UNIVERSITI PUTRA MALAYSIA

VULNERABILITY OF PADDY FARMERS TO CLIMATE CHANGE VARIABILITY IN PENINSULAR MALAYSIA

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By

DANLADI YUSUF GUMEL

Thesis Submitted to the School of Graduate Studies Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

January 2018

DEDICATION

To the memory of my beloved mother, late Fatima Umaru (Chime Doguwa), who untiringly and single handedly took the responsibility through toil (after the demise of my late father at my infancy, Yusuf Kitawuri), and nurtured as well as inspired my intellectual acumen. But unfortunately, she had never had the opportunity to survive and witness my journey and stepping my feet into this world of Academia, literally and axiomatically. I know you will be smiling from your grave to hear your loving son attained this academic feat. May ALLAH (SWA) reward your efforts and place you in the highest abode of Al-Jannah Firdaus.

To my Loving wife Maryam Abdulkadir, and my beloved children Ummi Rukayya, Abdul-Jalal, Abdul- Malik, Abdul- Hakim and Abdul- Karim for your love, patience, perseverance, support and prayers during the hectic period of my study.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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January 2018

Chairman : Associate Professor Ahmad Makmom Bin Abdullah, PhD
Faculty : Environmental Studies

Climate changes greatly affect agricultural crop production and the associated farming community. The magnitude of the climatic stressor, the sensitivity and capacity of the affected communities to adapt with such stressors affect farmer vulnerability. This study assessed the vulnerability of paddy farmers to climate change variability in Peninsular Malaysia. The study employed an integrated vulnerability assessment approach using three component of vulnerability i.e. exposure, sensitivity and adaptive capacity. Trend analysis was conducted using Mann – Kendall to detect temperature and rainfall variability from 1981- 2014. DSSAT Ceres- rice model was used to predict rice yield for the study areas from 2016 until 2035 and determine the sensitivity of rice yield to temperature and rainfall changes. Household survey was conducted using multi- stage systematic random sampling on 450 sampled respondents to measure their adaptive capacity. Trend analysis shows that annual maximum temperature warming trend ranges from 0.008^{0}C to 0.014^{o}C per year, while annual minimum temperature warming trend ranges from 0.018^{o}C to 0.063^{o}C per year.Rainfall variability analysis revealed greater variability in terms of annual, monthly as well as seasonal patterns for all the areas under this study. The mean annual rainfall ranges from as low as 2016.7mm to as high as 2576.5mm for all the areas. The DSSAT model rice yield prediction result shows that Muda Agricultural Development Area (MADA) Kedah, will have highest increase in yield of 24.9% in 2029, with few years of decreasing yield by up to -10.1% in 2035. In the Integrated Agricultural Development Area (IADA) Northwest Selangor, the model predicted decrease in yield of up to -7.1% by the year 2024. In the Kemubu Agricultural Development Area (KADA) Kelantan, the model predicted highest increase in the yield (14.0%) in the year 2028 and highest yield decline of -13.3% by the year 2030. 22.9% of respondents were found to be less vulnerable, 32% were vulnerable and45.1% were highly vulnerable.Based on granaries, MADA has the highest vulnerability followed by KADA with IADA as the least vulnerable. Ordinal logistic regression revealed that 17 factors have significant influence on the

vulnerability outcome of the respondents. Conclusively, the respondents in the study areas are vulnerable to the effects of climate change variability. Therefore, decision makers should tailor policies to address local specific conditions by placing climate change vulnerability issues within the broader developmental context.

Abstrak tesis ini dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KERENTANGAN PETANI PADI TERHADAP PERUBAHAN IKLIM DI SEMENANJUNG MALAYSIA

