Climate Change Induced Adaptation by Paddy Farmers in Malaysia

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Abstract

The climatic factors are changing very rapidly in Malaysia. For the farmers to adapt with the changes, government and other external agencies are providing several supports. But still there is a gap between farmers' adaptability with climate change and current level of supports. This study uses descriptive statistics, ordinal regression, and percentile analysis to measure the level of farmers' adaptability to climate change as a result of the various existing supports and encouragements provided by the government and other external agencies, and new supports expected by farmers. The data were collected through questionnaire survey on 198 paddy producing farmers in the area of Integrated Agricultural Development Area (IADA), North-West Selangor, Malaysia. The study found that among current types of supports provided by different agencies, only farmers' accessibility in the market is statistically significant for influencing their current adaptability to climatic changes. Though 58.6% of the farmers agree that government supports are enough to cope properly with climate change, 12.1% of farmers are not able to cope with climate change with the current level of supports. Farmers' expectations of several new supports has no statistically significant influences on their current adaptability with climatic changes, but their priority ranking for these expected supports will help policymakers to determine the future supports for climatic change adaptation for agriculture sustainability and livelihood sustainability under adverse climatic changes scenarios, especially for Malaysia.

Key words: Agricultural Productivity; Climate change; Adaptation; Paddy; Malaysia

Introduction

Currently, Malaysia, with a population of about 27 million, is the 26th largest greenhouse gas emitter in the world. It may move up the list quickly due to the growth rate of emissions in the country. Due to high greenhouse gas emissions the temperature is projected to rise by 0.3-4.5°C. Warmer temperature will cause sea level to rise by about 95 cm over a hundred-year period. The changes in rainfall may fluctuate from about -30 to +30%. This change will reduce crop yield and cause drought in many areas so that cultivation of some crops such as rubber, oil palm, and cocoa will not be possible (NRS 2001). The projection shows maximum monthly precipitation will increase up to 51% in Pahang, Kelantan and Terengganu, and the minimum precipitation will decrease by 32-61% for the entire Peninsular Malaysia. Consequently, annual rainfall will increase by 10% in Kelantan, Terengganu, Pahang and North-West Coast and decrease by 5% in Selangor and Johor (NAHRIM 2006). This variation of climatic factors will cause the agricultural system to be vulnerable in Malaysia.

The average temperature in the rice growing areas is about 26°C in Malaysia. Under current climate change scenario, temperature above 25°C may cause decline in grain mass by 4.4% per 1°C rise in temperature (Tashiro and Wardlaw 1989) and grain yield may decline as much as 9.6 - 10.0% per 1°C rise (Baker and Allen 1993). Singh et al. (1996) shows that the actual farm yield of paddy rice in Malaysia vary from 3-5 tons per hectare, when the potential yield is 7.2 tons. They also says that there is a decline of rice yield between 4.6 - 6.1% per 1°C temperature increase under the present CO₂ level, but a doubling of CO₂ concentration (from present level of 340-680ppm) may offset the detrimental effect up to 4°C temperature increase on rice production in Malaysia. In a recent study it is found that a 1% increase in temperature leads to a 3.44% decrease in current paddy yield and 0.03% decrease in paddy

yield in next season, and a 1% increase in rainfall leads to 0.12% decrease in current paddy yield and 0.21% decrease of paddy yield in next season (Alam et al. 2010c).

Tisdell (1996) finds that rainfall variability increases the level of environmental stress that affects the capability of the system to maintain productivity. It is projected that any change in rainfall, both positive and negative, by more than only 0.4% by 2020 will cause decline in yield of paddy production in Malaysia (NRS 2001). Alam et al. (2011a) indicate that total yearly rainfall in Malaysia is increasing and its monthly variation is too high. The effect of lower rainfall can be checked through proper irrigation system, but the opposite phenomenon of over rainfall for any particular time, especially at the end of the crop cycle or at the maturity period that causes serious damages to crops, is absolutely uncontrollable.

The climatic factors affect, directly or indirectly, the social and economic sustainability of the farmers. Climate changes cause crop damages, low productivity and high production cost leading to income losses for farmers, increase their poverty level, and increase their seasonal unemployment rate (Siwar et al. 2009; Alam 2010d, 2011b, 2011c). This is because the farmers are dependent on agriculture. In Malaysia, the most possible vulnerable states in terms of poverty rates are Sabah (23%), Terengganu (15.4%), Kelantan (10.6%), Sarawak (7.5%), Kedah (7%), Perlis (6.3%) and Perak (4.9%), where the projected temperature and rainfall changes are also very high (Malaysia 2006; NAHRIM 2006). It is also observed that the most vulnerable groups of people are the poor engaged in agricultural activities and having relatively larger number of household members (NRS 2001).

