UNIVERSITI PUTRA MALAYSIA

IMPACT OF CLIMATE CHANGE ON PRODUCTION OF SELECTED AGRICULTURAL COMMODITIES IN MALAYSIA

ALI CHIZARI

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By

ALI CHIZARI

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

May 2017

DEDICATION

I dedicate this to my dear mother, father, and my beloved wife Maryam

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

IMPACT OF CLIMATE CHANGE ON PRODUCTION OF SELECTED AGRICULTURAL COMMODITIES IN MALAYSIA

By

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May 2017

Chairman : Professor Zainal Abidin Mohamed, PhD
Faculty : Agriculture

Climate change is arguably one of the most important factors influencing agricultural production in developing countries such as Malaysia. Malaysian population rely mostly on agriculture and other climate-dependent resources. However, inadequate attention has limited the country's capacity towards adapting to climate change, while population increase continues to pose a serious challenge to food security. Therefore, it becomes important to explore the impacts of climate change on agricultural yield and production.

In this study, efforts were made to figure out the impacts of climate change (rainfall and temperature) on 12 strategic agricultural commodities production. Efforts were also intensified towards developing market model for each of the commodities. These commodities were selected based on their contribution to the GDP and their role in food security issues.

This study applied the autoregressive distributed lag (ARDL) co-integration approach over the periods (1980 – 2014). The model provides a convenient framework for analyzing the effects of climate change on agricultural commodities production.

The data analysis was based on the bound testing approach for co-integration. Essentially, the Bounds testing approach employs a Wald or F-test of significance for the lagged levels of the variables which are reformulated in a conditional error correction version of the ARDL model. In the present study, the Bounds procedure followed three steps: the optimal lag length p for the equation was selected to correct simultaneously for endogeneity and serial correlation. Once the lag length is confirmed, the long-run relationship in the equations was tested by estimating the equation over the baseline period of 1980-2014 and finally, the values of the F-statistic corresponding to the null hypotheses were computed.

To commence the forecasting and simulation of all the commodities models, the year 2014 was chosen as the base year. There are two main methods including the Regional Climate Model (RCM) which can reasonably produce appropriate projections that can be used for climate scenario generation in a country-scale. Based on this information, this study considered three scenarios: 1) First Scenario, Temperature changes: Based on the anticipated temperature changes in Malaysia by 2020 which is expected to increase by +1.15°C more than the normal trend. 2) Second Scenario, Rainfall changes: Based on the projected rainfall changes in Malaysia by 2020 which is expected to increase by +6% more than the normal trend. 3) Third Scenario, Scenario 1 and 2 simultaneously.

Preliminary results from the Autoregressive Distributed Lag (ARDL) model applied indicated that despite the projected changes in the climate variables (temperature and rainfall), beef production will increase from 53,840.97 Metric Tonne (MT) in 2014 to 137,169.1 MT in 2020. Besides, the average trend compared to the baseline is positive and expected to increase by +6.06% annually. Finally, the results showed that the overall trend is positive and climate change will also have positive impacts on the industry.

Broiler production will also increase from 1,481,684 MT in 2014 to 2,004,610 MT in 2020. However, the aggregate trend compared to the baseline is negative and expected to drop by -1.068% annually. Finally, the results showed that the overall trend is positive but climate change will have negative impacts on the industry. Similarly, cocoa yield will also increase from 0.154 t/ha to 0.189 t/ha by 2020. The average trend compared to the baseline is positive and expected to increase by +6.06% annually. Finally, the results showed that the overall trend is positive and climate change will also positive impacts on the industry. Furthermore, eggs production will also increase from 10,739.33 mu to 11,369.81 mu by 2020. However, the aggregate trend compared to the baseline is negative and expected to drop by -2.64% annually. Finally, the results showed that the overall trend is positive but after considering climate impacts, it has negative influence on the industry. Based on the projected changes in temperature and rainfall, palm oil yield will increase from 17.51 in 2014 t/ha to 17.81 t/ha in 2020. However, the aggregate trend compared to the baseline is negative and expected to drop by -0.82% annually. Finally, the results showed that the overall trend is positive but after considering climate impact, it has negative effect on this industry. In paddy industry even though the yield will increase from 3,811.32 t/ha to 4,037.40 t/ha by 2020, the total trend compared to the baseline is negative and expected to drop by -0.36% annually. Finally, the results showed that the overall trend is positive but after considering climate impacts, it has negative influence on paddy production. In pepper, the yield will increase from 1.78 t/ha in 2014 to 1.67 t/ha in 2020. The aggregate trend compared to the baseline is positive and expected to develop by 0.68% annually. Finally, the results revealed that the overall trend is negative. However, climate change will have no negative influence on the industry. The pineapple yield will fall from 21.59 t/ha to 16.23 t/ha by 2020. Also, the overall trend compared to the baseline is negative and expected to drop by -5.57% annually. Finally, the results revealed that the overall trend is negative and climate change will also have negative impacts on the industry. In Pork, production will drop from 156,830.4 MT in 2014 to 76,341.35 MT in 2020. Also, the aggregate trend compared to the baseline is negative and expected to drop by -9.40% annually. Finally, the results showed that not only the overall trend is negative but climate change will also have negative impacts on the industry. Furthermore, the rubber yield will increase from 1.57 t/ha to 1.64 t/ha by

2020. However, the aggregate trend compared to the baseline is negative and projected to drop by -0.53% annually. Finally, the results revealed that the overall trend is positive although climate change will have negative impacts on the industry. In tobacco, the yield will increase from 990.26 kg/h in 2014 to 1,054.94 kg/h in 2020. However, the aggregate trend compared to the baseline is negative and projected to drop by -0.42% annually. Finally, the results showed that the overall trend is positive but after considering climate impacts, it has negative influence on the industry.

