Impacts of Climate Change on Agricultural Sustainability and Poverty in Malaysia

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Abstract

The impacts of both climate change and agricultural practice in Malaysia are generally seen to have been connected one with other in an interesting and circular way. The depth of the impacts of the both is certainly difficult to measure as it might require a comparative benefit-cost analysis, which is beyond the scope of the present study. This study is primarily aimed at reviewing the impacts of climate change on Malaysian agricultural sustainability and poverty. Analysis of the study has thus been developed with particular reference to appraisals concerned with the climate change and current agricultural practice and policy. The study reveals that climate change is a major threat for attaining agricultural sustainability in Malaysia as it continuously changes and affects the agriculture in diversified ways. Therefore, good measurement of its impacts on sustainable agriculture is needed to ensure long run agricultural sustainability in Malaysia.

Field of Research: Environmental Economics

1. Introduction

The economies of least developed countries and many developing countries are still dependent on agriculture. These countries spend a lion's share of their expenditures for purchasing food. Agricultural sector has got much attention recently from both pundits and common people alike amid soaring global food crisis in 2008. Under the present circumstances, even developed countries including United States and European Union are also emphasizing much on the agricultural sector.

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The agricultural sector has gone through evolution over the past decades when many new ideas were implemented and many new technologies were introduced. Producing more food for higher demand had became a continuous challenge around the globe, leading to food security problems in the medium and long terms. In the late 1960s and early 1970s it was assumed that the growth of agricultural production would be unable to meet the world demand, but in the mid 1970s world food production grew rapidly by using various newly introduced farming methods. Since the late 1980s however, high food production raised new threat due to depletion of environmental and natural resources and land degradation (United Nations, 1997). Considering these facts, the concept of sustainable agricultural development and international food security has got priority (Lancker and Nijkamp, 2000; Nijkamp, 1999).

While prioritizing the sustainable agriculture, it was found that climate change played a major role in determining crop performance. The climatic factors as expressed by the amount of rainfall, sunshine hours, temperature, relative humidity and length of the drought period result in year-to-year variability of crop production. Climate change is one of the major potential threats to national food security and sustainable agriculture for a country. As the change of climate is a continuous and long term process, its impacts will continue for long successive years and finding out its remedy will also be a very time consuming process.

The concept of climate change has both positive and negative impacts on sustainable agriculture of a country, where sustainable agriculture affect agricultural productivity, food security, technology, and environment which have different components, with varying priorities in global and regional levels. There are many empirical works to measure agricultural sustainability through use of diverse indicators, but few are on the impact of climate change. In this paper we try to draw attention on these resources in arriving at a theoretical framework for deriving a core set of indicators of agricultural sustainability and integrate them.

2. The Concept of Sustainability and Agricultural Sustainability

The general description of sustainable development in the Brundtland Report (WCED, 1987) is that it is a means of meeting the needs of the present without compromising the ability of future generations to meet their own needs. The Food and Agricultural Organization (FAO) of the United Nations provides a specific description of sustainable agricultural development where the usage of resources and environmental management are combined with increased and sustained production, secured livelihoods, food security, equity, social stability and people’s participation in the development process is considered in a development path. If these conditions can be fulfilled, sustainable agricultural development will be environmentally non-degrading, technically appropriate, economically viable and socially acceptable. Therefore, the optimum welfare of the present and future can be achieved through a co-evolutionary strategy focused on economic, environmental and social objectives with agricultural production (Pearce and Atkinson, 1993).