Oleh

DANLADI YUSUF GUMEL

Januari 2018

Pengerusi : Profesor Madya Ahmad Makmom Bin Abdullah, PhD
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Perubahan iklim telah menjejaskan pengeluaran tanaman pertanian dan secara tidak langsung menjejaskan komuniti petani. Mangnitud tekanan iklim, kepekaan dan kapasiti komuniti yang terjejas untuk penyesuaian terhadap pelbagai tekanan telah menjejaskan kerentanan petani. Kajian ini menilai kerentangan petani padi terhadap perubahan iklim di Semenanjung Malaysia. Kajian ini menggunakan pendekatan penilaian kerentangan bersepadu menggunakan tiga komponen kerentangan iaitu pendedahan, kepekaan dan kapasiti penyesuaian. Analisis trend dijalankan menggunakan Mann - Kendall untuk mengesan perubahan suhu dan hujan dari tahun 1981 hingga 2014. Model DSSAT Ceres telah digunakan untuk meramal hasil beras bagi kawasan kajian dari tahun 2016 hingga 2035 dan menentukan kepekaan hasil beras terhadap perubahan suhu dan taburan hujan. Kajian isi rumah telah dijalankan dengan menggunakan pensampelan rawak sistematik pelbagai peringkat pada 450 orang responden untuk mengukur kapasiti penyesuaian. Analisis Trend Mann-Kendall menunjukkan bahawa trend suhu pemanasan maksimum tahunan adalah dari 0.0080C hingga 0.0140C setahun, manakala suhu pemanasan suhu minimum adalah antara 0.018^{o}C hingga 0.063^{o}C setahun. Penemuan dari analisis kepelbagaian taburan hujan mendedahkan kepelbagaian yang lebih besar dari segi taburan hujan tahunan, bulanan dan hujan bermusim untuk semua kawasan di bawah kajian ini. Purata taburan hujan tahunan adalah dari serendah 2016.7mm hingga setinggi 2576.5mm untuk semua kawasan. Keputusan kajian ramalan hasil padi daripada model DSSAT menunjukkan bahawa Kawasan Pembangunan Pertanian Muda (MADA) Kedah, akan mengalami kenaikan tertinggi hasil mencecah 24.9% pada tahun 2029, dengan beberapa tahun penurunan hasil hingga -10.1% pada tahun 2035. Dalam Kawasan Pembangunan Pertanian Bersepadu (IADA) Barat Laut Selangor, model meramalkan penurunan hasil sehingga -7.1% menjelang tahun 2024. Di Kawasan Pembangunan Pertanian Kemubu (KADA) Kelantan, model meramalkan kenaikan tertinggi hasil (14.0%) pada tahun 2028 dan penurunan tertinggi hasil -13.3% menjelang tahun 2030. 22.9% responden didapati kurang terdedah, 32%

terdedah dan 45.1% sangat terdedah. Di peringkat kawasan jelapang, MADA mempunyai kerentanan tertinggi diikuti oleh KADA dan IADA yang paling lemah.Hasil daripada regresi logistik ordinal menunjukkan bahawa 17 faktor didapati mempunyai pengaruh yang signifikan terhadap hasil kerentanan responden. Secara keseluruhan, disimpulkan bahawa responden di kawasan kajian terdedah kepada pengaruh perubahan iklim.

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I certify that a Thesis Examination Committee has met on 18 January 2018 to conduct the final examination of Danladi Yusuf Gumel on his thesis entitled "Vulnerability of Paddy Farmers to Climate Change Variability in Peninsular Malaysia" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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Declaration by graduating student

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LIST OF ABBREVIATIONS

AEZ	Agro Ecological Zone
ANOVA	Analysis of Variance
ASPIM	Agricultural Production System sIMulator
BERNAS	Padiberas National Berhad
BLS	Barat Laut Selangor
CERES	Crop Environment Resource Synthesis
CGE	Cumulative General Equilibrium
COV	Coefficient of Variance
CRM	Coefficient of Residual Mass
CROPGROW	Crop template module
CROPSYST	Cropping System Simulation
CROPWAT	Crop Water Model
CSM	Crop Simulation Model
CV	Coefficient of Variation
D- Index	Index of Agreement
DOA	Department of Agriculture, Malaysia
DSSAT	Decision Support System for Agricultural Technology
ENSO	EL Nino South Oscillation
FAMA	Federal Agricultural Marketing Authority
FAO	Food and Agricultural Organization
FAOUN	Food & Agricultural Organization of the United Nation
FEM	Fixed Effect Model
FILEX	Experiment File
GCM	General Circulation Model
GCOS	Global Change Observational System
GHG	Green House Gases
HSD	Honest Significance Difference
IADA	Integrated Agricultural Development Authority
IBSNAT	International Benchmark Sites Network for Agro-technology Transfer Project

