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IMPACT OF RAINFALL, AGRICULTURE LAND AND CARBON DIOXIDE EMISSIONS ON PRIMARY AGRICULTURE SECTOR: SELECTED ASEAN COUNTRIES

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Statement of Originality

The work described in this Final Year Project, entitled
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is to the best of author's knowledge that of the author except where due to reference is made.

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ABSTRACT

IMPACT OF RAINFALL, AGRICULTURE LAND AND CARBON DIOXIDE EMISSIONS TOWARD PRIMARY AGRICULTURE SECTOR IN SELECTED ASEAN COUNTRIES

By

Gooi Siew Foung

Agriculture development is critically important in improving the food security and nutrition of population in the world. Primary agriculture sector plays a crucial and important role in the economic growth especially the developing countries and providing the main source of food and salary to the residents. However, the crop yields nowadays have slowly declining from year to year and become a global issue. It is because of several existential threats such as climate change, rising energy costs, insufficient agriculture land use, aging workforce, low level of land ownership and the other reasons. Hence, this research study is conducted to examine the impact of rainfall, agriculture land and carbon dioxide emissions on primary agriculture sector in five selected ASEAN countries which are Malaysia, Indonesia, Philippines, Thailand and Vietnam. The study used time series data from 1980 until 2014 annually. There are a few methodologies applied in the study such as unit root test, JJ cointegration test, vector error correction model test, variance decomposition, impulse response function and diagnostic tests. All of the variables are tested using E-views 10 software. Different results and analyses have done based on the countries. Based on the findings, some policy implementations and recommendations are discussed in order to improve the primary agriculture sector by raising up the crop productions.

ABSTRAK

KESAN HUJAN, TANAH PERTANIAN DAN KARBON DIOKSIDA TERHADAP SEKTOR PERTANIAN PRIMER DI NEGARA ASEAN TERPILIH

OLEH

Gooi Siew Foung

Pembangunan pertanian amat penting dalam meningkatkan keselamatan makanan dan pemakanan penduduk di seluruh dunia. Sektor pertanian primer memainkan peranan penting dalam pertumbuhan ekonomi terutamanya negara-negara yang sedang membangun dan juga menyediakan sumber makanan dan gaji utama kepada penduduk. Namun, hasil tanaman pada masa ini semakin menurun dari semasa ke semasa dan telah menjadi isu global. Hal ini demikian disebabkan oleh beberapa ancaman seperti perubahan iklim, penggunaan tanah pertanian yang tidak mencukupi, tahap pemilikan tanah yang rendah dan lain-lain lagi. Oleh itu, kajian penyelidikan ini dilakukan untuk mengkaji kesan hujan, tanah pertanian dan pelepasan karbon dioksida pada sektor pertanian primer di lima negara ASEAN terpilih iaitu Malaysia, Indonesia, Filipina, Thailand dan Vietnam. Kajian ini menggunakan data tahunan dari 1980 hingga 2014. Terdapat beberapa metodologi yang digunakan dalam kajian dengan menggunakan aplikasi E-views 10. Hasil dan analisis yang berbeza dilakukan berdasarkan negara masing-masing. Berdasarkan penemuan tersebut, beberapa implementasi dan saranan kebijakan dibincangkan untuk meningkatkan sektor pertanian primer dengan meningkatkan produksi tanaman.

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CHAPTER ONE

INTRODUCTION

1.0 Introduction

In the nutshell, primary agriculture sector is highly vital throughout ASEAN economies consisting of Malaysia, Indonesia, Philippines, Thailand and Vietnam for a significant share of gross domestic product and the population's livelihoods since it creates the employment opportunities for the residents with over 60% and consequently lead to poverty reduction (Teng and McConville, 2016). Agriculture sector is very important to drive a social inclusive growth as exporter income to prevent the shortage of food supply. According to Association of Southeast Asian Nations (2019), ASEAN countries considers as one of the most productive agricultural producer and exporter around the world.

For instance, the region recorded the total of agriculture productions in 2012 including rice yield (129 million tons), sugarcane yield (171 million tons), soybean yield (1.44 million tons) and cassava yield nearly 70.34 million tons. In the other words, primary agriculture sector also has an essential character in the socioeconomic status of ASEAN nations because most of the production or yield originates from an agricultural society. Historically, the agriculture is dominated by the public sector, but it becomes evident in promoting the production and productivity after "Green Revolution" era due to the modern and advance technology.