The issue of sustainable development has gained much attention and different concepts of sustainability have been developed by different groups. Based on policy options and action-oriented concept to solve environmental change issues, sustainable industry, sustainable tourism or sustainable transport (Bergh, 1996), sub-global spatial units like sustainable regions or sustainable cities (Giaoutzi and Nijkamp, 1994; Nijkamp and Perrels, 1994), global impacts which lead to global environmental issues (Cline, 1992; Fankhauser, 1995), the distinction between strong and weak sustainability essentially means different categories of land use (Pearce and Turner, 1990; Pelt 1995) was developed. The dilemma here is how the land will be used for different sectors like agriculture, industry, tourism etc. and how to optimize the economic performance and how to compensate usage of land for various competing sectors. Even within the agricultural sector, where it is not possible to use the same land simultaneously there are various competing sub-sectors like cereal crop production, livestock, cash crop production etc (Barnett and Payne 1995), and even for different types of intervention such as, use of pesticides, herbicides, etc. (Douven, 1997; Simmons, 1997).

In a survey a series of research priorities on socio-economic aspects of land use and climate change were identified by Ierland and Klaassen in 1996. Some of these issues are long term and related to national or international security such as, soil erosion, chemical poisoning or nuclear waste (Daly and Cobb, 1990); some issues are related to daily quality of life such as, water pollution, shortage of food or resources (Homer-Dixon, 1992). The combined effects of these issues are difficult to predict such as, natural and environmental catastrophes in recent times- floods, landslides, long periods of drought etc (United Nations, 1997). Latter studies examined vulnerability defined in terms of yield, farm profitability, regional economy and hunger explicitly considering uncertainty about future climate-change impacts (Reilly, 1999; Schimmelpfenning et al., 1996).

From ancient times in the history of economic thought, varying attention has been given to land as an important economic production factor. In the neoclassical theory productivity and welfare differences between regions explained by soil conditions of different areas means land assumed mainly a functional economic place (Giaoutzi and Nijkamp, 1994). With the emergence of ecological economics, the use of land again getting more attention from economists and policymakers (Bergh 1996). In addition, soil condition has a variety of direct and indirect impacts on the quality and resilience of ecosystems which has global impacts on biodiversity (Douven, 1997). As a consequence, soil management has become an important policy task in many countries where it aims at improving the soil condition by utilizing the land at its optimum level for various agricultural sub-sectors. For example, a same piece of land can be used for both cereal crops and cash crops all round the year based on the season and crop patterns so that planned cultivation on a piece of land reduces soil erosion and increases fertility of a land.

According to experts, sustainability indicators are quantifiable and measurable attributes of a system (Panell and Schilizzi, 1999). Sustainable agriculture meets current and long-term needs for food, fibre, and other related needs of society (Tilman et al., 2002). One set of suggested indicators, that USDA uses to assess agricultural sustainability at farm and regional levels, is based on six measurable variables- yield, profit, frequency of crop failure, soil depth, organic carbon and permanent ground cover (Gomez et al., 1996). Another set of five basic attributes for indicators of agricultural sustainability are: productivity, stability (internal factor), reliability, resilience and adaptability (external factors) (Lopez-Ridaura, 2005).

There is no universal definition for the concept of sustainable agriculture among economists and practitioners. The concept of sustainable agriculture is still evolving. While green-revolution agriculture concept of mid twentieth century addressed mainly productivity issues, sustainable agriculture system address productivity issues beyond mere intensively, but keeps into consideration multidimensional concerns of sustainability in sight like economic, environmental and social concerns. According to different existing literature, there are many important elements of agricultural sustainability, such as, soil fertility, soil loss, topsoil depletion, soil conservation methods- including strip cropping, reduced tillage and no-till, prevent loss of soil due to wind and water erosion, water conservation and protection, improve the quality of drinking and surface water, groundwater contamination, protect wetlands, growing plants - rye, clover or vetch after harvesting a grain, intercropping, growing variety of crops and livestock to reduce risks from extremes in weather, pest management, wildlife habitat and increased populations of beneficial insects, intensive grazing systems with high-quality forage and reduced feed costs, animal selection, reproduction, hard health, confined livestock production, nutrients of food and livestock, managing of manure, nitrogen and other plant nutrients and reduces purchased fertilizer costs, agro-forestry, wildlife diversity, decline of family farms, living and working conditions for farm labourers, increasing costs of production, the disintegration of economic and social conditions in rural communities, long term yield, long term profitability, contribution to community, product value, social/human capital, local economy, social and political context of food and agricultural policy, land ethics- long-term good of all members of the land community, land use, labour, rural community development, consumers and the food system, market conditions, innovative marketing strategies of selling at or through the World Wide Web, direct marketing to farmers markets, roadside stands, restaurants and small grocers, running community-supported agriculture (CSA) enterprises, rate of environmental degradation, prudent use of renewable and recyclable resources etc.