IOD	Indian Ocean Diapole
IPCC	Intergovernmental Panel on Climate Change
KADA	Kemubu Agricultural Development Authority
KETARA	North Terengganu Integrated Agricultural Development Authority
KMO	Kaiser – Meyer - Olkin
MADA	Muda Agricultural Development Authority
MARDI	Malaysia Agricultural Research & Development Institute
MK	Mann- Kendall
MMD	Malaysia Meteorological Department
MR- 219	Malaysia Rice Variety – 219
MR-84	Malaysian Rice variety- 84
MSD	Mean Squared Deviation
NAHRIM	National Hydrologic Research Institute of Malaysia
NEM	Northeast Monsoon
NOA	North Atlantic Oscillation
OECD	Organization For Economic Co-operation and Development
OLLRM	Ordinal Logistic Linear Regression Modelling
OLR	Ordinal Logistic Regression
OLS	Ordinary Least Square
ORYZA1	A Crop growth simulation for Rice
PCA	Principal Component Analysis
PDO	Pacific Decadal Oscillation
PPK	Pertubuhan Peladang Kawasan (Area Farmers' Organization)
PRECIS	Providing Regional Climates for Impact Studies
R&D	Research & Development
RCM	Regional Circulation Model
RM	Malaysian Ringitt
RMSD	Root Mean Squared Deviation
RMSE	Root Mean Squared Error

RMSPE	Root Mean Squared Percentage Error
SD	System Dynamic
SRES	Special Report on Emission Scenarios
SSL	Self- Sufficiency Level
SWB	Soil Water Balance Irrigation Scheduling
SWM	Southwest Monsoon
Turkey’s HSD	Turkey- Kramer method of HSD
UHI	Urban Heat Island
UKMO	United Kingdom Meteorological Office
UNFCCC	United Nation Framework Convention on Climate Change
UNISRD	United Nations International Strategy For Disaster Reduction
WMO	World Meteorological Organization
WTO	World Trade Organization

CHAPTER 1

GENERAL INTRODUCTION

1.1 Background of the study

Climate changes characterised by the increasing temperature, precipitation and extreme events are predicted along with the increase in Green House Gas(GHG) emissions(IPCC, 2007b). This has been one of the issues of primary concern all over the world for the past two decades. The variability and changes of climate condition affects the environment physically, socially, and economically all over the world. In the same vein the dominant influence of climate on agriculture set limits to food production (Fazal & Abdul Wahab, 2013), creating negative consequences on the farmers in terms of their food security and livelihood across the world, especially in the developing countries (FAO, 2008; Fazal & Abdul Wahab, 2013; IPCC, 2007b; Khee, Mee, & Keong, 2011).

The impacts of climate change variability on agricultural crop production has been negative in recent times, through increase in temperatures, rainfall variation and extreme events like flooding, droughts, cyclones and the rise in sea levels(IPCC, 2007b, 2012b; Kotir, 2011). As such, many scientific and policy analysts have doubted whether farmers will have the capacity to adapt as agriculture is becoming more vulnerable to the current climate changes (Mertz, Halsnaes, Olesen, & Rasmussen, 2009; Reid, Smit, Caldwell, & Belliveau, 2007).

Malaysia's tropical climate for the last twenty years has shown uniform characteristics of high temperature, humidity, precipitation, cloud cover and less variation of solar radiation all the year round, but in recent times the climate has witnessed an unprecedented widespread weather variability resulting to an extended dry spell and rising temperature. Hence, many parts of the country experiences reduction in rainfall of about 5% in others up to 26% and rising temperatures ranging from 0.5^0c and 1.7^0c(Tawang, Ahmad, & Abdullah, 2001). These changes in the climate conditions have created serious consequences on agricultural productivity and pattern of land use. Drought condition which is the result of climate changes is normally associated with two forms of stresses; water deficiency and rising temperature. The high temperature condition lead to serious water stress by setting in high rate of water loss through transpiration and there by increases dehydration in plant (Tawang et al., 2001).

Yields of crops and its annual variability and pattern of world agriculture are all weather dependent. Effective crop growth depends on the environmental factors of rainfall, temperature, solar radiation and atmospheric gases particularly carbon dioxide and oxygen. Any change in these factors will certainly affect productivity of crops and land use patterns. Moreover, water deficiency can affect plant growth in a number of ways depending on its intensity, extent and the period at which the stress sets in whether it coincided with the plants biological stage of growth and development. Most plants normally flourishes better in an average annual rainfall higher than 2000mm and also not less than 150mm of average monthly rainfall. There is therefore a linear relationship between rainfall and plant productivity and production is seriously affected when rainfall amount falls below 1000mm, and this condition is more or less the same with most perennial and annual crops including rice which shows high sensitivity at the stages of flowering and fruit development (Tawang et al., 2001). Amount of solar radiation like rainfall and temperature is equally another environmental factor that has significant control over crop productivity as it directly influence plant photosynthetic and other biological mechanisms. Increase in yields of rice like most other crops corresponds with high amount of solar radiation at the crop's stage of reproduction. Besides climate there are non-climatic factors that significantly influence crop yield performance and output with time, these factors includes changes in technology, farm inputs and better farm management practices amongst others (Tawang et al., 2001).

