Veridian E-Journal, Silpakorn University
ISSN 1906 – 3431

Economic Impact Assessment of Climate Change on Cassava Production*

Apinan Phatcharopaswatnagul**

Abstract

This objective of this research was to study the impacts and adaptation strategies of cassava growers in Chaiyaphum province. This research uses Cobb-Douglas production function and estimation method the Generalized Least Squares (GLS) in this study, using a secondary data from 2000 to 2016.

The estimation result of Cobb-Douglas equation shows that average temperature statistically had a negative significant effect on the yield of cassava. In terms of cassava planting area, factors which includes total rainfall, and time trends statistically had a positive significant effect on cassava yield. In terms of adaptation tendency of cassava growers in Chaiyaphum province, the first approach found that 95 percent of farmers, which are been used as sample in this study divert to the usage of drought-tolerant cassava varieties. The second approach found that, 64 percent seek for other occupation apart from the agricultural sector in order to increase their income thereby, they engage in construction job as a labor. The third approach found that, 73 percent of the farmers follow up news and information pertaining to climate changes and they did so by listening to official announcement via community radio. Suggestions from this study suggests that Agricultural promotion agencies should provide knowledge and information to farmers on climate change. Organize training; advise them on how to grow cassava in the proper manner in accordance to the changing seasons. Including research on cassava varieties and develop production technologies to be in accordance with the climate change, which occurs in each area, and this will lead to an increase in the production of cassava yield.

Keywords: climate change, cassava, average temperature, rainfall

* This article aims to disseminate research results and it benefits for the public and private sectors in applying.

** Lecturer. Dr.,in Economics Faculty of Business and Information Technology Rajamangala University of Technology Tawan-Ok : Chakrabongse Bhuvannarth Campus Email : apinanart@gmail.com

Introduction

Climate change and its potential impacts have now become issues that are of great interest today, when considering the fact that Thailand is a country that based on agricultural activity or agricultural production. The lifestyle of most people in the agricultural sector depends on appropriate climate condition. Including sufficient water resources for agricultural activities. Most of the country's agricultural land are still dependent on climate condition as an important factor. (Chinvanno S, 2009). When it comes to climate change, it is generally understandable that it will affect climatic factors such as; rainfall and average temperature. The study of Faculty of Environment and Natural Resources (2008) found that climatic changes in the Northeast during year 2010-2039 when compared to year 1970 to 1989 (which is the base year), there is a tendency of about 1 degree Celsius increase in average temperature. However, apart from this, total rainfall is likely to increase by 17 millimeters per year. These changes would have an inevitable effect on the agricultural sector of the region where there main crops are rice, maize, cassava and sugarcane. (Buddhaboon, 2004).

Cassava can be grown in almost all areas of the country. Because cassava is a plant that can be grown in low fertility soils, in 2016 Thailand grows cassava on 8,975,865 rai. The Northeast region has the highest amount of planting area at 4,604,972 rai, followed by the Central region at 2,408,901 rai and the Northern region at 1,961,992 rai, respectively. Chaiyaphum province serves as the province where the highest plantation of cassava in Thailand is been done with a plantation area of 1,674,339 rai and harvested area of 1,536,026 rai. There total yield is at 5,776,880 tons, equivalent to the average yield of 3,761 kilograms per rai (Office of Agricultural Economics, 2016). Cassava is a very easy grown plant and it’s popular grown during raining season (March - February) and toward ending of raining season (September - August) (Department of Agriculture, 2016), but over the past 20 years, the climatic condition has been quite hot. This makes cassava lack water for it growth, the cassava yield are small and abnormal in size, there is a large spread of aphid disease. (Chaiyarat Petchanuuwat, 1999) Even though there are research investment in plant breeding and agricultural technology development, but the production of cassava in Thailand is still low if compared with current demands. found that the long-term effects of climate change would result in Somchai Boonprasert et al. (2009) lower cassava yields and indirect effect on climate variability will make cassava production have a high variability most especially in the Northeast, which was been affected critically.