Despite the contribution of agriculture in selected ASEAN economies like Malaysia, Indonesia, Philippines, Thailand and Vietnam are declining from year to year, but it still remains as the primary source of employment for the rural residents and offers a lot of added value to the food production and supply industry. One of the reason is because the Mother of Earth faces a lot of environmental concerns globally nowadays like climate change, waste disposal, global warming, ozone layer depletion and miscellaneous impacts influencing the human, flora and fauna in the Earth due to the anthropogenic activities such as deforestation, human reproduction, overconsumption of goods, pollutions including air and water and also overexploitation of natural resources.

The top environmental issue and biggest challenge for the declining gross domestic product in agriculture sector is climate change. It refers to the changing in climate variables within period of year in the particular countries. Approximately 97% of scientists have studied the climate change and pointed out that the harmful or excessive quantities of gasses overloading atmosphere with carbon naturally or human activities (Nichols, 2019). One of the harmful gas is greenhouse gasses from those emitted by the population which have been reached a dangerous tipping point and lead to irreversible changes and negative externalities to ecosystem, agriculture, marine, natural disasters and planetary climate system.

It can be seen that the global temperatures keep rising up, ice sheets are melting per decade, ocean acidification, declining arctic sea ice, droughts, wildfires and super hurricanes are raging across the landscape. Not only rising in the temperature of Earth, but also the sea levels are rising, both of the ocean and planet become warmer, the severity of extreme weather events is increasing, air quality diminishes and the unstable natural systems (Luber and Natasha, 2009). Even though the truth is obvious and every people can see, but those who are irresponsible and refuse to take any action will only make the climate crisis worse.

Besides, as the world becomes warmer recently, that unusual warming has provoked many other changes in the Earth's climate through extreme weather and climate events such as extreme precipitation, hurricanes, tornadoes, wildfires, heat waves and droughts which are unexpected, unpredictable and unseasonal weather due to human activities. The higher temperatures will make the evaporation rates rising up. Although the precipitation in certain area does not declining, but the rising in surface evaporation and water loss through plant leaves will lead to dry soil.

Consequently, the agriculture output and food supply will be threatened if the frequency of storms, droughts and floods, changing in hydrological cycles and precipitation raise up especially those countries emphasizes on the primary agriculture as export income. Even though the overall food chain and production might not be affected as terrible, but the countries with less capable may suffer more adverse effects. Hence, this paper aims to identify the consequence of temperature, rainfall and carbon dioxide emissions on the primary agriculture sector in selected ASEAN countries such as Malaysia, Indonesia, Philippines, Thailand and Vietnam.

1.1 Background of Study

1.1.1 Malaysia

Primary agriculture sector is an important key to the Malaysian economy since it occupies approximately 12% of gross domestic product and opens the chances for the employment with our 16% of labor force (Nations Encyclopedia, 2019). It is also one of the ASEAN country and Southeast Asia which has a stable 32.7 million. Malaysian economy is based on the main driven such as over half percentage of services (55.5%), manufacturing industry as 23% and only 7.8% in agriculture sector. Even though Malaysia strict at the requirement of Halal for specific goods and products in the marketplace, but the government always open for the imported food and beverage products due to lax rules of international trade and regulatory policy. Malaysia has recorded around 18.5 billion US dollar of total import of agriculture food and beverage in 2018 (Malaysia Country Commercial Guide, 2019).

Malaysia has ranked as the third good indicator in economic development in Ninth Malaysia Plan from 2006 to 2010 which has the ability to cushion effectively Asian financial crisis in the year of 1997 and 1998 (Jamal and Yaghoob, 2014). The major agriculture productions in Malaysia such as rice, palm oil, rubber and cocoa via private and public sector to dominate the export of primary yields. For example, the largest and well-known rice production and cultivation is available in Kedah and Perlis as rice granaries covering around 82,968 hectares of land and 17,717 hectares of land respectively (MADA, 2017). Besides, Malaysia also produces the other agriculture production including tropical fresh fruits like durians, mangosteen and coconut, organic or non-organic vegetables, horticulture and miscellaneous of yields.