As climate change is a continuous and long term process, its effects and solutions are similarly time and effort consuming process. Most of the warming during the next 30 years will be due to emissions that have already occurred. Over the longer term, the degree and pace of warming mainly depend on current and near future emissions (Stern 2007). In recent years, adaptation has gained prominence as an important response measure especially for vulnerable countries. It has become clear that some impacts are now unavoidable in the short to medium term. According to IPCC (2001), adaptation refers to “adjustments in ecological, social or economic systems in response to actual or expected stimuli and their effects or impacts. This term refers to changes in processes, practices and structures to moderate potential damages or to benefit from opportunities associated with climate change”. It outlines few basic principles: adaptation to short-term climate variability and extreme events for reducing vulnerability to long-term climate change; adaptation policy and measures assessed in a developmental context; adaptation occurs at different levels in society, including the local level; adaptation strategy and the process by which it is implemented are equally important. According to UNDP (2005), “A climate change adaptation strategy for a country refers to a general plan of action for addressing the impacts of climate change, including climate variability and extremes. It may include a mix of policies and measures, selected to meet the overarching objective of reducing the country's vulnerability.”

Adaptation strategies for the vulnerable groups are crucial because failure to adapt could lead them suffer from to “significant deprivation, social disruption and population displacement and even morbidity and mortality” (Downing et al., 1997). The most critical problem is to identify the appropriate adaptation policies that favour the most vulnerable groups. Policy makers should be mindful of the fact that adaptation strategies for climate change may not ensure equal benefits for all areas and groups of people; and a win-win situation among stakeholders is unlikely. In many cases it is faced with situations of conflicting interest among groups. IPCC (2001) mentioned few issues while referred to

adaptation assessment as “practice of identifying options to adapt to climate change and evaluating them in terms of criteria such as availability, benefits, costs, effectiveness, efficiency and feasibility”. Policy makers also need to focus on the determinants of adaptation capacity that have been suggested by Yohe and Tol (2001) as: the range of available technological options for adaptation; the availability of resources and their distribution across the population; the structure of critical institutions, the derivative allocation of decision-making authority, and the decision criteria that would be employed; the stock of human capital, including education and personal security; the stock of social capital, including the definition of property rights; the system’s access to risk-spreading processes, e.g., insurance; the ability of decision makers to manage information, the processes by which these decision-makers determine which information is credible and the credibility of the decision-makers, themselves, and the public’s perceived attribution of the source of stress and the significance of exposure to its local manifestations.

In the planning processes, policy makers need to take account of the barriers to adaptation including ecological, financial, institutional, and technological barriers, as well as information and cognitive hurdles. Other few important issues need to be focused upon, such as stakeholders may not sufficiently be informed about the needs and possible strategies of climate change (Eisenack and Kropp 2006; Eisenack, Tekken and Kropp 2007), farm level faces uncertain future which hinders the development process and poses as obstacle the implementation of adaptations policy (Behringer et al. 2000; Brown et al. 2007), and the policy deals with different conflicting interest groups. Policy makers also need to understand the impact of climate change on changing socioeconomic condition.

In Malaysia, the Second National Agricultural Policy (1992-1997) was revised in 1998, to emphasize on the impacts of climate change; and the Third National Agricultural Policy (1998-2010) recognised this fact. Provisions of necessary incentives and initiatives were incorporated in these plans to achieve the goal of maximizing income of the stakeholders through optimal utilization of resources. Due to the adverse effects of the climatic factors on agriculture in Malaysia, income stabilization and poverty reduction program among the farming community is under threat. So, to ensure the sustainability of the agriculture and the livelihood, adaptation with climatic changes is very essential. Currently government and nongovernment sectors are providing several supports, incentives, and subsidy; but the empirical measurement of the adequacy of these supports is missing in the literature. Therefore, this study is an attempt to measure the influence of external supports, like subsidy, incentive, training, and other supports, etc. provided by government, NGOs and others, on farmers’ adaptability to climate changes. This study also tries to identify different types of new supports, beyond the existing supports that farmers expect for adaption to climate changes, and its linkage with the current adaptability of the farmers.

Data, Model and Methodology

To determine the climate change adaptation of the farmers in Malaysia, this study relies on primary data from a research project entitled “The economics of climate change: Economic dimensions of climate change, impacts and adaptation practices in agriculture sector: Case of paddy sector in Malaysia”, conducted by the Institute for Environment and Development (LESTARI) of the National University of Malaysia (UKM) funded by Ministry of Science, Technology and Environment of the Government of Malaysia (Alam et al. 2010a). Data for this project were collected through a sample survey of paddy producing farmers in the eight sections of the Integrated Agricultural Development Area (IADA) of North-West Selangor,

Malaysia (Fig 1). Geographically the agricultural land of IADA in North-West Selangor covers an area of 100,000 hectare (ha), with 55,000 ha used for palm oil, 20,000 ha for coconut, 5,000 ha for fruits and vegetables and 20,000 ha for paddy. This 20,000 ha for the paddy area include major rivers, i.e Sungai Sireh and Sungai Karang, a 75 km irrigation system, and other infrastructures. The total paddy producible area is 18,638 ha, and currently paddy is planted on 18,355 ha. Total paddy irrigated area is 18,980 ha, with the additional 625 ha being used for drainage. There are a total of 10,300 paddy farmers and 30,000 other crops producers. The total size of the agricultural community is 50,000.