The general conclusion based on scenario 3 (simultaneous changes in rainfall and temperature) showed that the changing climatic conditions have no negative impacts on beef and cocoa, and more efforts need to be directed towards enhancing the yield in these industries. Also, the negative impacts of climate change on paddy, palm oil, pepper, tobacco and rubber is very minimal. Thus, Production in these sub-sectors can be enhanced by developing models that include other variables such as transportation, the timing of flowering, improved farming practices, and technology. Lastly, changing climatic conditions has a considerable negative impact on broiler, mutton, pork, egg and pineapple as it threatens the production and yield in these industries. Therefore, these sub-sectors require more comprehensive investigations regarding climate change and its effects on yield and productivity. As it has been confirmed, the effects on the livestock sub-sector are much more pronounced than crop sub-sector. Therefore, introducing supporting policies and programs such as improved technology, new resistant-breed, adjustment of the market and the control of diseases can go a long way in enhancing the performance of the livestock sector.

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

KESAN PERUBAHAN CUACA TERHADAP PENGELUARAN KOMODITI PERTANIAN DI MALAYSIA

Oleh

ALI CHIZARI

Mei 2017

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Perubahan iklim boleh dikatakan salah satu faktor yang paling penting yang mempengaruhi pengeluaran pertanian di negara-negara membangun seperti Malaysia. Malaysia penduduk bergantung kebanyakannya kepada pertanian dan sumber iklim yang bergantung kepada yang lain. Walau bagaimanapun, perhatian yang tidak mencukupi telah menghadkan keupayaan negara ke arah menyesuaikan diri dengan perubahan iklim, manakala peningkatan penduduk terus menimbulkan cabaran yang serius kepada keselamatan makanan. Oleh itu, ia menjadi penting untuk meneroka kesan perubahan iklim ke atas hasil pertanian dan pengeluaran.

Dalam kajian ini, usaha telah dibuat untuk memikirkan kesan perubahan iklim (hujan dan suhu) pada 12 strategik pengeluaran komoditi pertanian. Usaha juga dipergiatkan ke arah membangunkan model pasaran bagi setiap komoditi. Komoditi dipilih berdasarkan sumbangan mereka kepada KDNK dan peranan mereka dalam isu-isu keselamatan makanan.

Kajian ini digunakan autoregresif lag diedarkan (ARDL) bersama integrasi pendekatan sepanjang tempoh (1980 - 2014). Model ini menyediakan satu rangka kerja yang mudah untuk menganalisis kesan perubahan iklim ke atas pengeluaran komoditi pertanian.

Analisis data adalah berdasarkan kepada pendekatan ujian terikat untuk bersama integrasi. Pada asasnya, pendekatan ujian Bounds menggaji Wald atau F-Ujian kepentingan untuk tahap yang tertinggal pembolehubah yang dirumus semula dalam versi pembetulan ralat bersyarat model ARDL ini. Dalam kajian ini, prosedur Bounds yang sejajar tiga langkah: optimum panjang lag p untuk persamaan itu dipilih untuk membetulkan secara serentak untuk endogeneity dan korelasi bersiri. Setelah panjang lag itu disahkan, hubungan jangka panjang dalam persamaan diuji dengan menganggarkan

persamaan dalam tempoh yang asas daripada 1980-2014 dan akhirnya, nilai-nilai F-statistik yang sepadan dengan hipotesis nol telah dikira.

Memulakan itu ramalan dan simulasi semua komoditi model, tahun 2014 telah dipilih sebagai tahun asas. Terdapat dua kaedah utama termasuk Model iklim Wilayah (RCM) yang semunasabahnya boleh menghasilkan unjuran sesuai yang boleh digunakan untuk penjanaan senario iklim di negara-besaran. Berdasarkan maklumat ini, kajian ini dianggap tiga senario: 1) Senario Pertama, Suhu perubahan: Berdasarkan perubahan suhu dinanti-nantikan di Malaysia pada tahun 2020 yang dijangka meningkat sebanyak + 1.15 ° C lebih daripada trend biasa. 2) Senario Kedua, perubahan hujan: Berdasarkan perubahan hujan dijangka di Malaysia pada tahun 2020 yang dijangka meningkat sebanyak + 6% lebih daripada trend biasa. 3) Senario Ketiga, Senario 1 dan 2 serentak.

Keputusan awal dari Autoregresif Lag Diedarkan model (ARDL) digunakan menunjukkan bahawa walaupun perubahan yang diunjurkan dalam pembolehubah iklim (suhu dan hujan), pengeluaran daging lembu akan meningkat daripada 53,840.97 metrik tan (MT) pada tahun 2014 untuk 137,169.1 MT pada tahun 2020. Selain itu, trend purata berbanding asas adalah positif dan dijangka meningkat sebanyak + 6.06% setiap tahun. Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif dan perubahan iklim juga akan mempunyai kesan positif ke atas industri.