Study from Supachian Chinwarnano (2009), shows that the agricultural sector in northeastern region is vulnerable to climate change. This is also in accordance to Yuthachai Anitatipan (2014) found that the problems to be faced by the northeastern region, especially in Chaiyaphum, were drought, floods, and so on. This problem directly affects the decline of cassava production and it will lead to farmer's adaptation in order to respond to change, reducing the effects and create immunity to climate change that might occur in the future. Lasco, Habito, Delfi, Pulhin, and Concepcion (2011) suggested the following common practicable adaptation approach in the whole Southeast Asia region: 1) Change of varieties that is more resistant to climatic changes. 2) Changes in planting calendar in order to respond to seasonal changes; 3) Changes in farm management style that is more environmentally friendly and 4) Distribution of income risks from agricultural income.

From the above mentioned, this makes the researcher to be interested in studying the effects of climate change on cassava in Chaiyaphum province through economic model. Thereby, find appropriate adaptation method for farmers to climate change.

Objectives of the Study

1. Analyze the impact of climate change such as average temperature and rainfall to the yield of cassava production in Chaiyaphum province.

Research scope

Content scope : Study the impact of average temperature and rainfall through Cobb-Douglas Production Function. Secondary data were used from 2000 to 2016, Climate information were retrieved from Department of Meteorology, Office of Agricultural Economics and Department of Agriculture.

The area and population scope includes : Chaiyaphum Province

Expected Benefits

The research will make us know the effects of climate change on cassava production. Also, find appropriate adaptation strategy to farmers in order to reduce risk from climate change.

Related Literature review

Murdiyarso, (2000) study estimates that agricultural output in Asia may decline by 3.8 percent by 2100 due to the overall impact of increased carbon dioxide emissions. The usage of too much fertilizer and increase in temperature will have an Impact on early flowering of rice and water shortages. However, recent studies such as Cline (2007), estimate that agricultural output may decline by 19 percent in a situation where the reaction of carbon dioxide has not been considered in allowing the plants to grow in Asia at the end of this century. The downfall level ranges from 15 percent in Vietnam to 26 percent in Thailand and the study of Zhai and Zhuang (2009) estimates that the decline in the aforementioned productivity might affect the real GDP to shrink down to 1.4 percent per year by 2080. In addition, the results of the Global Integrated Assessment Model (IAM). In four countries Indonesia, Philippines, Thailand and Vietnam confirmed the above-mentioned study. Most importantly, the result of gas emission scenario shows that, annual average temperature of these four countries will increase by 4.8 degrees Celsius by 2100 from the 1990's levels. Indonesia, Thailand and Vietnam may experience increase drought in the next 20-30 years. Climate change will have an impact on both economic and human activity in these four countries over the next ten decades where agricultural production potentials is expected to decline by about 50 percent by the year 2100. When compared with the average rate for 1990's, which was the base year, on the assumption that there is no adaptation, no technical and technological improvements, and the expected trend will begin to emerge in 2020 in most countries. However, efforts to stabilize climate and adaptation will help prevent tendencies of low rice production. Therefore, countries in the Southeast Asian need to work practically in order to adapt and build up immunity and thereby cope with the effects of climate change. Including the reduction of excess capital as a result unavoidable effect when it comes to adaptation. Including adaptation in the natural or human systems, in order to responds to the effects of climate change or expected effect that might occurs as a result of climate changes. This will reduce the danger or take advantage of the opportunity gathered from such adaptation. For this reason, adaptation to climate change will reduce vulnerability and increase immunity. It can be done at the individual, household, manufacturing group, community, business, and government levels. The study of Lasco, Habito, Delfi and Concepcion (2011) suggested the following common practicable adaptation approach in the whole Southeast Asia region: 1) Change of varieties that is more resistant to climatic changes. 2) Changes in planting calendar in order to respond to seasonal changes; 3) Changes in farm management style that is more environmentally friendly and 4) Distribution of income risks from agricultural income.

This went in accordance with Abid's (2016) study which shows that, farmers adopt in three forms 1) Reduce risk factor in the cultivation of cassava 2) Create Immunity in order to cope or prepare for climate risks. 3) Search for more knowledge on cassava.