3. Climate Change, Agricultural Sustainability and Recent Food Crisis

Since the beginning of the 1980s, many climatologists predicted significant global warming in the coming decades due to increasing atmospheric concentration of carbon dioxide and other trace gases. In 1988 the Intergovernmental Panel on Climate Change (IPCC) was established by the United Nations Environmental Programme (UNEP) and the World Meteorological Organization (WMO) to assess the scientific, technical and socioeconomic information relevant for the understanding of human induced climate change, its potential impacts and options for mitigation and adaptation. Major possible changes in atmospheric, soil and hydrological regimes were forecasted to occur with a direct impact on food supply and demand.

Food security was the main issue in earlier 1990s (Kane et al., 1992) and the investigation was generally focused on regional or domestic agricultural impact (Adams et al., 1990; Mooney and Arthur, 1990). The recognition of the global nature of climate change and of the interdependencies between economies led successively to various attempts to introduce international trade into the picture (Rosenzweig et al., 1993; Reilly, 1994; Fischer et al., 1993; Adams et al., 1990). Farmers' response to the climate and natural environmental change was thus taken into account (Mendelsohn, 1994, 1999; Reilly, 1994; Adams et al., 1988, 2000). Finally, Sustainable agricultural development has caught up attention of economists and experts rapidly after the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. Earlier when the Brundtland Report published in 1987 it was recognized that a greater commitment to environmental protection and sustainable development was needed because of the use of natural resources and the rise in pollution.

The recent crisis of rice all over the world showed a very good indication about the necessity of monitoring agricultural sustainability on regular basis. Due to this acute food crisis all over the world, many countries have been forced to reconsider the issue of agricultural sustainability and high rates of production, which have strong interactive impacts on climate change. This activity also forces us to develop an appraisal system to monitor the state of sustainable economic system from time to time.

WORLD FOOD CRISIS
Sept. 7, 2007: Vietnam, the world's third- biggest rice exporter, restricts rice exports to slow inflation.
Dec. 4, 2007: Argentina temporarily restricts grain exports.
Jan. 1, 2008: China, the world's biggest grain producer, starts to curb overseas sales of wheat, corn and rice by issuing export permits.
Jan. 19, 2008: Egypt bans rice exports.
Feb. 8, 2008: The American Bakers Association asks the U.S. Department of Agriculture to curb wheat exports.
Feb. 27, 2008: At least four people are killed during three days of protests over high commodity prices in Cameroon.
March, 2008: Philippines authorities begin to crack down on hoarders.
March 17, 2008: India halts all exports of non-basmati rice. It also extends an existing export ban on crops such as peas and beans.
March 28, 2008: Vietnam extends rice export restrictions.
April 4, 2008: Haitians riot over rising food prices. At least three people are killed.
April 6, 2008: Egyptians riot over rising food prices.
April 9, 2008: Corn commodities on the Chicago Board of Trade reach a record $6.16 a bushel.
April 12, 2008: Police clash with 10,000 workers in Bangladesh who smashed vehicles and attacked factories, demanding higher wages to pay for food. The Haitian prime minister is forced to step down in an attempt to defuse anger over food prices. A U.N. police officer bringing food to his unit in Port-au-Prince is killed.
April 14, 2008: U.N. Secretary-General Ban Ki-moon says that a global food crisis has reached "emergency proportions." The World Bank has forecasted that 33 nations from Mexico to Yemen may face social unrest.
April 16, 2008: Malawi plans to restrict corn exports.
April 17, 2008: Kazakhstan, the world's sixth-largest wheat exporter, bans wheat exports between April 27 and Sept.1.
April 18, 2008: India permits rice exports to Bhutan. Indonesia, the world's third-largest rice producer, says it will hold back surplus rice.