1.2 Paddy Rice Production in Malaysia

Paddy rice is an important crop for Malaysia's food security being the main staple food of majority of the people in the country. It is therefore, based on this consideration that government gave considerable attention to this sector of the economy even before the country attained its independence in 1957 (Fahmi, Abu Samah, & Abdullah, 2013). Starting with the establishment of a Rice Production Commission in 1937, and in 1956 a Federation of Rice Malay Commission was created for the same purpose. In 1965 post- independence, Federal Agricultural Marketing Authority was then formed as an institution responsible for marketing other agricultural commodities including rice, later on in 1971 National Paddy and Rice Board was created to substitute FAMA in rice marketing. To give more support to national paddy rice industry, the board was privatized in 1996 which resulted in changing its name to Padiberas National Berhad (BERNAS). Paddy rice is considered very significant by the government mainly because of two reasons. Firstly as a staple food its per capita consumptions accounted to about 500 to 799 of calorie intake per day and secondly, it has served as the main source of livelihood to majority of small scale farmers whose income largely depend on rice cultivation (Fahmi et al., 2013).

Paddy rice production is mainly carried out in Peninsular Malaysia which accounted for More than 85.5% of the total rice production (Radin Firdaus, Abdul Latiff, & Borkotoky, 2013). The total rice production per annum in Malaysia is about 2.0 million tons, and the production figure has been in the increase since 1980. The total production figure rose from 2,044,604 tons in 1980 to 2,126,000 tons in 1995, but it started to decline in 1997 when production figure fell to 1,970,000 and later began to rise up to 2,235,000 in the year 2000 (DOA, 2014).Since then rice production figure continue to fluctuate along with paddy parcels (see Table1.1).

Table 1.1 : Paddy Statistics in Malaysia (2005-2013)

Item/Year	2005	2006	2007	2008	2009	2010	2011	2012	2013
Parcel Area (Ha)	440,961	429,805	426,224	426260	320931	320931	292500	292500	289882
Planted Area(Ha)	666823	676034	676111	656602	674928	677884	687940	684545	671679
Paddy Production ('000 Tones)	2,314	2,187	2,375	2,384	2511	2465	2579	2599	2604
Rice Production ('000Tones)	1,490	1,407	1,531	1,516	1,620	1,588	1,661	1,209	1,207
Av.Yield (kg/ha.)	3471	3236	3514	3556	3720	3636	3746	3797	3876
Rice Imports ('000 Tones)	5847	8433	7987	6579	1086	930	1031	1006	876

Source: Department of Agriculture (DOA), 2014

Moreover, Malaysia seriously needs sustainability in rice production as a means of ensuring food security and at the same time tackling poverty. The desire of increase in food safety is receiving serious attention nationally and internationally. As such, the National Agro- food Policy (NAP) for Malaysia was designed to substitute the Third National Agricultural Policy (NAP3). It was a policy that aimed at increasing food production in the country in order to match with its expanding demand as well as high cost of development of agriculture. It means expanding the share of rice production in national income and developing entrepreneurship in agriculture (Siwar, Idris, Yasar, & Morshed, 2014). The major thrust of the policy was to enhance production and productivity to guarantee food availability, high value agricultural exploration, enhancement of the supply chain, implementation of sustainability in agricultural operations , development of human capital, private sector participation and efficient support by the government (MOA, 2011).

Climate change scenarios developed by the National Hydraulic Research Institute of Malaysia(NAHRIM (2006), the Malaysian Meteorological Department (MMD (2009)and other recent climate change impact studies (Al-Amin , Filho, Kabir, Azam, & Abdul Hamid, 2011; Al Amin & Filho, 2011; Kwan, Tangang, & Juneng, 2013; Masud, Rahman, Al-Amin, Kari, & Leal Filho, 2014; Radin Firdaus et al., 2013), by and large revealed the vulnerability of paddy rice farming activity. In particular, the smallholder farmers will be more vulnerable to this change due to their low adaptive capacity. One of the ways to manage these challenges arising from the climate change is to examine the vulnerability and how to build their adaptive capacity for the farmers to adapt effectively to the changing situations.