Scope of Research Concepts

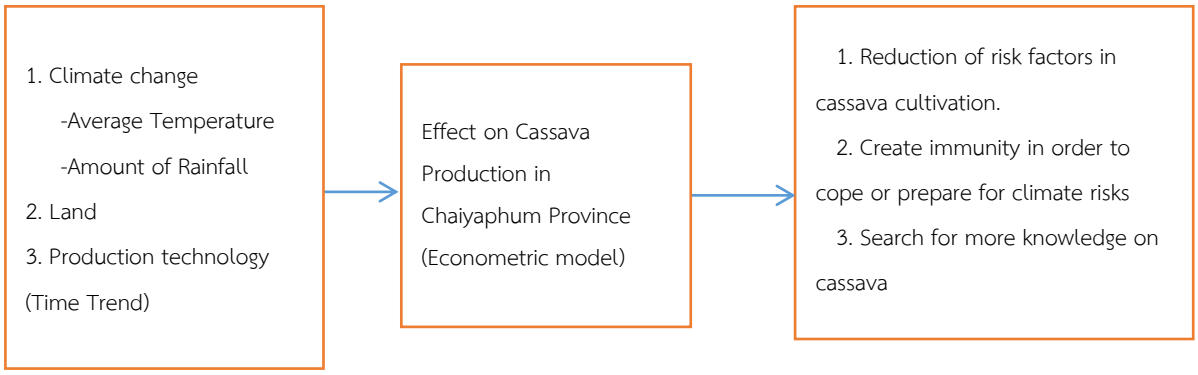

Diagram 1: Conceptual framework

Methodology of Research

In response to the first objectives, the following procedures took place.

1. Stationarity test was conducted by performing Unit Root on the studied variables using Dickey-Fuller (ADF-Test) method.

2. Multivariate linear test was conducted which specify each independent variable to be independent. In testing this condition, it must be check using statistical value, which includes Tolerance and Variance Inflation Factor (VIF). If the Tolerance value of a variable approaches 1, that is the variable is independent of one another. However, if the value approach zero, this indicates multi - collinearity problem. However, the Variance Inflation Factor value is too close to 10, that is the independent variable degree of correlation in the multiple linear regression equation is too much that is there is multi - collinearity problem

3. Test for Heteroscedasticity was conducted. This is a problem related to discrepancies and White Heteroscedasticity test method was performed.

4. Autocorrelation test was carried out using Durbin-Watson method to determine if each error value must be independent. The testing method was considered by the researcher based on Durbin-Watson statistical value, where if Durbin-Watson value is close to 2

5. Analysis of Generalized Least Square (GLS) results based on literature review using computer application software.

The application of Deressa, T. (2007) and Cline, W. R. (2007) where the production function is identified as Stochastic Production Function based on the theoretical model of equation 1

$$y_t = f(x_t, \beta_t) + u_t \quad \text{...1}$$

Where Y_t is the yield in time t, X_t is the vector of explainable variable in time t, the number of k variable $f_1(x_t, \beta_t)$ is the production mean function and u_t is the error time of the production.

In this study, the researcher used the following model according to equation 2

$$\ln \text{Prod}_t = \alpha_1 + \beta_1 \ln Land_t + \beta_2 \ln AT_t + \beta_3 \ln TR_t + \beta_4 \ln Time_t + u_t \quad \text{...2}$$

Prod_t is the yield of cassava (tons per rai) in year t. $Land_t$ is cassava cultivation area (Rai) in year t. AT_t is the average temperature (Degrees Celsius) in year t. TR_t is the total rainfall (mm) in year t. $Time_t$ is the time trend representing the change in technology at year t and u_t is the annual error term in year t.

Result and discussion

Answer to the first objective analyze the impact of climate change such as average temperature and rainfall to the yield of cassava production in Chaiyaphum province. It consist of the following process.

1. Unit Root test results using ADF - Fisher Test method shows that all the data were static at confidence level of 99 percent or at I (0) level for all variables.

2. Multi - collinearity test result shows that Independent variable does not relate to each other. Using Collinearity statistic, it shows that, the maximum Variance Inflation Factor (VIF) was 1.678 (i.e. it is normal value it not more than 10) and Tolerance value was very low at 0.596 (i.e. it normal value not less than 0.2). In summary, the independent variables are not related i.e. there is no Multi-collinearity.

3. The results of Autocorrelation or Serial correlation from Durbin-Watson test equals 1.8573. According to Durbin-Watson table, d statistic shows that the achieved values were in the negative range H_0, which means there is no Autocorrelation problem.

4. Heteroscedasticity test result shows that chi-square statistic calculated value is lower than the critical value at confidence level of 99 percent. Therefore, the null hypothesis was accept Which means the model is Homoscedasticity.