< Figure 1>

The target group of the survey was paddy producing farmers. The survey was conducted by regular enumerators of the IADA authority using a structured questionnaire under the direct supervision of IADA officials. The population size of the area was 10,300 while the sample for the study consisted of 198 respondents proportionately distributed among the eight areas based on the size of the irrigated land area. The 198 households covered 577.53 ha of paddy areas. The sample within the area is selected randomly. Details of socioeconomic profiles of the respondents are available at Alam and others (2010a, 2010b).

To measure farmers' abilities to adapt with climate change, this study uses a 5-point scale with 1 as very low and 5 as very high adaptability. To determine the statistical relationships between the climate change adaptability of the farmers and currently available external supports, this study runs ordered dependent regression/ ordinal regression (Equation 1).

$$Q_1 = \Omega_1 S_1 + \Omega_2 S_2 + \Omega_3 S_3 + \Omega_4 S_4 + \varepsilon_i \quad (1)$$

Here, Q_1 = Farmers' capability to adapt with climate change; S_1 = Government supports are enough to cope with climate change effect; S_2 = NGO (non-governmental organization) supports are enough to cope with climate change effect; S_3 = Other agencies' supports are enough to cope with climate change effect; S_4 = Market support as availability of additional fertilizers in the market; Ω = Coefficient of respective explanatory variable; ε_i = Independent and identically distributed random variables.

Based on the current adaptability of the farmers, this study further looks at other supports that they expect to improve their ability to adapt with climatic changes. Smit and Skinner (2002) mentioned that the options for agricultural adaptation could be grouped as technological developments, government programs, farm production practices, and farm financial management. Alam et al. (2010e) also provided a guideline to consider for adaptation policy in Malaysia. Here, these options are broadly considered to determine the required supports based on farmers perceptions by using a 5-point scale with 1 as very low and 5 as very highly needed for adaptation. To determine the statistical relationships between the current adaptability of the farmers and required external supports to cope with climate change, this study runs another ordered dependent regression/ ordinal regression (Equation 2).

$$Q_2 = \beta_1 V_1 + \beta_2 V_2 + \beta_3 V_3 + \beta_4 V_4 + \beta_5 V_5 + \beta_6 V_6 + \beta_7 V_7 + \beta_8 V_8 + \beta_9 V_9 + \beta_{10} V_{10} + \beta_{11} V_{11} + \beta_{12} V_{12} + \beta_{13} V_{13} + \beta_{14} V_{14} + \beta_{15} V_{15} + \mu_i \quad (2)$$

Here, Q_2 = Farmers' capability to adapt to climate change; V_1 = Water management innovations is required to cope with climate change effect; V_2 = Irrigation system innovations is required to cope with climate change effect; V_3 = Moisture deficiency relevant innovations is required to cope with climate change effect; V_4 = Crop development is required to cope with climate change effect; V_5 = Early warning about weather and climate information is required to cope with climate change effect; V_6 = Daily and seasonal weather forecasts is required to cope with climate change effect; V_7 = Proper guidelines or suggestion is required to cope with climate change effect; V_8 = Raw materials subsidy is required to cope with climate change effect; V_9 = Cash incentive is required to cope with climate change effect; V_{10} = Insurance support is required to cope with climate change effect; V_{11} = Infrastructural support, such as irrigation, transportation is required to cope with climate change effect; V_{12} = Diversify crop types and varieties is required to cope with climate change affect; V_{13} = Adjustment in land use pattern is required to cope with climate change effect; V_{14} = Adjustment in wage and leasing system is required to cope with climate change effect; V_{15} = Merge individual farmers to farm is required to cope with climate change effect; β = Coefficient of respective explanatory variable; μ_i = Independent and identically distributed random variables.

Government's Supports for Adaptation

Currently the Government of Malaysia is providing large amount of subsidy to the paddy producers to encourage paddy cultivation and to ensure more production for increasing the country's self-sufficiency level. The types and contents of these subsidies have been summarized below:

- *Input subsidy*: 12 bags (20 kg each) of compound fertilizer and 4 bags (20kg each) urea fertilizer per hectare – worth USD\$133, and pesticide incentive USD\$66 per hectare.
- *Price Subsidy*: Provided at the selling price – USD\$82.7 per ton.
- *Rice Production Incentive*: Land preparation/plowing incentive – USD\$33 per hectare and organic fertilizer 100kg per hectare – worth USD\$46.
- *Yield Increase Incentive*: Provided if producers (farmers) are able to produce 10 tons or more per hectare – USD\$216 per ton.
- *Free Supports*: Free supports for irrigation, infrastructure, and water supply.

In order to support the farmers to increase productivity and increase income, government's subsidy for agricultural sector is increasing each year (Table 1). The subsidies for urea and compound fertilizer have been continuing since 1979. The incentives for land preparation and using organic fertilizer have been continuing since 2007. Providing the package of compound and urea fertilizers and pesticide incentives was introduced in 2008 and is still continuing (Alam et al. 2011d).