pengeluaran ayam daging juga akan meningkat daripada 1,481,684 MT pada tahun 2014 untuk 2,004,610 MT pada tahun 2020. Walau bagaimanapun, trend agregat berbanding asas adalah negatif dan dijangka singgah -1.068% setiap tahun. Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif tetapi perubahan iklim akan memberi impak negatif kepada industri. Begitu juga, hasil koko juga akan meningkat daripada 0.154 t/ha kepada 0.189 t/ha pada tahun 2020. Trend purata berbanding asas adalah positif dan dijangka meningkat sebanyak + 6.06% setiap tahun. Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif dan perubahan iklim juga akan memberi kesan positif kepada industri. Tambahan pula, pengeluaran telur juga akan meningkat daripada 10,739.33 mu kepada 11,369.81 mu pada tahun 2020. Walau bagaimanapun, trend agregat berbanding asas adalah negatif dan dijangka singgah -2.64% setiap tahun. Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif tetapi selepas menimbangkan kesan iklim, ia mempunyai pengaruh yang negatif ke atas industri. Berdasarkan kepada kenaikan di diunjurkan dalam suhu dan hujan, hasil minyak sawit akan meningkat daripada 17.51 pada 2014 t/ha kepada 17.81 t/ha pada tahun 2020. Walau bagaimanapun, trend agregat berbanding asas adalah negatif dan dijangka singgah -0.82% setiap tahun . Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif tetapi selepas menimbangkan kesan iklim, ia mempunyai kesan negatif kepada industri ini. Dalam industri padi walaupun hasil akan meningkat daripada 3,811.32 t/ha kepada 4,037.40 t/ha pada tahun 2020, jumlah trend berbanding asas yang negatif dan dijangka singgah -0.36% setiap tahun. Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif tetapi selepas menimbangkan kesan iklim, ia mempunyai pengaruh yang negatif terhadap pengeluaran padi. Dalam lada, hasil akan meningkat daripada 1.78 t/ha pada 2014 -1.67 t/ha pada tahun 2020. Trend agregat berbanding asas adalah positif dan dijangka berkembang dengan 0.68% setiap tahun. Akhirnya, keputusan mendedahkan bahawa trend keseluruhan adalah

negatif. Walau bagaimanapun, perubahan iklim akan mempunyai pengaruh yang negatif ke atas industri. Hasil nanas akan jatuh dari 21.59 t/ha kepada 16.23 t/ha pada tahun 2020. Juga, trend keseluruhan berbanding asas yang negatif dan dijangka singgah -5.57% setiap tahun. Akhirnya, keputusan mendedahkan bahawa trend keseluruhan adalah negatif dan perubahan iklim juga akan memberi impak negatif kepada industri. Dalam daging babi, pengeluaran akan jatuh dari 156,830.4 MT pada tahun 2014 kepada 76,341.35 MT pada tahun 2020. Juga, trend agregat berbanding asas adalah negatif dan dijangka singgah -9.40% setiap tahun. Akhirnya, keputusan menunjukkan bahawa bukan sahaja trend keseluruhan adalah negatif tetapi perubahan iklim juga akan memberi impak negatif kepada industri. Tambahan pula, hasil getah akan meningkat daripada 1.57 t/ha kepada 1.64 t/ha pada tahun 2020. Walau bagaimanapun, trend agregat berbanding asas yang negatif dan dijangka singgah -0.53% setiap tahun. Akhirnya, keputusan mendedahkan bahawa trend keseluruhan adalah positif walaupun perubahan iklim akan memberi impak negatif kepada industri. Dalam tembakau, hasil akan meningkat daripada 990.26 kg/h pada tahun 2014 kepada 1,054.94 kg/h pada tahun 2020. Walau bagaimanapun, trend agregat berbanding asas adalah negatif dan unjuran untuk singgah -0.42% setiap tahun. Akhirnya, keputusan menunjukkan bahawa trend keseluruhan adalah positif tetapi selepas menimbangkan kesan iklim, ia mempunyai pengaruh yang negatif ke atas industri.

Kesimpulan umum berdasarkan senario 3 (perubahan serentak dalam hujan dan suhu) menunjukkan bahawa keadaan cuaca yang berubah-ubah tidak mempunyai kesan negatif ke atas daging lembu dan koko, dan lebih banyak usaha perlu ditumpukan ke arah meningkatkan hasil dalam industri-industri. Juga, kesan negatif perubahan iklim ke atas padi, kelapa sawit, lada, tembakau dan getah adalah sangat minimum. Oleh itu, pengeluaran dalam subsektor ini boleh dipertingkatkan dengan membangunkan model yang termasuk pembolehubah lain seperti pengangkutan, masa berbunga, amalan pertanian yang baik, dan teknologi. Akhir sekali, mengubah keadaan iklim mempunyai kesan negatif yang besar ke atas ayam daging, daging kambing, daging babi, telur dan nanas kerana ia mengancam pengeluaran dan hasil dalam industri-industri. Oleh itu, subsektor ini memerlukan siasatan yang lebih menyeluruh mengenai perubahan iklim dan kesannya terhadap hasil dan produktiviti. Seperti yang telah disahkan, kesan ke atas subsektor ternakan adalah lebih ketara daripada tanaman sub-sektor. Oleh itu, memperkenalkan dasar-dasar dan program-program sokongan seperti teknologi yang lebih baik, baru tahan baka, pelarasan pasaran dan pengawalan penyakit boleh pergi jauh dalam meningkatkan prestasi sektor ternakan.

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I certify that a Thesis Examination Committee has met on 4 May 2017 to conduct the final examination of Ali Chizari on his thesis entitled "Impact of Climate Change on Production of Selected Agricultural Commodities in 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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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ADF	Augmented Dickey Fuller
AFTA	ASEAN Free Trade Area
AIC	Akaike's Information Criteria
AOGCM	Atmosphere-Ocean General Circulation Models
ARDL	Autoregressive Distributed Lag
AYQP	Broiler meat production
AYFE	Poultry feed price
AYRP	Broiler meat retail price
CBYDMY	Cocoa Bean yield in Malaysia
CEM	Climate Economic Model
CLRM	Classical Linear Regression Model
CO_2	Carbon Dioxide
CSDP	Cocoa Smallholder Development Program
DOS	Department of Statistics
DVS	Department of Veterinary Service
EGQP	Egg production
AYFE	Poultry feed price
EGRP	Egg retail price
FFB	Fresh Fruit Bunch
GDP	Gross Domestic Product
GEM	General Equilibrium Model
GHG	greenhouse Gas
GNI	Gross National Income
GNP	Growth National Production
ha	hectare
IKRP	Pork farm price
IPC	International Pepper Community
IPCC	Intergovernmental panel on Climate Change
KZQP	Pig production
KZRP	Pork retail price
KZSL	Pig Slaughtered