5. The equation was calculated using Generalized least squares (GLS) method. In order to and the result is shown below.

Veridian E-Journal, Silpakorn University
ISSN 1906 – 3431

$$\ln \text{Prod}_t = \underset{(2.8459)^{**}}{-0.2904} + \underset{(0.0948)^{**}}{0.3851}\ln Land_t - \underset{(0.0749)^{**}}{0.2958}\ln AT_t + \underset{(0.0097)^{**}}{0.2194}\ln TR_t + \underset{(0.0649)^{**}}{0.3248}\ln Time_t$$

R-squared	=	0.9263	Adjust R-squared	=	0.9021
Prob (F-statistic)	=	0.0000			

Note: The number in ( ) are Standard error.

** indicate that the parameter is significant at the 1%

The estimation results of Cobb-Douglas production function has been considered carefully, adjusted R-squared of equation was 92.63 percent. This implies that, cassava yield is explainable with the following factors such as: cultivated area, average temperature, total rainfall, and time trend at 92.63 percent, while the remaining 7.37 percent were impact from other factors, they are not included in this equation.

The co-efficient value of cassava cultivating area equals 0.3851, this implies that cassava cultivating area increased by 1 percent, making other factors stable, this would however increase cassava yield to 0.3851 percent. This shows that cultivating area is related in the same direction to yield, which is in accordance with agricultural supply theory and the study of Isik, M., and Devadoss (2006). Which shows that cultivating area has a statistically significant effect on yield. Average temperatures has a coefficient of -0.2958. This implies that, when the average temperature during the growing season of cassava increase by 1 percent, making other factors stable, this would however reduce cassava yield by 0.2958 percent. Because average temperature has a negative effect on the yield of cassava. This went in accordance with the study of Sahamachai Kongton et, al (2004) which shows that average temperature a factor that significantly affect the yield of cassava in the opposite direction. If the average temperature is high, it will cause dehydration for cassava plant and eventually dried up. (Office of Agricultural Economics, 2016) The co-efficient of total rainfall was 0.2194. This implies that, an increase of one percent in total rainfall during the cultivation period of cassava, making other factors stable, this would increase the yield of cassava at 0.2194 percent. This shows that water is an important factor in the cultivation of cassava (Department of Agriculture, 2016). The result was in accordance with the research study of G.C.Aye, P.IAter (2012) where they found that most agricultural crops used water as an important factor in cultivating them at different quantities. The co-efficient of time trend is 0.3248 percent, that is when time trend which is the representative of technology development increases by one percent, making other factor stable, it would increase the yield of cassava at 0.3248 percent.

This signifies that time trend is the representative of production technology development in the same direction and It also contributes to the growth of agricultural products such as; agricultural practices, specialization in crop management, timing, and amount of used chemical fertilizers, properly organized cropping systems etc. This come in accordance with the study of Saha et al. (1997) which shows that, innovation development and production technology, including research into plant varieties will significantly increase agricultural productivity.

In respond to the second Objective: Analyze adaptation strategies of farmers to climate change. The study shows that, general information of cassava growers in the year 2016/17 in Chaiyaphum province states that majority of the households head are between the ages of 41-50 years old, with an average age of 48.99 years. They are graduates of the fourth grade in an elementary school, they have about 3 - 4 members in their household, an average of 2.64 people engage in the cultivation of cassava per household. Most of the farmers has a cultivating area of their own, with an average cultivating area per household of 53.85 rai. They have been growing cassava for more than 10 years. In addition, the farmers also engage in the planting of other crops apart from cassava simultaneously, which include rice, sweet corn and sugarcane. However, farmers in the region still have to borrow money from Bank for Agriculture and Agricultural Co-operative in order to fund their cassava cultivation. In the second part, which has to do with the production plan of cassava, shows that before the plantation process, the farmers must prepare their soil before plantation and they mostly prefer to apply organic fertilizer rather than other type of fertilizer. In terms of weeding, most of them use herbicides or control methods. Most of the farmers prefer to plant Huai Bong variety of cassava which is been distributed to them by agricultural district office or agricultural cooperatives in the area. This variety is been preferred by because it give high cassava yield and it's more resistant to drought. The second variety of cassava that is most planted is Rayong variety because it has high percentage of starch in it. A total amount of 2,000-3,000 pieces are used per rai, farmers prefer to grow in March and harvest in February of the following year. In terms of harvesting, cassava harvest are been harvested at about 12 months after planting, the starch content and weight were quite high. Therefore, they were able to sell at good price. Most of the farmers harvest using manual labor and use an equipment to yank cassava roots. The average yield cassava falls between 2,951.19 kilograms per rai. In the third part, which has to do with been aware of information about climate change, shows that 85% of the farmers received information from the community radio, followed by television at 21 percent. The frequency of receiving information shows that they received information at an average of at least once a month at 32 percent, followed by 24 percent per week respectively.

