer place	Increased risk of infectious disease, self-conflict
Biological impact of air pollution changes (including pollens and spores)	Asthma and allergies; other acute and chronic respiratory disorders and deaths
Social, economic, and demographic dislocation through effects on economy, infrastructure, and resource supply	Wide range of public health consequences: mental health and nutritional impairment, infectious diseases, civil strife

Source: Adapted from Anthony and Andrew (1997)

Drawing on a study led by Jensen (2011), who looked specifically at the relationship between psychological health and the changing climate phenomenon, rising temperatures can obstruct communities in terms of performing their daily routines, which can result in anxiety, depression, stress and substance abuse. Moreover, via global warming, farmers are exposed to diseases (e.g. cholera) caused by polluted water supplies. This is because global warming causes water pollution; as Deni et al. (2008) and IPCC (2007) suggested, a warmer world will decrease the amount of available water, which will lead to increased concentrations of contaminants such as heavy metals, industrial chemicals and pesticides, sediments and salts. In addition, in a warmer world water supplies will be vulnerable to the threats of algal blooms and other microorganisms.

Global warming is also associated with changing patterns of rainfall. Barclay (2008) clarified the relationship between changes in rainfall and an increased number of dengue cases; this is supported by findings from the World Health Organization (WHO) (2011), who highlighted an increasing trend of dengue cases from in Malaysia from 2000 (7,103) to 2010 (46,171 cases) - a scenario that can be related to the increased frequency of rainfall.

4. The Need for Adaptation towards Global Warming

Global warming will pose formidable challenges to groups such as children, women, the elderly, fishermen and farmers. Past studies have confirmed that the situation will worsen in the future, and people should prepare via

suitable adaptation practices. According to Burton et al. (2007):

Adaptation refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts. It refers to changes in processes, practices, and structures to moderate potential damages or to benefit from opportunities associated with climate change (pp. 879).

The best adaptation practices should consist of both reactive responses (responses in the event of a disaster) and proactive responses (preparation for disaster). In this way, during any disaster, people will know where to go, what to avoid, what to look for and who to contact. Such adaptation practices will save a large number of lives and contribute to protecting people's property (Halady & Rao, 2007).

Although plans to reduce the greenhouse effect have been actively supported by a number of responsible organizations, the world's temperature is predicted to keep increasing (Wigley, 1999). Therefore, failing to focus on adaptation strategies would be a huge mistake. Adaptation will reduce and delay the impacts of global warming, as it will strengthen communities' readiness for extreme events, which will consequently reduce their vulnerability and increase their alertness to any advantages caused by the changes. As adaptive capacity varies according to each individual, related parties need to strategize their adaptation planning by considering a number of factors, such as financial, technology literacy, level of information received, infrastructure and institution (Burton et al., 2007).

Butler (2007) accentuated that the sustainability of the agriculture industry will rely heavily on how farmers cope with the changing climate. Thus, measuring farmers' adaptive capacity towards global warming is crucial, as it will permit the concerned parties to develop strategies that focus on the environment, while simultaneously supporting the sustainability of agriculture-dependent industries and communities. Furthermore, by measuring adaptive capacity, concerned parties will have an awareness of the strengths and weaknesses of farmers in relation to facing the threats of the changing climate. To date, there have been a number of adaptation frameworks developed by established bodies such as the International Union for Conservation of Nature and Natural Resources (IUCN) and the Intergovernmental Panel on Climate Change (IPCC); these may help to measure farmers' adaptive capacity.

5. Conclusion

Agriculture relies heavily on environmental stability, and global warming is expected to pose problems for this industry. As local and international studies confirm that temperatures in Malaysia have increased, and are forecasted to keep increasing in the future, there is a crucial need to strengthen the adaptation strategies among farmers. Such adaptation is vital, as the impacts of global warming on farmers' socio-economic aspects are potentially disastrous. Measuring farmers' adaptive capacity is seen as a wise step, as being informed on the farmers' strengths and weaknesses will assist concerned parties to formulate adaptation strategies that are in line with farmers' needs and abilities.