LAFP	Pepper farm price (RM/kg)
LAYD	Pepper yield in Malaysia
LKTN	Malaysian Kenaf and Tobacco Board
MCB	Malaysian Cocoa Board
MDGs	Millennium Development Goals
MIDA	Malaysian Investment Development Authority
mm	milliliter
MMD	Multi-Model Data
MOA	Ministry of Agriculture
MPB	Malaysian Pepper Board
MPIB	Malaysian Pineapple Industry Board
MPIC	Ministry of Plantation Industries and Commodities
MPOB	Malaysian Palm Oil Board
MRB	Malaysian Rubber Board
MSAP	Malaysian Society of Animal Production
MT	Metric Tonne
MUQP	Mutton production
MURP	Mutton retail price
N_2O	Nitrous Oxide
NAP	National Agro-food Policy
NASA	National Aeronautics and Space Administration
NEYD	Pineapple yield
NEFP	Pineapple farm price
NFC	National Feedlot Centre
NKEA	National Key Economic Areas
NR	Natural Rubber
OLS	ordinary least squares
PCYDTO	Fresh Fruit Bunch Yield
PCFP	Crude palm oil Farm price
FTP	Fertilizer price
RAIN	Average annual Rainfall
TEMP	Average annual Temperature
Trend	Trend dummy proxy for technology

t	Time period
PDYD	Yield of paddy
FERT	Fertilizer subsidy
PDFP	Paddy farm price
PEQ	Productivity, Efficiency, and Quality
PMP	Positive Mathematical Programming
QP	Total beef production
SL	Total slaughters beef
RP	Retailer price
RCBFP	Cocoa farm price
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RMSE	Root Mean Square Error
RMSPE	Root Mean Square Percentage Error
RNYDMY	Natural Rubber yield
RNXP	Natural Rubber FOB Price
PCFP	Crude Palm Oil Farm Price
RRIM	Rubber Research Institute of Malaysia
SBC	Schwarz-Bayesian criterion
SSL	Self Sufficiency Level
t/ha	Tonne/hectare
TBYD	Tobacco yield of cured leaves
TOT	Transfer of Technology
UNEP	United Nations Environment Program
UNFCCC	United Nation Framework Convention on Climate Change

CHAPTER 1

INTRODUCTION

Climate is defined as long-term averages and differences in weather measured over a period of several decades. The Earth's climate system includes the surface of the land, the atmosphere, oceans and ice. Many aspects of the global climate are changing quickly, and the primary drivers of this change are human in origin. Scientists and engineers from around the world have collected evidence of climate change using satellites, weather balloons, thermometers at surface stations, and many other types of observing systems that monitor the Earth's weather and climate.

1.1 Overview of Global Climate Change

Climate is defined as long-term averages and differences in weather measured over a period of several decades. The Earth's climate system includes the surface of the land, the atmosphere, oceans and ice. Several aspects of the global climate are changing rapidly, and the primary drivers of this change are human in origin. Scientists and engineers from around the world have collected evidence of climate change using satellites, weather balloons, thermometers at surface stations, and many other types of observing systems that monitor the Earth's weather and climate. Changes in the climate system are abundantly evident, from the outer edges of the atmosphere to the depths of the oceans (Figure 1.1) (Kennedy et al., 2010).

Figure 1.1 : Major climate change indicators
(Source: Kennedy et al., 2010)

The white arrows indicate increasing trends, and the black arrows indicate decreasing trends. The indicators in Figure 1.1 and others measured globally over many decades indicate unambiguously that the Earth's climate is changing and is consistent with global warming (Kennedy et al., 2010). Temperatures at the surface, in the troposphere (the

active weather layer extending up to about 5 to 10 miles above the ground), and in the oceans have all increased over recent decades (Figure. 1.2) (Karl et al., 2009).

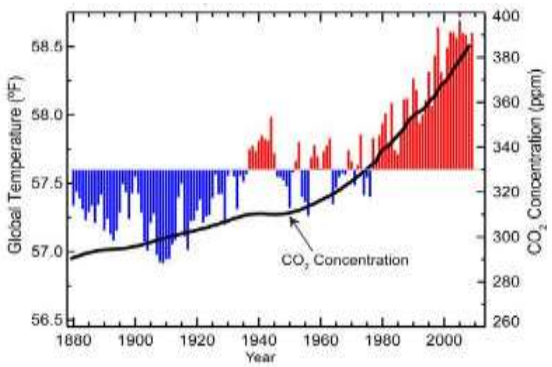

Figure 1.2: Global temperature and atmospheric carbon dioxide
(Source: Karl et al., 2009)

Red bars indicate temperatures above the long-term average, and blue bars show temperatures below the long-term average. The black line indicates atmospheric carbon dioxide (CO_2) concentration in parts per million (ppm). Worldwide yearly normal temperature (as measured over both land and seas) expanded more than 1.5˚F (0.8˚C) from 1880 to 2012. While there is an unmistakable long haul drift towards a worldwide temperature alteration, some years don't demonstrate a temperature increment in respect to the earlier years while some years indicate more prominent changes than others. These year-to-year changes in temperature are due to normal procedures such as the impacts of El Ninos, La Ninas, and volcanic ejections (Karl et al., 2009). Consistent with our logical comprehension, the biggest increments in temperature are occurring nearer to the posts, particularly the Arctic. Snow and ice covers have diminished in many zones. Barometrical water vapor is expanding in the lower air as a hotter climate can hold more water. Likewise, ocean level is also expanding. Changes in other atmosphere applicable pointers, for example, the lengths of developing seasons have been seen in numerous ranges.