< Table 1>

Current Supports and Farmers' Adaptability to Climate Change

On the issue of availability of external supports, most farmers were found not aware of the current supports provided by external parties to adapt to climate change. 58.6% of the farmers agreed that government supports were enough to cope properly with climate change. But still 12.1% reported that they could not cope with climate change with the current level of

external supports. 29.3% farmers did not respond to this question. 52.5% farmer mentioned about the supports from NGO, and 49.5% mentioned about the supports from other external agencies to be enough to cope with current climate change. But interestingly many farmers were not sure about what sorts of supports they receive from these agencies (Table 2). Basically NGOs provide very little supports. Their supports include small scale training and experimental plot to test the productivity rate.

According to 75.3% of the farmers, the fertilizer provided by the government was enough for paddy production. This indicates that these farmers never use extra fertilizer except the fully subsidized quantity. Beyond the free fertilizers, extra fertilizers were available in the market as reported by 60.1% of the farmers. But 16.7% claimed that extra fertilizers were not available in the market or they did not have enough access in the market.

< Table 2>

To check the reason for the differing farmers' ability to adapt to climate change, this study ran regression based on ordinal data. This model, where farmers' ability is dependent on external supports, did not show a good fit of model due to high p-value (0.27) of LR stat (Table 3). However, among different types of external supports, at 3% significance level, only market showed significant impacts on farmers' ability to adapt to climate change. The odd ratio was 1.166, which is closed to the value of not important. That means farmers significantly believe that buying additional fertilizer from market is not important for their current adaptation ability with climate change.

< Table 3>

Under the IADA the most influential external supports were same for all the farmers, such as government subsidy and incentives. Therefore, the influences of these supports on farmers' adaptation capacity were the same for all. Only for the access in market - indicates buying fertilizer, pesticides and other necessities from market - differed from farmers to farmers.

Required Supports and Farmers' Adaptability to Climate Change

Farmers expect several types of external supports to cope properly with the changes in climatic factors. To check the relationship between farmers' ability to adapt and required external supports to adapt to climate change this study ran ordinal regression. The P-value (.000038) of LR stat showed a very good fit of the model. The output of the regression showed that, among several types of external supports, farmers significantly needed moisture deficiency related innovations, crop development, cash incentive, infrastructural supports, and adjustment in wage, and leasing system to adapt to climate change (Table 4). However, the necessity of extra supports in respects of their current ability to adapt showed vary low odd ratio, indicating that these supports were not influencing the farmers' current adaptation ability. These supports might be related with their future adaptation ability. Individual requirement analysis will give a clearer picture in this regard.

< Table 4>

As the needs of farmers differ from farmer to farmer, more in-depth and specific requirement is possible to measure by categorical and individual type of variable analysis.

Among all types of resource management innovations, water management innovation, irrigation system innovation and moisture deficiency protection related innovation are important to adapt to climate change. 70.7% of the farmers expected water management innovation to cope with climate change, where only 8.1% disagreed. Further, 70.2% of the farmers mention irrigation system innovation was required to adapt to climate change, where only 7.1% disagree (Table 5). Furthermore, 72.2% of the farmers emphasized on the need for moisture deficiency protection innovations, while only 4.5% mentioned it was not that important. 68.7% of the farmers reported that development of new crops or finding out varieties of crops, or innovation of climate change tolerant crops were needed to cope with changing climate, where only 9.1% felt it was not important.

< Table 5>

Among different types of information related supports, farmers mostly expect early warning system for the changes in climate factors, accurate and timely forecasting system, and proper guidelines and suggestion to cope with climate change properly. Better information system for early warning about changes in climate factors was considered important by 80.8% of the farmers, while only 4% did not see it as important. Moreover, 72.2% of the farmers agreed that weather forecast was important to adapt to climate change, whereas only 5.1% feel it is not necessary. The highest number of the farmers (80.8%) emphasized on the importance of proper guidelines and suggestions to adapt to climate change properly. However 4.5% felt it was not that important.

Among the financial and relevant other external supports from government, NGOs and other local and international agencies, raw materials subsidy, cash incentive, insurance or minimum income protection etc. from any external agencies are important to cope with climate change. Raw materials subsidy and cash incentive were found necessary and needed for 79.8% of the farmers to cope with climate change impacts. Though for 7.6% farmers, it was not import (Table 6). Among those who needed raw materials subsidy 54% of farmers emphasized it as very important, and among those who need cash incentive 47% mention it was very important to cope with climate change. 78.3% emphasized on insurance supports or minimum income ensuring supports to adapt to climate change; only 4% felt it was not necessary.

< Table 6>

Among different encouraging relevant supports, proper infrastructural supports, such as transportation and irrigation, are important for farmers to adapt to changes in climate factors. 78.8% of the farmers agreed about the necessity of infrastructure related supports whereas 6.1% mention it was not at all important.

Among the production practices related supports, diversify crop types, improve varieties of crops, change land usage patterns, change wage and leasing system, and merge individual farmers to farm are important supports to enable farmers adjust to climate changes. Many farmers (27.3%) considered diversifying crop types and varieties of crops were not necessary to cope with climate change; however 51% farmers considered this needed to adapt to climate change (Table 7). 71.7% emphasized on importance of land usage pattern to cope with climate change. Only 5.6% felt it was not necessary.