Agricultural system affects the environment, but interestingly the agricultural system is also affected by the changes in environment and climate conditions (Socolow, 1999; Alexandratoss, 1999; Tilman et al., 2002). Adding to this, a sudden natural disaster can have a severe negative impact on the overall agricultural sustainability. These disasters increase global demand for food and countries struggle to meet domestic food demands. International collaboration is essential in these situations. Keeping this in mind, from our view point, international collaboration is also required to be incorporated in sustainable agriculture system. Not only does the sustainable agriculture system address many environmental and social concerns, but it also may offer innovative and economically viable opportunities for farmers, labourers, consumers, policymakers and many others in the entire food system and the economic system.

4. Impacts of Climate Change on Malaysian Agriculture

The global aggregate effect of climate change on agricultural production is likely to be small to moderate. However, regional impacts could be significant. Crop yields and changes in productivity will vary considerably across regions. These regional variations in gains and losses will probably result in a slight overall decrease in world cereal grain productivity. The effect of the temperature on crops mainly governs the timing of physiological process, the rate of expansion and survival reproductive structures. Increases in temperature affect the moisture availability through effects on evaporation; in general evaporation increases by about 5% for each 1^{o}C increase in main annual temperature. This would be significant in tropical regions where most crops are generally constrained by water availability (NRS, 2001; Al-Amin and Chamhur, 2008).

Geographic limits and yields of different crops may be altered by changes in precipitation, temperature, cloud cover and soil moisture as well as increases in CO_2 concentrations. High temperatures and diminished rainfall reduce soil moisture, reducing the water available for irrigation and impairing crop growth in non-irrigated regions. And climate change could influence food production adversely due to resulting:

- Geographical shifts and yield changes in agriculture,
- Reduction in the quantity of water available for irrigation, and
- Loss of land through sea level rise and associated salinization.

The risk of losses due to weeds, insects and diseases is likely to increase. The range of many insects will expand or change, and new combinations of pests and diseases may emerge as natural ecosystems respond to shifts in temperature and precipitation profiles. The effect of climate on pests may add to the effect of other factors such as the overuse of pesticides and the loss of biodiversity which already contribute to plant pest and disease outbreaks (Al-Amin and Chamhur, 2008).

The impact of climate change on agriculture (rice) production 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^{-1}in the tropies and over 13 tons ha^{-1} in temperate region (Al-Amin and Chamhur, 2008). The actual farm yields in Malaysia vary from 3-5 tons ha^{-1}, (i.e. potential yield in Malaysia per ha^{-1} 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 CO_2 concentration. The development rates of rice crop were accelerated in response to an increase in CO_2 concentration from 160 ppm (parts per million) to 900 ppm. However the yield response to CO_2 varies with cultivars, location and management practice. It is evident that the average response to an increase of potential yields of about 10kg/ha/ppm CO_2 or about 15kg/ha/ ppm CO_2. However the negative effects occur in unexpected high or low temperature (Penning de Vries, 1993). Temperature affects rice growth in two ways; first, a critically low or high temperature defines the environment under which the life cycle can be completed. Secondly, within the critically low and high temperature range, temperature influences the rate of development of leaves and panicles and the rate of ripening, thereby fixing the duration of growth of a variety under a given environment and eventually determining the suitability of the variety to the environment (Yoshida, 1981).