Worldwide, changes in average condition have been observed as increasing extremes in high temperatures and precipitation and decreasing extremes in cold temperatures (Philpott, 2015). Natural drivers of climate change cannot explain the observed warming trend. Over the last five decades, natural warming factors such as radiative forcing and volcanoes would alone have led to a slight cooling (Figure 1.3) (Gillett et al., 2012). The extent of warming observed at the global scale over the past 50 years can only be explained by human influences (Santer et al., 2013; Stott et al., 2010). The emission of gasses, such as carbon dioxide (CO_2), methane and nitrous oxide, and particles such as black carbon (soot), trap heat and, hence, exert warming influences. In contrast, sulfates exert an overall cooling influence (Wigley, 2013). Other human factors, such as crop irrigation, and natural variability also contribute to climate change (Ashley et al. 2012; Lo and Famiglietti, 2013). The most important human factors influencing the climate have been identified as the emissions from burning fossil fuels (coal, oil, and natural gas) as well as deforestation.

Multiple lines of independent evidence indicate that human influences are the primary drivers of recent climate change. The first line of evidence is the response of the climate to heat-trapping gasses. The second line of evidence is the reconstruction of past climates using dendrochronology and changes in ice cores and coral. Both lines of evidence indicate that the global surface temperatures have been unusually high during the last several decades. The last decade (2000–2009) has been the warmest in 1300 years and perhaps much longer (Nature Geoscience, 2013).

Climate models developed to simulate climate changes over the past century allow the effects of human and natural factors to be separated. When the human factors are removed, the models showed that solar and volcanic activity alone would have cooled the Earth slightly, and other natural variations were too small to explain the observed warming. The models reproduce the warming observed over the past 50 years only when human influences are included (Figure 1.3) (Huber and Knutti, 2012). These simulations strongly suggest that climate change since 1950 cannot be explained by natural factors or variability, but rather by human factors.

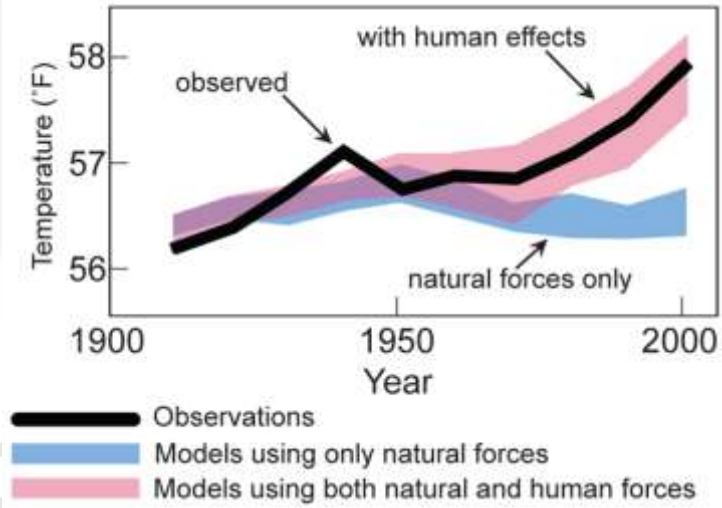

Figure 1.3 : Separating Human and Natural Influences on Climate
(Source: Huber and Knutti, 2012)

Observed global temperatures are indicated with a black line. Simulation using natural and human factors (solar and volcanic) is indicated with a pink line while the blue line represents simulation using only natural factors. Simulations have also been used to predict future changes in temperature and precipitation (Figures 1.4 and 1.5) based on different levels of heat-trapping gasses.

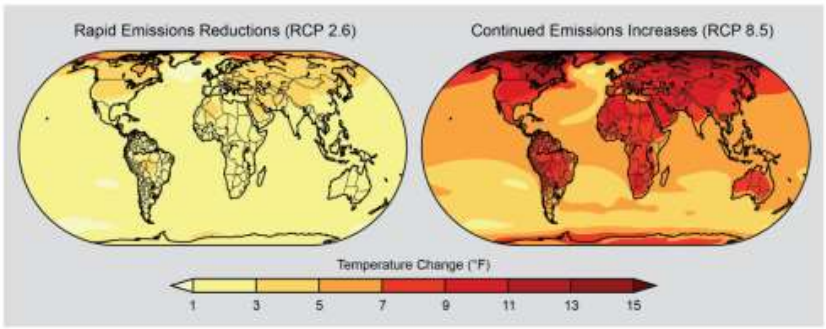

Figure 1.4 : Projected Change in Average Annual Temperatures
(Source: NOAA NCDC/CICS-NC, 2010)

Anticipated temperatures for the years 2071–2099 (in view of genuine temperatures for the years 1970–1999) were ascertained accepting a fast diminishing in discharges and, in this manner, centralizations of warmth-trapping gasses (RCP 2.6) and consistent increment in emanations (RCP 8.5).

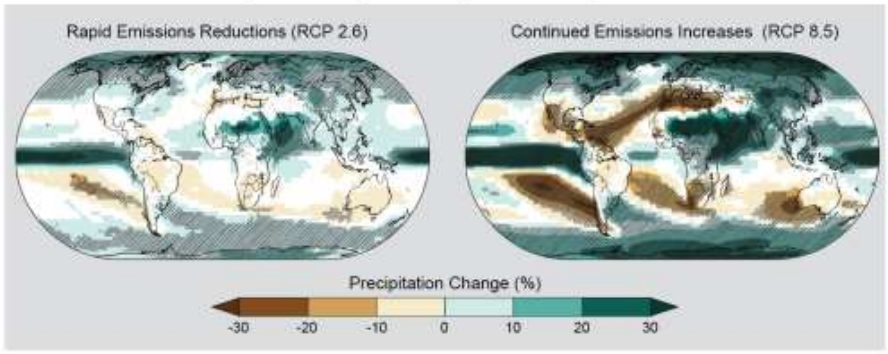

Figure 1.5 : Projected Change in Average Annual Precipitation
(Source: NOAA NCDC/CICS-NC, 2010)

Previewed net yearly precipitation for the years 2071-2099 (in light of genuine temperature ranges for the years 1970-1999) were ascertained accepting a moment diminish in depletes and, therefore, centralizations of warmth catching gasses (Representative Concentration Pathways, RCP 2.6) and persistent increment in discharges (RCP just about 8.5). Brought forth regions recommend certainty that the assessed changes are critical and normal among models. White shaded regions demonstrate that the progressions are not previewed to be bigger than could be foreseen from regular changeability. By and large, north parts of the Circumstance (particularly the Northeast and Alaska) were assessed to get more foresight, while the southern parts (particularly the Southwest) were evaluated to acquire less.