< Table 7>

73.2% of the farmers mentioned that the leasing system and agricultural wage were important factors toward adaptation to climate change, whereas only 8.1% did not see it as important. To adapt to climate change, 71.2% of the farmers thought merger of individual farmers into single, large farms was necessary,

Among different types of external supports, the farmers setup the priority of supports based on the perceived importance of each categorical support to adapt to climate change (Table 8). Farmers firstly needed financial and encouraging supports (agreed by 41.9%). Secondly, they needed information related supports (agreed by 32.3%). Thirdly, they needed resource management innovation related supports (agreed by 31.3%). Fourthly, they needed crop development related supports (agreed by 33.8%). Finally, they needed production practice related supports (agreed by 43.4%). The priority setup is based on the highest number of choice for each category, which differs among farmers based on individual necessities.

< Table 8 >

Conclusion and Recommendations

Like in many other countries, changes in climatic factors have negative impacts on productivity of paddy cultivation in Malaysia. Projections of climatic change and its adverse effects on paddy productivity and socioeconomic status of the farmers are alarming. In this regard, an adaptation is essential in the long run for agricultural and livelihood sustainability. To improve the adaptability of the farmers, government and other agencies continuously increase the subsidy as well as other supports. At the same time, farmers also expect different types of new supports. So this study tries to measure the current level of adaptability of paddy producing farmers based on current level of supports and expected new supports.

The study found that none of the external supports except the accessibility in the market - to buy fertilizer, pesticides and other necessities from market – is statistically significantly related with the current adaptation ability of farmers. It indicates farmers' belief that buying additional fertilizer from market is not important for their current adaptability with climate change. Though 58.6% of the farmers agree that government supports are enough to cope properly with climate change, 12.1% of farmers are not able to cope with climate change with the current level of supports. Beyond the current level of supports, farmers also expect several other types of new supports. But the statistical output for the necessity of extra supports in respect of their current ability to adaptation shows very low odd ratio, indicating that the expected new supports are not influencing the farmers' current adaptability. Farmers expected new supports might be related with their future adaptability. At the same time, farmers also prioritize on their expected new supports. This will help policymaker to determine the future supports for climatic change adaptation for agricultural sector.

Since sustainability of agriculture and farmers' livelihood are strongly dependent on the subsidy and support in Malaysia, and the present level of farmers' adaptability to climate change lacks behind the expected level, there is a need for additional support and efforts by the government and other agencies beyond the current strategies of subsidy and incentives. Adaptation to climate change is a broad issue. It needs to be undertaken at many levels,

including at the household and community levels. Many of these initiatives are self-funded (Stern 2007). Farmers also need training and conceptual supports.

To enable farmers to adapt to climate change, the very first important step required is to make them aware of future risks of climate change, especially climate change related socioeconomic vulnerabilities. It will help them prepare their mindset to deal with climate change and other socioeconomic stresses and think about how to respond in adverse situations. Moreover, the production practices of farms and individual farmers are needed to be kept up to date with the changes in climatic factors. They should also take all precautions and be aware of the uncertainty of low rainfall and heavy rainfall. They must be careful in arranging proper water management, both in terms of irrigation facilities and quick water logout facilities. Apart from that, they also need to understand the importance of proper timing and react quickly at the sight of upcoming rainfall events.

As the supply of irrigation water and changing crop cycle are emerging problems in the IADA North-West Selangor, farmers should be informed about crop rotation, crop portfolio and crop substitutions to address the environmental variations and economic risks associated with climate change, especially for near future. Moreover, they need to utilize land properly and change the locations of crop production, if possible, to cope with extreme cases. Further, they need to adapt to the changing length of growing seasons and associated changes in climate factors.

The financial management of farms and farmers too needs to be secured for a minimum of two seasons so that if crop is damaged in one season, they will be prepared and have the seeds for next season; their ability to bear the cost of another crop production will guarantee their survival financially up to the collection of the new crops. Currently heavy rainfall and storm is a very common phenomenon in the study area. For that reason, farmers should take the initiative for crop sharing, forward rating, hedging and insurance. Farmers also need crop insurance facilities, but no such option is currently available. Moreover, they need to take income stabilization programmes, such as portfolio of investment, saving scheme, minimum income protection by government or insurance to reduce the risk of income loss due to changing climatic conditions and variability. At last, it has been suggested to prepare a planned and proactive adaptation strategy in Malaysia to secure sound functioning of the economic, social and agricultural system.

The need for climatic change adaptation supports depend on the intensity of climatic effects which is mostly geographical area specific. Due to the location specific limitation, the findings of the study may not be appropriate for other regions, but it will help the policy makers to determine the supports for climate change adaptation in paddy production as well as agriculture sector, in Malaysia.