In terms of adaptability, measures of cassava growers in Chaiyaphum province, their first approach shows that the 95 percent of sample farmers changed to cassava varieties that are resistant to drought, followed by the use of cassava varieties that gives high percentage of starch at 78 percent. The varieties were given to them from government agencies such as Department of Agricultural Extension and agricultural cooperatives in the area. In terms of the second approach, preparing for climate change risks, it shows that 64 percent of the farmers are still seeking for alternate job outside the agricultural sector in order to increase their income, where they spread out to engage on construction labour jobs. Followed by 26 percent of the farmers engage on agricultural activities where they plant different variety of crops such as sugar cane, maize, rubber etc. In terms of the third approach, which has to do with risk management, shows that 73 percent of the sample farmers follow-up on climate change, where they followed official announcements via the community radio channel, followed by 22 percent engage in a training workshop that was organized by government agencies. Such as agricultural cooperatives on issues relating to method of cultivating cassava and get high yields in returns.

Conclusion

The estimation of Cobb-Douglas production function equation using GLS estimation method with secondary data from 2000 to 2016. All independent variables had a significant effect on cassava yield at 99% confidence level. After considering the elasticity between average temperature, it was revealed that they were in opposite direction to cassava yield. An increase in average temperature cause cassava to grow slowly. In terms of cultivating area, total rainfall, and time trends are in same direction to cassava yield. Considering the coefficient, it was found that elasticity of average temperature is greater than the elasticity of total rainfall. This shows the magnitude effect of the both factor, which implies that average temperature responds to cassava yield rather than total rainfall. Because If an increase in average temperature occurs, it will affect the moisture content of the soil, which is also an important factor to the growth of cassava Department of Agriculture (2016). In terms of farmers' adaptation to climate change in the planting of cassava, guidelines by Gbetibouo, A.G. (2009) and Abid et al. (2016) were used. It shows that, in the first guideline approach, the sample change to the use of drought resistant variety of cassava, followed by a change to the use of cassava variety. This current planting year of 2016/2017, they use Huai Bong variety, this went in accordance with the research study of Deressa, T. (2007), which shows that farmers would use cassava variety they obtained from the local authorities in the area, because they

are well-researched varieties, they are developed to suit the climatic condition and cultivated soil. In terms of the second approach, the sample farmers were prepared for climate change risks. It shows that farmers are still seeking for alternate job outside in order to increase their income, where they spread out to engage on construction labour jobs. Followed by 26 percent of the farmers engage on agricultural activities where they plant different variety of crops such as sugar cane, maize, rubber etc. This went in accordance with Nirote et.al (2016), which says farmers has alternate jobs, while waiting for the harvest of their agricultural products, in order to serve as a means of increasing their family income. In terms of the third approach sample farmers has a method of managing risk factors from climate change and it shows that the farmers follow-up on climate change information official announcements via the community radio channel, followed by engaging on training workshop that was organized by government agencies. Such as agricultural cooperatives, agricultural districts etc. on issues relating to the appropriate usage of cassava varieties to the cultivated soil, choosing growing seasons, appropriate season for growing cassava, fertilizer usage, weeding and applying water during off raining season.

Suggestion

Policy Recommendations

Government agricultural promotion agency should focus on research that has to do with climate-resistant and high content of starch cassava varieties, provide sufficient water resources, provide capital channel to farmers in order for them to adapt such as drip irrigation system, which will help increase production efficiency. They should also equipped the farmers on issues pertaining to climate change, related effects, engage them on training and advise farmers on proper ways to grow cassava.

Suggestions for further study

The climate variables used in this study are average temperature and total rainfall However, there are still some climate related variables that are not used in this study, such as humidity, numbers of raining days, maximum temperature, minimum temperature and the amount of carbon dioxide etc. all the aforementioned also affects climate change, including the addition of other controllable variables.