Generally, the effect of increasing temperature above the tolerance limit on rice potential production is generally negative. Temperature beyond the optimum level reduces the photosynthesis, increase the respiration and shorten the vegetation and grain-filling periods. Rice yield is negatively correlated with high (>35^oC) temperature during the reproductive phase (Stake and Yoshida, 1978). The average temperature in rice-growing areas in Malaysia is about 26^oC. An examination of the current climate change scenario under different future climate change indicates that temperature above 25^oC may decline grain mass of 4.4 % per 1^oC rise (Tashiro and Wardlaw, 1989) and grain yield may decline as much as 9.6 to 10% (Baker and Allen, 1993). Similar result found by Ziska et al. (1997) and they mentioned those flowering and grain-filling periods were markedly affected by an increase in temperature above the present ambient present level. Singh et al. (1996) found on rice production in Malaysia that a decline of rice yield between 4.6 to 6.1% per 1^oC under the present CO_2 level. Greater yield reduction is envisaged with increasing temperature at higher level. However, a doubling of CO_2 concentration (from present level 340 to 680ppm) may offset the detrimental effect of 4^oC rice in temperature (Al-Amin and Chamhur, 2008).

5. Vulnerability to Climate Change and Hardcore Poverty in Malaysia

Climate change is one of the most challenging threats facing the world. The most severe consequences include shortage of rainfall, droughts, high temperature, flooding and unpredicted weather. Developing countries particularly much vulnerable for climate change because their economies are generally more dependent on climate sensitive natural resources (i.e. land and soil moisture, and these countries are less able to deal with the impacts of climate change (Al-Amin & Chamhur, 2008). The vulnerability to climate change depends on various factors (WHO, 2003; Lemmen & Warren, 2004; Ebi et al., 2006; Haines et al., 2006; Confalonieri et al., 2007) such as;

- age distribution;
- population density;
- income level and distribution;
- food availability;
- local environmental condition;
- geographical position;
- economic development;
- pre-existing health status; and
- quality and availability of public health care.

Among and across the communities and demographic subgroups, the most affected and risk groups are children, elderly people, indigenous populations and native peoples, nomadic populations, chronically ill people, people with a low income, homeless people and coastal communities (Lemmen and Warren, 2004; Ebi et al., 2006; Confalonieri et al., 2007). Table 1 shows the incidence of poverty and hardcore poverty by state. The incidence of poverty and hardcore poverty among Malaysians decreased from 8.5% and 1.9% in 1999 to 5.7% and 1.2% in 2004, respectively, due to the successful implementation of poverty eradication programmes and favorable economic growth. In Malaysia, the incidence of hardcore poverty shows higher for the states of Sabah, Terengganu, Perlis, Kedah and Kelantan compared to the other states.

Table 1: Per Capita Poverty Line Income, Incidence of Poverty and Hardcore Poverty, 2004

State	**Household Size**		**Overall Poverty**		**Hardcore Poverty**		
		Gross PLI (RM)	**Per Capita PLI (RM)**	**Incidence of Poverty (%)**	**Gross Food PLI (RM)**	**Per Capita PLI (RM)**	**Incidence of Hardcore Poverty (%)**
Johor	4.3	634	151	2.0	384	91	0.3
Kedah	4.6	654	143	7.0	402	88	1.3
Kelantan	5.2	675	130	10.6	438	84	1.3
Melaka	4.4	650	151	1.8	385	89	0.2
Negeri Sembilan	4.2	598	146	1.4	371	90	0.2
Pahang	4.2	609	147	4.0	392	94	1.0
Pulau Pinang	4.1	615	152	0.3	373	91	neg.5
Perak	4.1	589	144	4.9	371	90	1.1
Perlis	4.2	587	140	6.3	367	87	1.7
Selangor	661	726	159	1.0	420	92	neg.5
Terengganu	888	734	148	15.4	469	94	4.4
W.P. Kuala	3.9	713	189	1.5	373	98	0.2
Peninsular Malaysia	**4.4**	**661**	**152**	**3.6**	**398**	**91**	**0.7**
Sabah	5.2	888	173	23.0	503	97	6.5
Sarawak	4.6	765	167	7.5	482	105	1.1
Malaysia	**4.5**	**691**	**155**	**5.7**	**415**	**93**	**1.2**