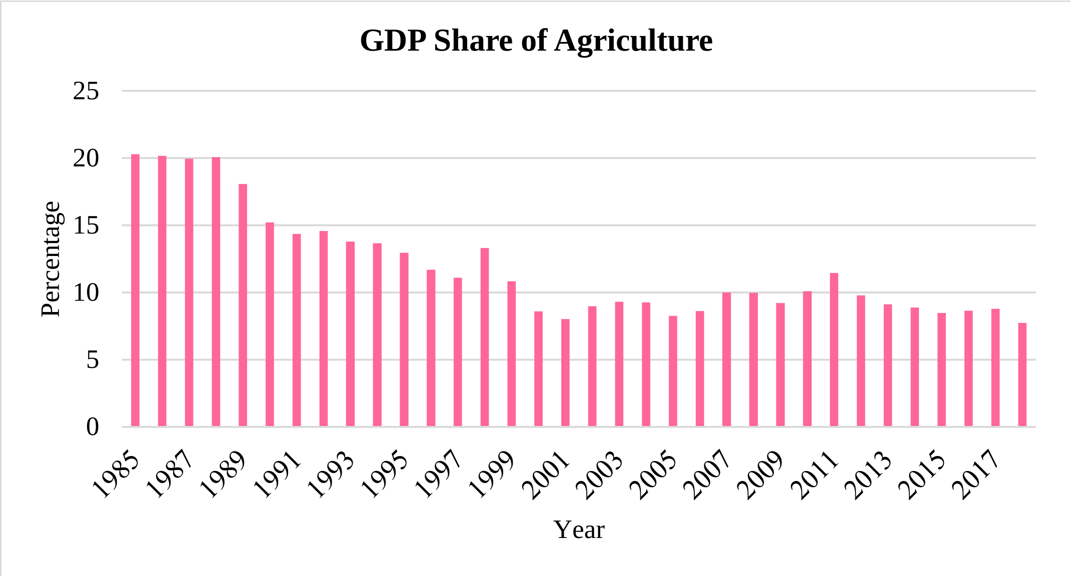


Figure 1: GDP share of agriculture in Malaysia from 1985 to 2018.

(Source: TheGlobalEconomy.com, The World Bank)

From the graph above, it indicates the gross domestic product share of agriculture in Malaysia from 1985 to 2018. In the year of 1985, Malaysia receives 20.28% of value added in the agriculture sector and started to diminish year by year and gets only 7.74% at the end of 2018 due to three challenges. Firstly, the gross domestic product share of agriculture along the years declines because the shortage of labour force leads to an increased in the idle agricultural land. This primary sector is more relying on the foreign workers and over 750,000 people are hired in the year of 2012. Secondly, the expensive production costs influences the GDP share decreasing such as an increased in wages or salaries and also the price of agricultural inputs and capital cost (Dardak, 2015).

Since the primary sector requires a sustainable transformation programs, so the low productivity and poor quality of agricultural production also attributes to the factor of GDP share diminishing (Dardak, 2015). Comparing to the other ASEAN countries like Indonesia, Philippines, Thailand and Vietnam, Malaysia gets the lowest rank of

GDP share of agriculture. The average value added GDP share of agriculture in Malaysia is 11.86% during 34 years from 1985 to 2018 with a minimum of 8.6% in 2000 and maximum 20.28% in 1985.

1.1.2 Indonesia

Indonesia has vast and fertile soil as a primary international trade producer in agriculture which produces a wide range of tropical products such as oil palm, coffee, cocoa, rubber and so forth. Even though the GDP share of agriculture in Indonesia has fallen significantly over past fifty years, it is also a part of most Indonesian households nowadays. The agriculture industry hired approximately 49 million of Indonesia population representing 41% of Indonesia's in the total labor force in 2012. However, although the absolute number of agricultural labor forces continues to increase, the relative share in Indonesia's total labor force has dropped sharply from 55% in the 1980s to 45% in the 1990s, then it continues to fall nearly 41% of GDP share agriculture (Maat, 2014.).

In the economy of Indonesia, palm oil industry contributes the most as exporter, foreign exchange earner and also as an important role in employment based on the rural areas of Sumatra and Kalimantan. Palm oil refers to a low cost of agriculture production and popular in Indonesia. The graph below shows the GDP share of agriculture in Indonesia from 1985 to 2018. Although the percentage of primary agriculture is declined to 12.81% at the end of 2018, but Indonesia still get the second highest rank of agriculture sector GDP among Malaysia, Philippines, Thailand and Vietnam. The average GDP share of agriculture in Indonesia is 16.76% during that period with a minimum of 12.81% in 2018 and maximum of 24.25 in 1986.