References

- Alam, M. M., Siwar, C., Talib, B., Mokhtar, M., & Jaafar, A. H. (2012). *Climatic Change and the Socioeconomic Sustainability of the Paddy Farmers in Malaysia*. Retrieved September 2, 2012, from <http://www.scirp.org/journal/ns/>
- Anthony, J. M., & Andrew, H. (1997). *Global Climate Change: The Potential Effects on Health*. Retrieved November 13, 2012, from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2127530/pdf/9345177.pdf>
- Baharuddin, M. K. (2007). *Climate Change: Its effects on the agricultural sector in Malaysia*. National Seminar on Socio-Economic Impacts of Extreme Weather and Climate Change, Malaysia.
- Barclay, E. (2008). Is climate change affecting dengue in the Americas? *The Lancet*, 371(9617), 973-974. [http://dx.doi.org/10.1016/S0140-6736\(08\)60435-3](http://dx.doi.org/10.1016/S0140-6736(08)60435-3)
- Bazaaz, F. A. (1996). *Global climate change and agriculture production*. Direct and indirect effects of changing hydrological pedological and plant physiological process. Food and Agriculture FOA Publisher.
- Burton, I., Challenger, B., Huq, S., Klein, R. J. T., & Yohe, G. (2007). *Adaptation to Climate Change in the Context of Sustainable Development and Equity*. Retrieved September 11, 2012, from <http://www.ipcc.ch/ipccreports/tar/wg2/pdf/wg2TARchap18.pdf>
- Butler, R. (2007). *Global Warming Reduced Crop Yields over Past 20 Years*. Retrieved April 19, 2013, from <http://news.mongabay.com/2007/0316-rice.html>
- Chamhuri, S., Mahmudul, A., Wahid, M., & Al-Amin. (2009). Climate Change, Agricultural Sustainability, Food Security and Poverty in Malaysia. *IRBRP J.*, 5(6), 309-321.

- Climate Change Science Program. (2008). Analyses of the effects of global change on human health and welfare and humansystems. In J. L. Gamble, K. L. Ebi, F. G. Sussman & T. J. Wilbanks (Eds.), *A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research*. U.S. Environmental Protection Agency, Washington, DC.
- Deni, S. M., Jamaludin, S., Zin, W. Z. W., & Jemain, A. A. (2008). Tracing trends in the sequences of dry and wet days over Peninsular Malaysia. *Journal of Environmental Science Technology*, 1, 97-110. <http://dx.doi.org/10.3923/jest.2008.97.110>
- Elsgaard, L., Børgesen, C. D., Olesen, J. E., Siebert, S., Ewert, F., Peltonen-Sainio, P., Rötter, R. P., & Skjelvåg, A. O. (2012). Shifts in comparative advantages for maize, oat and wheat cropping under climate change in Europe. *Food Additives & Contaminants (Part A)*, 1-13.
- FAOSTAT. (2010). *Production Crops*. Food and Agriculture Organization of the United Nations Statistics (FAOSTAT). Retrieved June 29, 2013, from <http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567#ancor>
- Gonzalez, A. M. R., & Sauliere, S. (2011). *Climate Change and Women Farmers in Burkina Faso Impact and Adaptation Policies and Practices*. Retrieved August 30, 2012, from <http://www.oxfam.org/sites/www.oxfam.org/files/rr-climate-change-women-farmers-burkina-130711-en.pdf>
- Halady, I. R., & Rao, P. H. (2009). Does awareness of climate change lead to behavioral changes? *International Climate Change Strategies and Management*, 2(1), 6-22. <http://dx.doi.org/10.1108/17568691011020229>
- Hannah, R., Sahlen, L., Stage, J., & Macgregor, J. (2008). Climate change impacts on Namibia's natural resources and economy. *Climate Policy*, 8(5), 452-466.
- Intergovernmental Panel on Climate Change (IPCC). (2007). *Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. In M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. Linden, & C. E. Hanson (Eds.), Cambridge University Press, Cambridge, UK and New York, NY.
- Jensen, E. (2011). *Mental Illness Rise Linked to Climate*. Retrieved August 31, 2012, from <http://www.smh.com.au/environment/mental-illness-rise-linked-to-climate-20110828-1jger.html>
- Lacey, S. (2012). *Corn Growers: Climate change is a grave threat to rural livelihood and quality of life*. Retrieved August 30, 2012, from <http://thinkprogress.org/climate/2012/04/20/467780/corn-growers-climate-change-is-grave-threat-to-rural-livelihoods-and-quality-of-life/>
- Lemmen, D. S., Warren, F. J., Lacroix, J., & Bush, E. (Eds.). (2008). *From Impacts to Adaptation: Canada in a Changing Climate, 2007*, 448. Government of Canada, Ottawa, ON. <http://dx.doi.org/10.4095/226455>
- McDonald, T. (2006). *The Impact of Global Warming on Sustainable Development Mitigating the Impact: Natural Hazards Mitigation*. Paper presented at The 2nd International Solar Cities Congress 2006, 4 April. Oxford University, Oxford.
- Mitchell, T., Sabates-Wheeler, R., Devereux, S., Tanner, T., Davies, M., & Leavy, J. (2008). *Rural disaster risk - poverty Interfaces*. Report prepared for Global Assessment Report on Disaster Reduction, IDS. University of Sussex, Brighton.
- Morris, D., & Wall, M. (2009). *Climate Change and Outdoor Recreation Resources*. Retrieved September 2, 2012, from http://www.rff.org/RFF/Documents/RFF-BCK-ORRG_ClimateChange.pdf
- Nasir, S. M., & Makmom, A. A. (2009). *Climate Change and Agricultural Development: Economic Impacts and Policy Responses*, *Academy of Sciences Malaysia*. Retrieved June 29, 2013, from http://www.akademisains.gov.my/download/relatednews/cc/Agri_Policy.pdf/
- Nelson, J., & Serafin, R. (1996). Environmental and Resources Planning and Decision Making in Canada: A Human Ecological Approach and Civics Approach. In R. Vogelsang (Ed.), *Canada in Transition: Results of environmental and human geographical research*. Brockmeyer University.
- NRS. (2001). National Response Strategies to Climate Change. *Ministry of Science, Technology and the Environment, Malaysia*. Retrieved November 15, 2012, from <http://gedung.nahrim.gov.my/wapi/mctweb.dll/getObject?MID=WATER%20RESOURCES&Sn=2038>