Source: Ninth Malaysia Plan, 2006

On the other hand, Table 2 shows the future climate change projections in Peninsular Malaysia which is based on the study undertaken by National Hydraulic Research Institute of Malaysia (NAHRIM). The data represent the maximum monthly values of two climate factors i.e. temperature and precipitation (rainfall) and it reveals that in the future, there is a substantial increase in temperature and rainfall over the North East region compared to the other regions of Peninsular Malaysia. Table 3 demonstrates the possible vulnerable states based on climate change projection undertaken by NAHRIM and hardcore poverty in Malaysia that is basically drawn from the Table 1 and Table 2. It can be seen from Table 3 that Terengganu, Kelantan, Perlis, Kedah and Perak are the most possible vulnerable states in terms of hardcore poverty and projected temperature and rainfall changes. It also shows that the most vulnerable peoples due to climate change are the poor and hardcore poor who have relatively larger household members.

Table 2: Future Climate Change Projections in Peninsular Malaysia by 2050

Regions/Sub-regions/states	Projected Change* in Maximum Monthly Value	
	Temperature (^{0}C)	Rainfall (%)
North East Region -Terengganu, Kelantan, Northeast- coast	+1.88	+ 32.8
North West Region-Perlis (west coast), Perak, Kedah	+1.80	+ 6.2
Central Region-Klang, Selangor, Pahang	+1.38	+ 8.0
Southern Region-Johor, Southern Peninsula	+1.74	+ 2.9

* Difference = Average 2025-2034 & 2041-2050 minus Average 1984-1993

Source: NAHRIM, 2006 (reproduced from Begum et al, 2009).

Table 3: Most Vulnerable States: Hardcore Poverty and Climate Change by 2050

States	Household Size	Incidence of Hardcore Poverty (%)	Projected Temperature Change (^{0}C)	Projected Rainfall Change (%)
Terengganu	5.0	4.4	+1.88	+ 32.8
Perlis	4.2	1.7	+1.80	+ 6.2
Kelantan	5.2	1.3	+1.88	+ 32.8
Kedah	4.6	1.3	+1.80	+ 6.2
Perak	4.1	1.1	+1.80	+ 6.2

Source: NAHRIM, 2006, Ninth Malaysia Plan,2006.
(reproduced from Begum et al, 2009).

The empirical downscaling scenario from the two tables, Table 2&3 (i.e. shortage of rainfall and high temperature up to the year 2050) make use of the quantitative relationships between the state of the larger scale climatic environment and adaptation policy. By coupling specific baseline climate projection data, it provides a valuable outcome between climate model projections and the policy investigation. According to the projection, in the long term, climate change is an additional problem that agriculture faces in meeting national food requirements. Since it is likely that some climate change will occur over the next 50-100 years, ‘adaptation’ has been suggested as the means to reduce the impact of climate change on individuals and societies which has been analysed by Al-Amin and Chamhuri Siwar (2008). Analysis and modeling of adaptation are gaining in importance in studies of climate change impacts.

5. Conclusion

The climate change impacts on agricultural sustainability varies from developed economy to developing economy, economic condition of country to country, region to region and time to time. The effect on agricultural crops in Malaysia governs by the timing of physiological process, the rate of expansion and survival reproductive structures and evaporation function due to climate change. Increases in temperature affect the moisture availability through effects on evaporation; in general evaporation increases by about 5% for each 1^oC increase in main annual temperature. Climate change is expected to result in long-term water and other resource shortages also which would be worsening soil condition, disease and pest outbreaks on crops and livestock, sea-level rise, and so on. Vulnerable areas are expected to experience losses in agricultural productivity, primarily due to reductions in crop yields and ultimate effect goes much on poor. So, climate change is a major threat for sustainable agriculture for Malaysia. As climate is continuously changing and affecting the agriculture in diversified ways, a good measurement of its impacts on sustainable agriculture and smooth adaptation are needed to ensure long run agricultural sustainability in Malaysia.

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