The climate change summit held in Paris from 30 November to 12 December 2015 consisted of 196 representatives with the aim of negotiating a global agreement on the reduction of climate change. With regards to the developing countries, the advanced industrial countries of the world were recognized to be crucial to the growth of developing economies through financial assistance and provision of necessary technology.

1.2 Climate Change in Malaysia

Malaysia is separated into two topographical locales: Peninsular Malaysia and East Malaysia. Peninsular Malaysia lies south of Thailand, north of Singapore and east of the Indonesian island of Sumatra. East Malaysia is situated on the island of Borneo and shares outskirts with Brunei and Indonesia. There are 11 states and two Federal Territories in Peninsular Malaysia, and two states, Sabah and Sarawak, in East Malaysia. The aggregate land zone of the nation is roughly 329,847 km^2 with the Peninsular Malaysia and East Malaysia contributing 132,090 km2 (39.7%) and 198,847 km2 (60.3%) respectively. It is the only nation with territory on both the Asian mainland and the Malay Archipelago (Rashid, Hamzah, and Joseph, 2013).

Malaysia is honored with tropical climate because of its closeness to the equator: the nation lies between scopes 0˚ 60' N to 6˚ 40' N and from longitudes 99˚ 35' E to 119˚ 25' E. Malaysia is a moist colorful nation and its atmosphere is viewed as sea rainstorm winds that happen to be liable to impedance by mountains in Peninsula Malaysia, Borneo, and Sumatra (Department of Statistics Malaysia, 2015).

The normal twelve-month to month precipitation is around 2,420 mm/yr in the promontory, 2,630 mm/yr in Sabah and 3850 mm/yr in Sarawak. Precipitation over these substantial zones is not uniform: the gross yearly water is more than 4,000 mm/yr in colossal mountain ranges of Sarawak in addition to more than 3,000 mm/yr in the northern 55% of Peninsular Malaysia and the waterfront territories of Sabah and Sarawak. The month to month mean air temperature is 25°C to 28°C in the beach front swamps and month to month relative stickiness is 75-90% (Climate Weather, 2015).

It is expected that significant climate change will affect the agricultural sector in terms of production as well as impact the socioeconomic condition of agricultural workers and the nation as a whole (Department of Statistics Malaysia, 2014). Agriculture in Malaysia contributed 7.1% to the gross domestic product (GDP) in 2013 and 9.2% in 2014 and in 2015 contributed 8.9% to the GDP.

Financial growth is essential for improving the standard of living in Malaysia. Be that as it may, constrained common assets must be utilized effectively to evade hopeless harm that could affect Malaysia's development. Green Growth takes a gander at efficient development from the three mainstays of natural developmental initiative- financial matters, interpersonal equity and ecological wellbeing and security to better set up the country so as to prevent future issues. In Eleventh Malaysia plan initially, Malaysia arranged and established a voluntary target for reducing greenhouse gas (GHG)

emissions to 40% by 2020 from the level recorded in June 2006 and then, to keep at least 17% of terrestrial and inland water areas, as well as 10% of coastal and marine areas as protected areas in line with the Aichi Biodiversity Targets. The power sector, a major contributor to the national GHG exhausts, has undertaken steps to raise and improve the use of clean and environmentally friendly resources. For example, through the implementation of 194 overflow mitigation projects, practically a million individuals have recently been shielded from the harmful and damaging impact of floods. In addition, 23, 264 hectares of forested areas have been declared as Long term Reserved Forest under the Central Forest Spine motivation in assisting and helping to sustain Malaysia's natural endowments (11th MP plan, 2016-2020).

The physical and financial effects of environmental change are of increasing concern in Malaysia as the country intends to become a high-income nation by 2020. To ensure environmental sustainability alongside economic development, a Cabinet Committee on Climate Change was set up in 2008 and a National Climate Change Policy was declared in 2009. However, challenges keep on plaguing the coordination, execution, monitoring and the assessment process (The Economic Planning Unit Prime Minister's Department, 2016).

The main objectives of the National Policy on Climate Change include mainstreaming climate change through the wise management of resources and enhanced environmental conservation. The policy also aims to strengthen institutional and implementation capacity to better harmonise opportunities to reduce negative impacts on climate change. The policy is based on the principles of sustainable development, coordinated implementation, effective participation and common but differentiated responsibilities. It is included 5 principles:

P1: Development on a Sustainable Path: Integrate climate change responses in national development plans to fulfil the country's aspiration for sustainable development.

P2: Sustainability of Environment and Natural Resources: Initiate actions on climate change issues that contribute to environmental conservation and sustainable use of natural resources.

P3: Integrated Planning and Implementation: Integrate climate change considerations into development planning and implementation.

P4: Effective Participation: Improve participation of stakeholders and major groups for effective implementation of climate change responses.

P5: Common but Differentiated Responsibility: International involvement on climate change will be based on the principle of common but differentiated responsibilities and respective capabilities.

The country experienced its worst floods in 2014. They were blamed on deforestation and climate change, which has also been termed the reason behind rising sea levels that

are eroding the coast. The annual haze has been blamed on forest fires, causing breathing problems that affect millions of people across the region. In response, the state government last January banned all plastic takeaway food packaging and carrier bags. The state's initiatives do not stop there. It is adding more electric buses to its fleet and there are free charging stations for private electric car owners. The government has allocated $285m for green projects in Melaka over the next five years. Nationwide, it plans to spend $700m annually until 2017.