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References

- Agriculture Statistical Handbook (2008) Paddy. Ministry of Agriculture. Malaysia
- Alam MM, Mohd Ekhwan T, Siwar C, Molla RI, and Talib B (2011d) The Impacts of Agricultural Supports for Climate Change Adaptation: Farm Level Assessment Study on Paddy Farmers. *American Journal of Environmental Sciences* 7(2): 178-182. DOI 10.3844/ajessp.2011.82.89. Cited 05 Aug 2011
- Alam MM, Siwar C, and Al-Amin AQ (2010e) Climate Change Adaptation Policy Guidelines for Agricultural Sector in Malaysia. *Asian Journal of Environmental and Disaster Management* 2(4):463– 469. DOI 10.3850/S1793924011000873.
- Alam MM, Siwar C, and Toriman ME (2010a) Socioeconomic Study of Climate Change: An Assessment of Agriculture and Livelihood Sustainability on Paddy Farming in Malaysia. LAP Lambert Academic Publishing, Saarbrücken
- Alam MM, Siwar C, Molla RI, Toriman ME, and Talib B (2010d) Socioeconomic Impacts of Climatic Change on Paddy Cultivation: An Empirical Investigation in Malaysia. *Journal of Knowledge Globalization* 3(2):71-84. <http://journals.sfu.ca/jkg/index.php/journal/article/view/57/44>. Cited 05 Aug 2011
- Alam MM, Siwar C, Molla RI, Toriman ME, and Talib B (2011b) Climate Change and Vulnerability of Paddy Cultivation in North-West Selangor, Malaysia: A Survey of Farmers' Assessment. *Voice of Academia* 6(1):45-56.
- Alam MM, Siwar C, Murad MW, Molla RI, and Toriman ME (2010b) Socioeconomic Profile of Farmer in Malaysia: Study on Integrated Agricultural Development Area in North-West Selangor. *Agricultural Economics and Rural Development* 7(2):249-26. ftp://www.ipe.ro/RePEc/iag/iag_pdf/AERD1013_249-265.pdf. Cited 05 Aug 2011
- Alam MM, Siwar C, Talib B, and Toriman ME (2011c) An Empirical Study on the Relationships between the Socioeconomic Profile of Farmers and Paddy Productivity in North-West Selangor, Malaysia. *Asia-Pacific Development Journal* 18(1). http://www.unescap.org/pdd/publications/index_apdj.asp. Cited 05 Aug 2011
- Alam MM, Talib B, Siwar C, Toriman ME (2010c) The Impacts of Climate Change on Paddy Production in Malaysia: Case of Paddy Farming in North-West Selangor. Proceedings of the international conference of the 4th International Malaysia- Thailand Conference on South Asian Studies. National University of Malaysia, Malaysia, Mar 25-26
- Alam MM, Toriman ME, Siwar C, and Talib B (2011a) Rainfall variation and changing pattern of agricultural cycle. *American Journal of Environmental Science* 7:82-89. DOI 10.3844/ajessp.2011.82.89. Cited 05 Aug 2011
- Baker JT, Allen JrLH (1993) Contrasting crop species responses to CO₂ and temperature: rice, soybean and citrus. *Vegetatio* 104/105: 239-260. <http://www.jstor.org/pss/20029749>. Cited 05 Aug 2011
- Behringer J, Buerki R, and Fuhrer J (2000) Participatory integrated assessment of adaptation to climate change in Alpine tourism and mountain agriculture. *Integrated Assessment* 1:331-338. DOI: 10.1023/A:1018940901744
- Brown K, Few R, and Tompkins EL (2007) Climate change and coastal management decisions: insights from Christchurch Bay, UK. *Coastal Management* 35(2-3):255-270. DOI: 10.1080/08920750601042328
- Downing TE, Ringius L, Hulme M, and Waughray D (1997) Adapting to climate change in Africa. *Mitigation and Adaptation Strategies for Global Change* 2:19-44. DOI: 10.1023/B:MITI.0000004663.31074.64
- Eisenack K, and Kropp J (2006) Regional stakeholder perceptions of climate change: Baltic case study screening. ASTRA document, Potsdam. <http://www.pik-potsdam.de/~eisenack/downloads/CSSreport-fd.pdf>. Cited 05 Aug 2011

- Eisenack K, Tekken V, and Kropp J (2007) Stakeholder Perceptions of climate change in the Baltic Sea Region. *Coastline Reports* 8:245-255. http://spicosa.databases.eucc-d.de/files/documents/00000816_Eisenack_Tekken_Kropp.pdf. Cited 05 Aug 2011
- IPCC (Intergovernmental Panel on Climate Change) (2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability*. IPCC Third Assessment Report, Cambridge University Press: Cambridge, UK
- Malaysia (2006) Ninth Malaysia Plan 2006-2010. Economic Planning Unit, Putrajaya, p 559. http://www.parlimen.gov.my/news/eng-ucapan_rmk9.pdf. Cited 05 Aug 2011
- NAHRIM (2006) Final Report: Study of the Impact of Climate Change on the hydrologic Regime and Water Resources of Peninsular Malaysia, National Hydraulic Research Institute of Malaysia (NAHRIM) and California Hydrologic Research Laboratory (CHRL), Malaysia. http://www.nahrim.gov.my/download/pksa/RegHCM_PM_Report_9_21_06_Ex%20v1.pdf. Cited 05 Aug 2011
- NRS (2001) National Response Strategies to Climate Change. Ministry of Science, Technology and the Environment, Malaysia. <http://gedung.nahrim.gov.my/wapi/mctweb.dll/getObject?MID=WATER%20RESOURCES&Sn=2038>. Cited 05 Aug 2011
- Singh S, Amartalingam R, Wan Harun WS, and Islam MT (1996) Simulated impact of climate change on rice production in Peninsular Malaysia. *Proceeding of National Conference on Climate Change*. p 41-49, UPM, Malaysia
- Siwar C, Alam MM, Murad MW, and Al-amin AQ (2009) A review of the linkages between climate change, agricultural sustainability and poverty in Malaysia. *International Review of Business Research Papers* 5(6):309-321. <http://www.bizresearchpapers.com/23.%20Siwar.pdf>. Cited 05 Aug 2011
- Smit B, and Skinner MW (2002) Adaptation options in agriculture to climate change: a typology. *Mitigation and Adaptation Strategies for Global Change* 7: 85–114. DOI: 10.1023/A:1015862228270
- Stern N (2007) *The Economics of Climate Change: The Stern Review*. Cambridge University Press, Cambridge
- Tashiro T, and Wardlaw IF (1989) A comparison of the effect of high temperature on grain development in wheat and rice. *Annals of Botany* 64:59-65
- Tisdell C (1996) Economic indicators to assess the sustainability of conservation farming projects: An evaluation. *Agriculture, Ecosystems and Environment* 57(2):117-131
- UNDP (2005) *Adaptation Policy Framework for Climate Change: Developing Policies Strategies and Measures*. In: Lim B, and Spanger-Sieghed E (eds). Cambridge University Press, Cambridge, UK
- Yohe G, and Tol RSJ (2001) Indicators for social and economic coping capacity: Moving toward a working definition of adaptive capacity. *Global Environmental Change* 12:25-40