Acknowledgments

The researcher is grateful to the Department of Meteorology, Department of Agricultural Extension, Office of Agricultural Economics and farmers in Chaiyaphum province for their co-operation in providing me necessary information for this study. I would also like to appreciate Assistant Prof. Dr. Nirote Sinnarong, including my four supervisors that gave me useful suggestion for completing this research work according to research ethics and process.

References

Abid, M., Schilling, J., Scheffran, J., & Zulfiqar, F.2016. Climate Change Vulnerability, Adaptation and Risk Perceptions at Farm Level in Punjab, Pakistan. Science of the Total Environment, 547, 447–460.

Buddhaboon, C., Kongton, S., & Jintrawet, A. 2004. Climate Scenario Verification and Impact on Rain-fed Rice Production. Bangkok: Southeast Asia START Regional Center Technical Report.

Chinvanno, S. 2009. Future Climate Projection for Thailand and Surrounding Countries: Climate change scenario of 21st century. The First China-Thailand Joint Seminar on Climate

Change, 23-24 March 2009. Bangkok: Thailand Research Funf (TRF) and NationalNatural Science Foundation of China (NSFC).

Cline, W. R. 2007. Global Warming and Agriculture: Impact Estimates by Country.Center for Global Development and Peterson Institute for International Economics, Washington, DC.

Deressa, T. 2007. “Measuring the economic impact of climate change on Ethiopian Agriculture”. Policy Research Working Paper No 4342. The World Bank. Washington, D.C.

G.C.Aye,P.IAter.2012. Impact of Climate Change on Grain Yield and Variability in Nigeria: A Stochastic Production Model Approach. Mediterranean Journal of Social Sciences Vol 3 (16).

Gbetibouo, A.G. 2009. Understanding Farms’ Perceptions and Adaptations to Climate Change and Variability: The Case of the Limpopo Basin, South Africa. International Food Policy Research Institute.

Gujarati D. N (2003), “Basic Econometrics”, McGraw Hill Education, fourth edition, pp. 300-560

Hasen,C.B.2007.Generalized least squares inference in panel and multilevel models with seria correlation and fixed effect.Journal of Econometrics.140:670-694

Hertel, T.W., and Rosch, S.D. 2010. Climate Change, Agriculture, and Poverty. Applied Economic Perspectives and Policy 32(3)

Lasco, R. D., Habito, C. M. D., Delfi, R. J. P., Pulhin, F. B., & Concepcion, R. N. (2011). Climate Change Adaptation for Smallholder Farmers in Southeast Asia. Philippines:World Agroforestry Centre

Lsik, M., and Devadoss, S. 2006. An analysis of the Impact of Climate Change on Crop Yields and Yield Variability. Applied Economics

Murdiyarso, D. 2000. Adaptation to Climatic Variability and Change: Asian Perspectives on Agriculture and Food Security. Environmental Monitoring and Assessment 61 (1,March):123–31.

Nirote Sinnarong. 2016. Essays on the Impact of Climate Change in Agricultural Production. Doctoral Dissertation of Applied Economics. National Chung Hsing University, Taiwan.

Saha, A., Havenner, A., and Talpaz, H. 1997. Stochastic Production Function Estimation: Small Sample Properties of MLE versus FGLS. Applied Economics

Somchai Boonprasert, Sukit Ratanasrivong, Sahasai Dumrong, Sompong Nilapan, Independent Buddhists, Preecha Kasem, Catsilaya Ekkachai, Viparat Dararak. 2007. Chulalongkorn University, Bangkok, Thailand. "The impact of global warming on rice, cassava and maize production in Thailand. Offered to the Office Research Fund. Bangkok

Supachian Chinwarnano. 2009. Effects of climate change in Thailand: trends and Issues to consider Documentation for the Science and Technology Conference The 35th, 15th - 17th October 2009, The Tide Resort, Chonburi

Yamane, Taro. 1976. Statistics and introduction analysis. 2nd en, Harper & Row, New York.

Yuthachai Anitatipan. 2014. Drought in the United States.The desert of Thailand. Bangkok: Bureau of Land Development Research and Development Department of Land Development,

Zhai, F., and J. Zhuang. 2009. Agricultural Impact of Climate Change: A General Equilibrium Analysis with Special Reference to Southeast Asia. ADBI Working Paper No. 131, Asian Development Bank Institute, Tokyo.