- Rosenzweig, C., & Hillel, D. (1995). *Climate Change and the Global Harvest: Potential Impacts on the Greenhouse Effect on Agriculture*. Oxford University Press, New York, NY.
- Singh, S., Amartalingam, R., Harun, W. S. W., & Islam, M. T. (1996). *Simulated impact of climate change on rice production in Peninsular Malaysia*. Proc. Of National Conference on Climate Change, 41-49. UPM.
- Siwar, C., Alam, M. M., Murad, M. W., & Al-amin, A. Q. (2009). A review of the linkages between climate change, agricultural sustainability and poverty in Malaysia. *International Review of Business Research*, 5, 309-321.
- Tucker, P., & Gilliland, J. (2007). The effects of season and weather on physical activity: a systematic review. *Journal of Public Health*, 121(12), 909-922.
- Vesselin, A. A., & Josef, E. (2005). The potential effect of climate change and elevated air carbon dioxide on agricultural crop production in Central and South Eastern Europe. *Journal of Crop Improvement*, 13(1-2), 291-331. http://dx.doi.org/10.1300/J411v13n01_14
- Wai, N. M., Carmelengo, A., & Khairi, A. W. A. (2005). A study of global warming in Malaysia. *Jurnal Teknologi*, 42(June), 1-10.
- Wigley, T. M. L. (1999). *The Science of Climate Change: Global and U.S. Perspectives*. Pew Center for Climate Change, Washington, DC.
- World Resources Institute (WRI). (2007). *Earth Trends*. Retrieved March 21, 2013, from <http://www.wri.org>
- Al-Amin, A. Q., & Siwar, C. (2008, November 24-26). *The economic dimensions of climate change: impacts and adaptation practices in Malaysia*. Proceedings of the 9th International Business Research Conference. Novotel Hotel, Melbourne, Australia.
- Kwan, M. S., Tanggang, F. T., & Juneng, L. (2011, November). Projected Changes of Future Climate Extremes in Malaysia. *Paper presented at National Symposium on Climate Change*, 16-17. Putrajaya, Malaysia.

Copyrights

Copyright for this article is retained by the author(s), with first publication rights granted to the journal.

This is an open-access article distributed under the terms and conditions of the Creative Commons Attribution license (<http://creativecommons.org/licenses/by/3.0/>).