1.3 Problem Statement

There is a general consensus among scientists globally that due to the anthropogenic greenhouse gas emissions along with the changes in the pattern of climatic elements will negatively affects the socio- economic and other aspects of the environment (IPCC, 2007; 2012b). Furthermore, the impact of climate change will seriously affect the developing countries even though these countries have contributed less to its causes (Nicholas, 2007). In view of this, it has been pointed out that the direct consequences of climate change will include loss of life, damages to resources, infrastructure and livelihoods for all places including Malaysia (Al-Amin et al., 2011). Moreover, evidences from modeling of climate and crop revealed the disproportionate impact of climate on agriculture more than all other sectors (Thornton, Jones, Ericksen & Challinor, 2011; Lobell *et al.*, 2008; Ericksen *et al.*, 2011).

Malaysia has encountered dramatic variability in its climatic settings for several years as demonstrated using scenarios developed by NAHRIM (2006). According to this simulation, temperature was forecasted to rise within Malaysia and the adjoining subtropical regions by 0.3 to 4.5°C for the next 50 years to come (NAHRIM, 2006). Also results from the initial simulation developed showed that there will be changes in rainfall by ±30% over Malaysia (NAHRIM, 2006). More so, estimation of the climate changes will cause a decline in the yield of major cereal crops, such as in South Africa maize production with about 30% by the year 2030, while in south East Asia including Malaysia the region was predicted to suffer major grain yield lost including rice and other cereal crops by up to 10% (Lobell et al., 2008).

Similarly, climatic change influence on pest and other factors have contributed to the further agricultural vulnerability by exacerbating declining crop yield, as well as subjecting vulnerable drought areas into marginal land which cannot support cultivation of many crops including oil palm, rubber, rice and cocoa. This situation will create serious food security uncertainties and decline in earnings from export (NRS, 2001; Al-Amin, Azam, Yeasmin, & Kari, 2010). Meanwhile, scientific researches were conducted to estimate the impact of climate change on agriculture within the last couple of years (Tilman, et al., 2002; Ching-Cheng, 2005; Ahmed, Sumalatha & Nik Mohamed, 2010). The outcome indicated the continuous decline in crop productivity. In such a way that, the potential average rice yield differs from around 10 tons per hectare in areas around the tropics to more than 13 tons per hectare in the high latitudes areas, but for Malaysia the actual farm yield varies from 3 tons to 5 tons per hectare (NRS, 2001).

Other climate prediction by MMD (2009) projected changes in the mean temperature (26^0 C)in Malaysia may probably rise and will continue to be warmer towards the end of the century(Al-Amin et al., 2011).Significant number of the previous studies in Malaysia including (Al-Amin, et al. 2011; Kwan, et al. 2013; Masud, et al. 2014; Radin Firdaus, et al., 2013) has consistently indicated that the impact of climate change variability will continue to militate against sufficient increase in paddy productivity. Specifically, the sensitivity of Paddy rice to climatic perturbation has been identified as one of the issues that led not only to decline in paddy productivity, but also reduction in the paddy farmers' income thus exacerbating their socio-economic wellbeing and poverty level (Alam et al., 2012).

These revelations have called for the pressing need for more interdisciplinary research efforts to provide comprehensive understanding into agricultural production along with assessment of the socioeconomic conditions of farming communities. This is required to systematically examine the real effects of climate change and variability on various systems of food production as well as rural livelihoods (Mueller *et al.*, 2012). An integrated approach enables various aspects of climate change and variability to be explored (Antwi- Agyei, 2012). However, to this date, there is little research done on vulnerability studies using integrated framework at the national as well as at local levels, especially in developing countries including Asia (UNFCCC, 2007). Moreover, other studies have also stressed the need to address issues of vulnerability and adaptation to climate changes in the developing countries, due to the fact that these countries highly depend on agriculture with low adaptive capacities (Ompraksah , Rishi, & Mudaliar, 2010).