1.3 Agricultural Industry in Malaysia

Despite the diminishing contribution of the farming sector to the GDP in Malaysia, it still a plays a major role in the development of the nation as it provides food, employment, export income, and raw material for agro-based industries. The largest contributors to the GDP in the farming sector are palm oil, rubber, sawn timber, and fisheries.

In 2015, agriculture contributed only 8.9% to the Malaysia GDP, an increase to its contribution in 2011 (7.7%). However, Malaysia GDP witnessed 1% growth in the first quarter of 2016 compared to the previous quarter. The GDP Annual Growth Rate averaged 4.75% for the period (2000 to 2016), reaching an all-time high of 10.30% in the first quarter of 2010 and a record low of -6.20% in the first quarter of 2009. In 2014, Malaysia's economy improved by 6.0% as compared to 4.7% in 2013 with the agricultural sector contributing 9.2% to the GDP. In the long-term, the Malaysia GDP Growth Rate is projected to be approximately 1.50% in 2020.

In 1970, the agriculture sector accounted for 55.7% of employment. By 2012, this contribution dropped to 12.6%, and the number of employed people in the agriculture sector decreased by 1.3% from 2013 to 2014. The share of agricultural export earnings also declined from 55.0% in 1970 to 14.7% in 2012 and declined further to 14.3% in 2014 (Department of Statistics Malaysia, 2016).

The agriculture sector in Malaysia has not progressed parallel with the non-agricultural sectors in many ways: the added value, production, and return to investments are incredibly high in the other sectors. Furthermore, the roles of agriculture have grown to be more multifunctional as the matrix of development includes the need to ensure sustainability, the reduction of global warming and the preservation of the rural community (Arshad et al. 2012). The achievement of socioeconomic goals, such as low-income reduction has progressed, however, income disparities between small farmers and commercial farmers with improved facilities persist and has recently been increasing. In addition, technological progress has recently been very sluggish, food importation bills are on the rise, labor shortage is a serious issue and resource constraints are limiting further growth.

The agriculture sector is evaluated to continue developing by 2.4% every year, bolstered by modernization in agro-nourishment and improving expertise. The farming area is also assessed to increase by 3.5% every year. Emphasis will be placed on improving

efficiency through the modernization of the sector, fortified by more noteworthy advancement and innovative work. Target will be given to the agro-food subsector to ensure that the desired level of self-sufficiency for staple items (rice at 100%, crisp vegetables at 95.1%, and hamburger at 50%) are met by 2020. The palm oil sub-division is expected to grow by 8% with an increasing number of developed ranches, especially in Sabah and Sarawak. The rubber sub-division is likewise assessed to develop by 7.6% due to the average value recuperation. Horticultural crops production is also expected to increase by 2.3% (11th Malaysia Plan, 2016-2020).

The improvement in the horticulture sub-division is supported by the State Agro-food Policy (2011-2020) and the National Commodity Coverage (2011-2020), with the aim of enhancing food production and fares of expert merchandise. In the Eleven Malaysia plan higher self-sufficiency level is expected from a couple of nourishment products such as poultry 103.7%, fruits 101.6%, vegetables 65.1%, beef 50%, mutton 24.6%, pork 83%, egg 130%, milk 13.6%, fish 95.8% and rice (100%) in 2020 (11th Malaysia Plan, 2016-2020).

1.4 Climate Change Effects on Agricultural Productions in Malaysia

Environmental change is presently viewed as a major worldwide ecological risk. Researchers foresee that the increasing climate change will escalate atmospheric fluctuation, activate extreme weather conditions and other potentially related fiascos. The consequence of adverse climate change could be calamitous to human, material, and physical assets (UNEP, 2011). Rural exercises are likely to be most affected by environmental change (IPCC, 2001). For instance, changes in warmth and precipitation could essentially influence the rural yields (Murad et al., 2010). Vaghefi et al. (2011) reported that a 2°C increase in temperature diminishes Malaysian rice yield by 0.36 ton for every section of land, which relates to a budgetary loss of roughly RM162.531 million every year under such environmental situation. Any unfavorable atmosphere will certainly affect rural development (Murad et al., 2010). Based on this, climate change is a critical issue that needs to be taken into consideration to ensure optimum yields. Different measures of product development are available for adjusting to environmental change and minimizing its effect in cases of eccentric terrible climate (Adger et al., 2007).

It is essential to note the pattern of atmospheric fluctuation so as to able to comprehend and distinguish the impact of environmental change. For instance, a change in the climatic condition can be determined by examining the day to day temperature and precipitation for certain period of the year (Al-Amin et al., 2011).

The Malaysian rural segment can be viewed as both contributor to climate change and victim to its effects. In 2011, CO_2 outflows from Malaysia were 225 million tons, positioning Malaysia twenty-eighth on the planet (World Bank, 2014). Carbon dioxide outflows increased fourfold in Malaysia somewhere around 1980 and 2014 (from 2.02 to 8.60 MT). The horticulture segment contributes 4.8% to the general CO_2 discharges in Malaysia.