Figure 1: Location of study area, IADA in North-West Selangor, Malaysia

Table 1: Government Subsidy (in USD\$) for Paddy Sector in Malaysia

Items	2004	2005	2006	2007
Subsidy For Paddy Price	158,876,101	147,739,347	148,583,299	148,000,000
Paddy Fertilizers	62,248,289	59,357,358	132,131,000	87,225,914
Paddy Production Incentive	NA	NA	NA	22,521,301
Yield Increase Incentive	NA	NA	NA	28,478,207
Paddy Seed Help	NA	NA	NA	5,666,667
Diesel Subsidy Scheme	NA	NA	329,909,139	366,333,574
Petrol	NA	NA	15,137,986	23,153,795
Total Subsidy and Incentive	221,124,390	207,096,705	625,761,425	681,379,458

Note: NA means data are not found available; Exchange Rate is considered as USD\$1= MYR3

Source: Agriculture Statistical Handbook 2008

Table 2: Available External Supports for Adaptation to Climate Change

Types of Supports	Observation Scale*					Average Value of Scale	S.D.	Agreed (4 & 5) Respondent	Disagreed (1 & 2) Respondent
	1	2	3	4	5				
Government Supports are Enough to Cope the Climate Change Effect	6 3%	18 9.1%	58 29.3%	44 22.2%	72 36.4%	3.8	1.12	116 58.6%	82 12.1%

NGO Supports are Enough to Cope the Climate Change Effects	10 5.1%	30 15.2%	54 27.3%	43 21.7%	61 30.8%	3.58	1.21	104 52.5%	94 20.2%
Other Agencies' Supports are Enough to Cope the Climate Change Effects	5 2.5%	18 9.1%	77 38.9%	57 28.8%	41 20.7%	3.56	1	98 49.5%	100 11.6%
Free Fertilizer from Government is Enough for Production of Paddy	6 3.0%	15 7.6%	28 14.1%	62 31.3%	87 43.9%	4.06	1.08	149 75.3%	49 10.6%
Additional Fertilizers are available to buy from market	13 6.6%	20 10.1%	46 23.2%	55 27.8%	64 32.3%	3.69	1.21	119 60.1%	79 16.7%

*Scale: 1 = Strongly Disagree, 2 = Disagree, 3 = No Comment, 4 = Agree, 5 = Strongly Agree

Table 3: Statistical Output (Equation 1) for Farmers Ability of Adaptation on Currently Available External Supports

Independent Variables	Coefficient (Ω)	z-stat	P-value	Odds Ratio
S ₁	0.0247	0.089	0.782	1.025
S ₂	-0.063	0.095	0.509	0.939
S ₃	-0.027	0.116	0.816	0.973
S ₄	0.153 [^]	0.070	0.028	1.166

The notation [^] indicates the variable is statistically significant at the 5% significance level, respectively

Note: The Odds ratio is calculated as (e^{β})

Table 4: Statistical Output (Equation 2) for Farmers' Ability of Adaptation on Required External Supports

Category of Supports	Independent Variables	Coefficient (β)	z-stat	P-value	Odds Ratio
Innovation Related Supports	V1	0.126	0.586	0.558	1.135
	V2	-0.153	-0.706	0.480	0.858
	V3	0.263~	1.912	0.056	1.301
	V4	-0.200~	-1.744	0.081	0.819
Information Related Supports	V5	0.068	0.502	0.616	1.071
	V6	0.025	0.189	0.850	1.026
	V7	-0.207	-1.365	0.172	0.813
Financial Supports	V8	0.086	0.579	0.562	1.090
	V9	0.596*	3.642	0.000	1.815
	V10	-0.206	-1.468	0.142	0.814
Encouraging Supports	V11	-0.478*	-2.622	0.009	0.620
Production Practice Related Supports	V12	-0.139	-1.242	0.214	0.870
	V13	0.198	1.298	0.194	1.219
	V14	0.297 [^]	2.527	0.012	1.345
	V15	0.130	1.250	0.211	1.138