In the case of Malaysia, no comprehensive vulnerability assessment studies were conducted at micro level using integrated framework in particular to assess the relative vulnerabilities of paddy farmers to enable effective adaptation planning. Many of the previous studies so far dwelt on the physical and economic impacts of climate change using econometric or eco-physiological modelling. There is the urgent need to understand the vulnerability of the paddy sector through multiple stressors approach by analyzing the exposure, sensitivity and adaptive capacity of the paddy farmers. Such a micro –level vulnerability study is desirable to enable policy makers to deal with climate change issues with all the precision that it requires (Klein et al., 2007). Furthermore, for individuals and communities to benefit from the opportunities and reduce the hazards associated with climate change it requires comprehension, good planning and adaptation (Madu, 2012).It is on this basis that this study is aimed at filling this gap through quantitative assessment of the vulnerability of paddy farmers to climate change variability in Peninsular Malaysia.

1.4 The Objectives of the Study

The main objective of this study is to assess vulnerability of the paddy farmers to climate change variability in Peninsular Malaysia. Therefore, to achieve this main objective, the following are the specific objectives;

1.4.1 The Specific Objectives

1) To analyse the variability of temperature and rainfall trends from 1981 to 2014 on the annual, monthly and seasonal timescale in the study area.
2) To assess the potential effects of climate change (temperature and rainfall) on paddy rice yield using DSSAT CERES- rice model in the study areas.
3) To develop an index for assessing the relative vulnerability of the farmers in the study areas.
4) To assess and determine the important factors influencing the relative vulnerability of farmers in the study areas.

1.5 Research Questions

The study will attempt to find answers to the following questions;

1) What are the trends of temperature (minimum & maximum) and rainfall in the study areas from 1981 to 2014?
2) How does temperature and rainfall variation affects rice productivity in the study areas?
3) What are the variables for developing vulnerability index for assessing the effects of climate change variability on farmers in the study areas?
4) What will be the level of, and the important factors influencing the relative vulnerability of farmers in the study areas?

1.6 Significance of the Study (Policy and Research Context)

There is the increase and urgent need among the scientific researcher communities, policy makers and non- governmental organizations to comprehend the role of adaptation in facilitation, supporting, and invariably sustaining those communities affected by the climate change risks (Coulthard, 2008). Perhaps, the raising consciousness of the looming threat posed by changing climate is what necessitates adaptation needs among societies (IPCC, 2007b). This instance is clearly demonstrated through two important changes in the global research and policy forums (Nelson , Kokic, Crimp, Meinke, & Howden, 2010). Firstly, by increasing the discussion looking at the most appropriate way of responding to the threats of climate change, the initial emphasis was on mitigation, and later the recent considerations shifted on adaptation needs (Adger , Arnell, & Tompkins, 2005; Smit & Pilifosova, 2003).

As climate change has become unavoidable (IPCC, 2007b; Smit, Burton, Klein, & Street, 1999), hence the need for adaptation is therefore inevitable (Howden et al., 2007). Moreover, it is evident that with the levels of past emitted GHG, it is enough to influence global temperature changes for the next centuries, even if current emission is to be reduced dramatically (Matthews, Gillett, Stott, & Zickfeld, 2009). Therefore, the high probability of the changing climate as evidenced from biotic systems (Lenoir, Gégout, Marquet, De Ruffray, & Brisse, 2008; Rosenzweig et al., 2008) makes mitigation to no longer be a lone option. Adaptation is indispensable (Schipper, 2006) and has become entrenched in the global climate change debate as an important remedy to the dangers of the current and or future climate changes arising from anthropogenic GHG emissions (Ford, 2007; Schipper, 2006).

Furthermore, with the high level of confidence that global climate will continue to change, the exactitude of the attendant consequences from these changes remain extremely uncertain due largely to the complexity of 'feedback mechanisms' associated with the various components of the climate systems (IPCC, 2007b). This necessitated changes in the old methods of managing risk associated with climate change. Traditionally, the science of climate change lends more credence to analysing and predicting climate change extremes and to model and predict their possible impacts(Keenan, Maria Serra, Lloret, Ninyerola, & Sabate, 2011; Schubert, Suarez, Pegion, Koster, & Bacmeister, 2008). Initially, modelling was employed to analyse the impact of climate change on agriculture to understand the pattern of the regional climate and its likely changes linearly (Parry , Rosenzweig, & Livermore, 2005; Schubert et al., 2008).