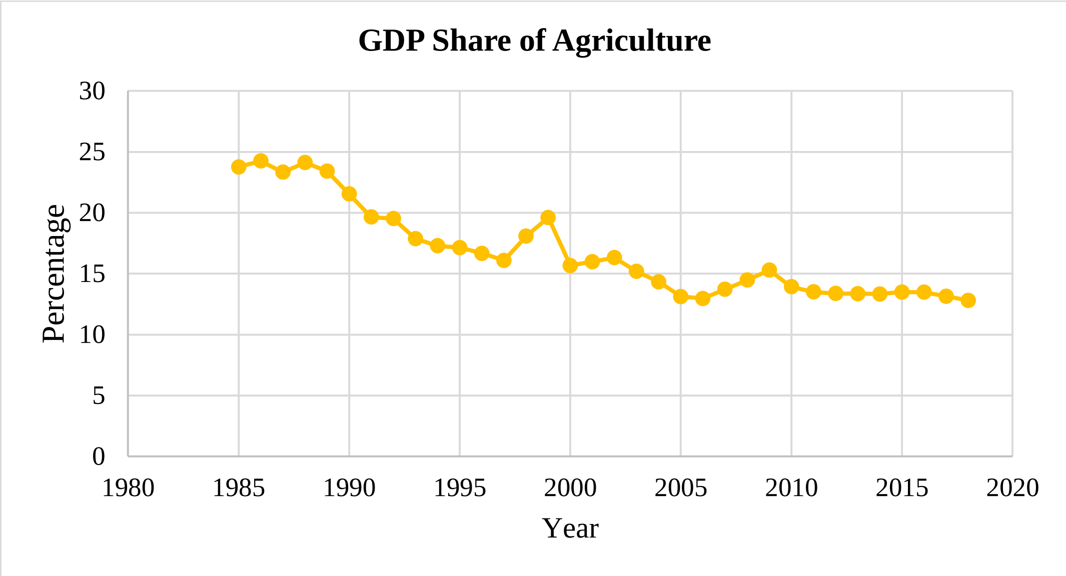


Figure 2: GDP share of agriculture in Indonesia from 1985 to 2018.

(Source: TheGlobalEconomy.com, The World Bank)

The graph above shows the GDP share of agriculture in Indonesia from 1985 to 2018. Although the percentage of primary agriculture is declined to 12.81% at the end of 2018, but Indonesia still get the second highest rank of agriculture sector GDP among Malaysia, Philippines, Thailand and Vietnam. One of the reason that affects GDP share of agriculture in Indonesia declining is because of the large amount of land traditionally utilised for other purposes and the imperfect or traditional farming methods which hindered the population from becoming farmers (Ribka, 2017). Thus, the diminishing contribution of primary agriculture is a serious issue and major concern for the population in Indonesia.

1.1.3 Philippines

Despite planning to become an industrialized economy by the year 2000, the Philippines remains as primarily agriculture producer in the country. Majority of the residents are still lived in the rural areas focusing on the agriculture for their livelihoods. The agricultural sector of Philippines includes four main sub sectors such as agriculture, fishing, animal husbandry and hunting. Around 39.8% of labor force are hired in the primary agriculture sector which recording 20% of gross domestic product.

Philippines produces the agriculture yields like rice, coconut, tobacco, coconut bananas, mango, abaca and the other products. Whereas the secondary yields produced by Thailand such as peanuts, rosemary (tuber crop), garlic, onion, cabbage, eggplant, pampas (various lemons), rubber and cotton. In 1998, the production of agriculture acquired undesirability gross domestic product because of the bad weather conditions. The industry's output value fell by 8.3%, but increased in the second year (Nations Encyclopedia, 2019). However, total income from pig farming and commercial fishing declined in 1999. Most crops in the sector are under-produced.

The other countries like United States, China, Japan, Europe and so forth exports the goods and services from Philippines especially the food and beverage. For instance, the export food and beverage such as coconut oil, coconut juice and other coconut products, fresh organic and non-organic fruits and vegetables, rice, and other products. Other exports include Cavendish bananas, Cayenne pineapples, tuna, seaweed and carrageenan. The export coconut products' value reached around 889 million US dollar in 1995, but then it diminishes to 569 million US dollar by 2000 (Nations Encyclopedia, 2019). Philippine also imports the agricultural products from other countries consisting of the soybeans, unground wheat, oil cakes, soy residues, malt flour, semolina and pellet fish, and whey.