In respect to the effect of climate change, Malaysia could experience the ill effects of temperature rise from 0.7°C to 2.6°C and precipitation changes decreasing from 30% to -30%. Ocean level is anticipated to rise between 15–95 cm in the next hundred years (Kwan Kok Foo, 2011). As indicated by Shamsudin et al., and A. Ahmad Makmom, (2009), the immediate effects of environmental change on farming include the following:

I. Reduction in agricultural productivity
II. Reduction in food security
III. Changes in the supply chain caused by the rise in sea level

Table 1.1 shows the general effects of the climate change on agricultural commodities in Malaysia:

Table 1.1: Summary of the climate change effects in Malaysia

Productions	Climate Factors	Cause	Effects
Crops [1]	Changes in Rainfall-Temperature	Yield	Negative
Rubber, palm oil, cocoa, rice [2,3]	Drought	Cultivation	Threat to national food security and exports earnings
Crops [1]	Rising in the air and water temperatures	Plant efficiency	Reduce
Crops [1,2]	Changes in precipitation, cloud cover, Co_2	Yield	Negative
Rubber[3]	Increase temperature and changes rainfall	Fungus and disease and Yield	Drop
Paddy and vegetables	Decrease rainfall	Wet condition of soil and production	Reduce
Rice[1,3]	Increase temperature	Yield	Decline
Crops[1]	Prolonged rainfall	Sunshine hours and yield	Drop
Paddy and Coconut [2,3]	Rising sea level	Abandoning of low-lying planted area	Decrease

(Source: Al-Amin[1], 2011; Chamhuri et al[2]., 2009; Sahibin[3], 2014)

1.5 Problem Statement

Rapid population growth is expected to continue in the developing countries with Asia as a whole growing at over 2%. In Malaysia, the population is projected to increase from 28 million in 2014 to above 33 million by 2020. Such population prospects and dynamics

besides being major determinants of the future national economic environment, both the supply and demand for agricultural commodities will also be affected.

South East Asia is a noteworthy agrarian region due to its position in the production of major crops such as rice, maize, cassava, coconut, palm oil and elastic. It is an important producer of grains items, for instance, the largest producer of palm oil and common elastic. The Millennium Development Goals (MDGs) were launched in 2000 to facilitate global progress on poverty and hunger eradication, education, health, gender equality, environment sustainability and partnership. Malaysia has successfully achieved one of the MDGs regarding the eradication of extreme poverty and hunger. In fact, Malaysia launched its first poverty eradication strategy in 1971, thirty years before the introduction of the MDGs. In the first 15 years, the country eradicated about half of the absolute poverty incidence. In the following 15 years, the poverty rate was brought down to 8.5% at the beginning of the new millennium. In 2014, the poverty rate stood at 0.6% and fortunately in 2016 it has improved and declined to 0.28% (World Bank, 2017).

However, more efforts are still needed towards improving the productivity and income of farmers and smallholders, promoting training and youth agro-entrepreneur development, strengthening institutional support and extension services, building capacity for agricultural cooperatives and associations along the supply chain, improving market access and logistics support, enhancing access to agricultural financing and Intensifying performance-based incentive.

In the Eleventh Plan (2016-2020), the farming sector is expected to develop at 3.5% yearly while contributing about 7.8% to the GDP by 2020. Industrial commodities and agro-sustenance are expected to contribute 57% and 42.4% respectively to the aggregate value of the share agricultural GDP by 2020. Efforts will be centered on improving food security, enhancing efficiency, increasing the ranchers and smallholders output, improving backing and conveyance administrations, reinforcing the production network and guaranteeing consistency in the universal market necessities. These improvements will take into consideration the effect of environmental change on the respective farming practices. In the past two decades, the advancement in horticulture has been on the decline. The share of agribusiness in the total national output (GDP) has also declined, this is essentially due to low efficiency, thereby leading to moderate development. The low efficiency is also connected to other elements listed below:

I. Decreasing investments and engagement in agriculture
II. Low level of production and contribution from small farm systems
III. Marginalization of small farmers and food production capacity

According to the impact of climate change on food production, a decline of between 9% and 21% in overall potential agricultural productivity will be experienced in the developing countries as a result of global warming. That is, climate change is now becoming increasingly important and requires urgent attention.

Climate change is one of the main threats to agricultural sustainability and development. Due to the impact of climate change on productivity and yield, it becomes necessary to determine how it has influenced agricultural commodities and the ways to prevent future occurrences through proper planning. Investigating these effects on each commodities and determining their influences will provide support to the Malaysia plans aimed towards achieving national goals such as eradication of poverty, improving food security, mitigating farmers condition through improving their livelihood and business, Increasing security of investment to avoid capital flight, ensuring accurate planning and setting appropriate policy to support and develop the agriculture sector.

A comprehensive look at the Malaysia agricultural sector shows that the sector has the ability to improve in the production of commodities such as rubber, palm oil, cocoa, pineapple, and pepper. Considering the effect of climate change in the production decision is necessary for optimum productivity and yield. Finally, the effect of climate change on agricultural productivity is genuine and huge while the lack of proper attention can render it more disastrous. Therefore, conducting a comprehensive study on the impact of climate change on agricultural commodities becomes crucial as it will reveal liable vulnerabilities and also suggest how farming activities can be effectively adapted to the current and projected climate changes to ensure optimum yield and productivity.

1.6 Objectives

The general objective of the study is to estimate the impacts of climate change on the production agricultural commodities.

The specific objectives are:

a) To develop agricultural commodities market model;
b) To investigate the relationship between climate change and agricultural commodities production;
c) To estimate, and forecast the level of production based on climate changes;
d) To simulate the level of production based on climate changes over selected period (until 2020); and
e) To suggest policy alternatives that will be effective in mitigating the impact of climate changes on the production agricultural commodities.

1.7 Significant of Study

Initially it can project and simulate the consequences of climate change on agricultural production. Furthermore, this study aim to mitigate and protect farmers against changes in climate based on comprehensive understanding of it impacts and finally, can suggest policy alternatives that will ensure adequate support to the national production.

1.8 Organization of the Study

The study is arranged into five chapters, which are structured as follows:

Chapter 1 introduces the effect of the climate change in the world and Malaysia and in chapter 2 displays outlines the current state of the Malaysia agricultural sector. Chapter 3 presents a critical analysis of the previous research in the area of prediction models. It also discusses previous studies and the methods employed. Chapter 4 presents the methodology used in the study. It investigates selected models based on the conceptual framework representing the climate change variables. Chapter 5 present and interpret the results. Chapter 6 summarizes the result of the study. Finally, the limitations of the study and recommendations for future research were presented.

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