In recent times, understanding the climate change impacts on agriculture do not necessarily depend on computer modelling alone. As the scale of management of variability to climate is inherent to agricultural practices, this has provided a premise on the existence of climate change adaptation (Howden et al., 2007). This has been so difficult to realise through computer model, largely due to the conceptualization of adaptation to climatic change and variability as a linear sequence of technically identifying, assessing and predicting source of risks (Nelson et al., 2010; O'Brien, Eriksen, Nygaard, & Schjolden, 2007). A limited understanding of the nature of risks to be assessed and determined can result in maladaptation, and cause accidental effect of underrating more enduring and thorough adaptive capacity (Barnston, Kumar, Goddard, & Hoerling, 2005). Such approach do not consider the essential limit to predicting global climate and always emphasize on the causes of climate variability and change which the policy decision makers could do nothing about (Meinke et al., 2009; Nelson, Kokic, & Meinke, 2007). Many of the previous studies on climate change impacts in Malaysia follow this tradition.

Available record shows that there are nearly 300,000 paddy farmers in Malaysia and 40% of them are full time farmers. Nearly 65% of the total farmers (195,000) are small holders with less than one hectare (DOA, 2008; Man & Ismaila, 2009).Recent climate change variability has been a threat to paddy rice cultivation, challenging the country's food security needs as a whole and to the farmers' livelihood in particular. Assessment of farmers' vulnerability and adaptation to climate change in Malaysia will give an insight into the extent of farmers' exposure, sensitivity and the extent of their adaptive capacity needs.

Such an assessment will create the opportunity of comprehending the farmers' potentials or capability to successfully adapt to the climate variability and change. This will serve as a fulcrum of successful adaptation planning policy (Adger et al., 2007). As effective adaptation to climate change depend on the availability of information to understand "what to adapt to and who to adapt, and the resources to implement the adaptation strategies" (Füssel, 2007). Therefore, this study will help to collect information regarding the extent of paddy farmers' vulnerability to the climate change through the various components or otherwise what Luers (2005) referred to as 'vulnerability layers'. This will help policy makers to effectively target the most vulnerable farmers and the nature and levels of the vulnerability and therefore, make optimum allocation and utilization of resources on climate change adaptation planning. This will help the farmers to prepare for and cope with the inevitable impacts of climate change as well.

Specifically, the result from this study will enhance local understanding of climate change vulnerability, and assist in mainstreaming climate change adaptation into planning and development for sustainable Paddy rice production. Thus, it is hope that the findings from this research will be directly beneficial to Department of Agriculture Malaysia, and other agencies such as Integrated Agricultural Development Authority, Muda Agricultural Development Authority and Kemubu Agricultural Development Authority.

In the context of academic research, the outcome of this study will further our understanding on the contribution of each factors of exposure, sensitivity and adaptive capacity to vulnerability of paddy farmers in Peninsular Malaysia. It is equally hope that this work will contribute to the existing body of literature on the vulnerability assessment of climate change variability using indicator approach and serve as a spring board for future micro- levels research endeavours.

1.7 Scope and Limitation of the Study

In this study, Paddy farmers' vulnerability will be assessed in terms their exposure, sensitivity and adaptive capacity. Vulnerability is viewed as "the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability therefore, is said to be a function of the character, magnitude, and rate of climate variation to which a *system* is exposed, its sensitivity, and its adaptive capacity"(IPCC, 2007b). Even though there are several concepts of vulnerability, this study focuses on framing of vulnerability as proposed by the Inter-Governmental Panel on Climate Change (IPCC, 2007b).

It is within the scope of this work also to survey only sampled paddy farmers within three granary areas consisting of the Integrated Agricultural Development Authority (IADA) Barat Laut Selangor, Muda Agricultural Development Authority (MADA) Kedah and Kemubu Agricultural Development Authority (KADA) Kelantan.

Every research endeavor has its own limitation. Similarly, this study was conducted with the following limitations:

1) The meteorological data used were selected based on availability, accessibility, completeness and proximity to the selected areas under this study. The meteorological data are very expensive. Three of the meteorological stations used in this study were the only one accessible to the researcher meeting up with the stated requirements and were gotten from principal meteorological stations. One of the chosen stations, Subang Jaya was the only principal station out of three stations in Selangor (Petaling, Sepang and Subang Jaya) which is somewhat closer to Barat Laut Selangor study area; and it is the only meteorological station data that is accessible.
2) The DSSAT model needs sufficient data for its calibration, though most of the data are optional. The minimum data set needed for the model which was available was used, but detailed data about soil profile could not be gotten.
3) The extent and scope of data collected were limited to items identified in the questionnaire; and
4) Due to time and financial constraints, this study was only done on three sampled granary areas from west and east coast regions of Peninsular Malaysia.

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