The notation *, [^], and ~ indicates the variable is statistically significant at the 1%, 5% and 10% significance level, respectively

Note: The Odds ratio is calculated as (e^{β})

Table 5: Innovation and Information Related Required External Supports for Adaptation to Climate Change

Types of Supports	Observation Scale*					Average Value of Scale	S.D.	Agreed (4 & 5) Observation	Disagreed (1 & 2) Observation
	1	2	3	4	5				
Water management Innovations	5 2.5%	11 5.6%	42 21.2%	40 20.2%	100 50.5%	4.11	1.08	140 70.7%	16 8.1%
Irrigation System Innovations	5 2.5%	9 4.5%	45 22.7%	40 20.2%	99 50%	4.11	1.06	139 70.2%	14 7.1%
Moisture Deficiency Related Innovations	4 2%	5 2.5%	46 23.2%	72 36.4%	71 35.9%	4.02	0.94	143 72.2%	9 4.5%
Crop Development	7 3.5%	11 5.6%	44 22.2%	54 27.3%	82 41.4%	3.97	1.09	136 68.7%	18 9.1%
Early Warning about Weather and Climate Information	4 2%	4 2%	30 15.2%	58 29.3%	102 51.5%	4.26	0.93	160 80.8%	8 4%
Daily and Seasonal Weather Forecasts	6 3%	4 2%	45 22.7%	60 30.3%	83 41.9%	4.06	1	143 72.2%	10 5.1%
Proper Guidelines or Suggestion	6 3%	3 1.5%	29 14.6%	70 35.4%	90 45.5%	4.19	0.95	160 80.8%	9 4.5%

*Scale: 1 = Strongly Not Needed, 2 = Not Needed, 3 = Not Sure, 4 = Needed, 5 = Strongly Needed

Table 6: Required Financial and Encouraging External Supports for Adaptation to Climate Change

Types of Supports	Observation Scale*					Average Value of Scale	S.D.	Agreed (4 & 5) Observation	Disagreed (1 & 2) Observation
	1	2	3	4	5				
Raw materials subsidy	5 2.5%	10 5.1%	25 12.6%	51 25.8%	107 54%	4.24	1.02	158 79.8%	15 7.6%
Cash Incentive	7 3.5%	8 4%	25 12.6%	65 32.8%	93 47%	4.16	1.03	158 79.8%	15 7.6%
Insurance Support	7 3.5%	1 0.5%	35 17.7%	83 41.9%	72 36.4%	4.07	0.94	155 78.3%	8 4%
Infrastructural Support, such as Irrigation, Transportation	7 3.5%	5 2.5%	30 15.2%	43 21.7%	113 57.1%	4.26	1.04	156 78.8%	12 6.1%

*Scale: 1 = Strongly Not Needed, 2 = Not Needed, 3 = Not Sure, 4 = Needed, 5 = Strongly Needed

Table 7: Production Practice Relevant Required Supports for Adaptation to Climate Change

Types of Supports	Observation Scale*					Average Value of Scale	S.D.	Agreed (4 & 5) Observation	Disagreed (1 & 2) Observation
	1	2	3	4	5				
Diversify Crop Types and Varieties	6 3%	48 24.2%	43 21.7%	31 15.7%	70 35.4%	3.56	1.28	101 51%	54 27.3%
Adjustment in Land Use Pattern	5 2.5%	6 3%	45 22.7%	63 31.8%	79 39.9%	4.04	0.99	142 71.7%	11 5.6%

Adjustment in Wage and Leasing System	7 3.5%	9 4.5%	37 18.7%	46 23.2%	99 50%	4.12	1.09	145 73.2%	16 8.1%
Merge Individual Farmers to Farm	7 3.5%	17 8.6%	33 16.7%	70 35.4%	71 35.9%	3.91	1.09	141 71.2%	24 12.1%

*Scale: 1 = Strongly Not Needed, 2 = Not Needed, 3 = Not Sure, 4 = Needed, 5 = Strongly Needed

Table 8: Priority of Required Supports for Adaptation to Climate Change

Types of Supports	Priority Position					Average Value of Scale *
	1	2	3	4	5	
Financial and Encouraging	83 41.9%	34 17.2%	39 19.7%	34 17.2%	8 4%	2.24 (1)
Information System	51 25.8%	64 32.3%	32 16.2%	33 16.7%	18 9.1%	2.51 (2)
Resource Management Innovations	35 17.7%	41 20.7%	62 31.3%	21 10.6%	39 19.7%	2.94 (3)
Crop Development	14 7.1%	34 17.2%	36 18.2%	67 33.8%	47 23.7%	3.5 (4)
Production Practices	15 7.6%	25 12.6%	29 14.6%	43 21.7%	86 43.4%	3.81 (5)

*The priority position from most important to least important as 1 to 5 is given in the parenthesis