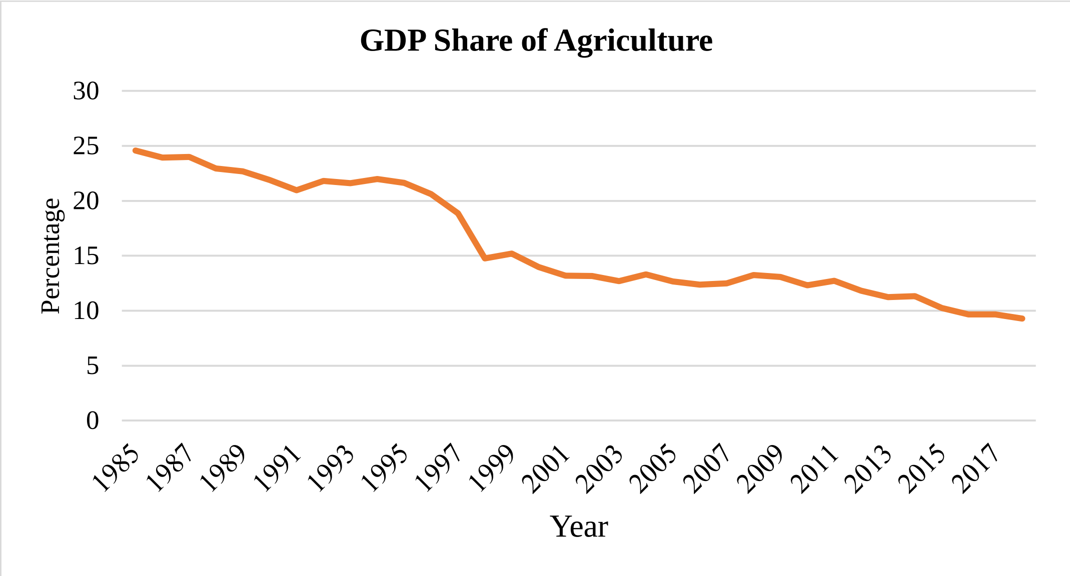


Figure 3: GDP share of agriculture in Philippines from 1985 to 2018.

(Source: TheGlobalEconomy.com, The World Bank)

From the graph above, it represents that the GDP share of agriculture in Philippines from 1985 to 2018 showing the declining trend. In the beginning of year 1985, Philippines is ranked as the second highest percentage of gross domestic product for primary agriculture sector with 24.58%. However, the GDP share of agriculture begins to decrease to 9.28% which is the third highest place comparing to Malaysia, Indonesia, Thailand and Vietnam. The average GDP share of agriculture in Philippines is 16.06% with a minimum of 9.66% in both 2016 and 2017 and also the maximum value of 24.58% from 1985 to 2018.

According to the head of Rizal Commercial Banking Corporation and Industry Research Division, the agriculture share of Philippines in 2018 is dropping compared to the previous year due to floods damage. It attempts to make the production growth of agriculture slowing down. Besides, it also leads to higher inflation on the petroleum price, transportation like lorry to deliver the outputs and other inputs that use in the production of agriculture. The determinants of weather disturbances, pest attacks and harvesting method may affect the gross domestic product of agriculture in Phillipines (World, 2018).

1.1.4 Thailand

Thailand contributes the most in the economic development or gross domestic product moving forward to be an industrialized nation. This is vital to the country's sustainable development and majority population of are hired in agriculture sector to improve the standard living of the citizens. Majority of 60% yields as Thailand's main production is rice and the farmers are still using the old method or traditional style due to insufficient money to buy or lease the machines. Besides, over half arable land is dedicated to rice cultivation and the country to be regarded as the largest and wholly rice suppliers. In the other words, rice can be defined as one of Thailand's staple foods, and the consumer will purchase the products with an average of nearly 115 kilograms (about 253 pounds) per year (Williams, 2018).

Apart from that, Thailand is the largest and top producers and exporters of rubber in the world. The country gives supply with nearly 40% of all the natural rubber around the world (Williams, 2018). The production of rubber can be mainly utilized to manufacture tyres for aeroplanes and motor vehicles. Due to high demand in the marketplace and the price of rubber is low influencing the farmers who are focused on rubber plantation living in poor conditions. The people of Thailand are always trust that the rubber yields will attract the attention of the consumers. Furthermore, Thailand is also the largest exporter of durian and sugar exporters in the world.

Thailand is also a major producer and exporter of ASEAN dairy products producing approximately 1 million tons of milk per year. The country to be known as the top three palm oil supplier all over the world although a big number of all locally production of palm oil is utilized domestically. Not only the agriculture products like rice, palm oil and rubber are produced by Thailand, but also the other major export products consisting of pineapple, coconut, cassava, tuna and shrimp. Surprisingly, Thailand is still to be well-known as the leading coffee producers in the world despite being relatively late and slow in the sector of coffee plantations industry.

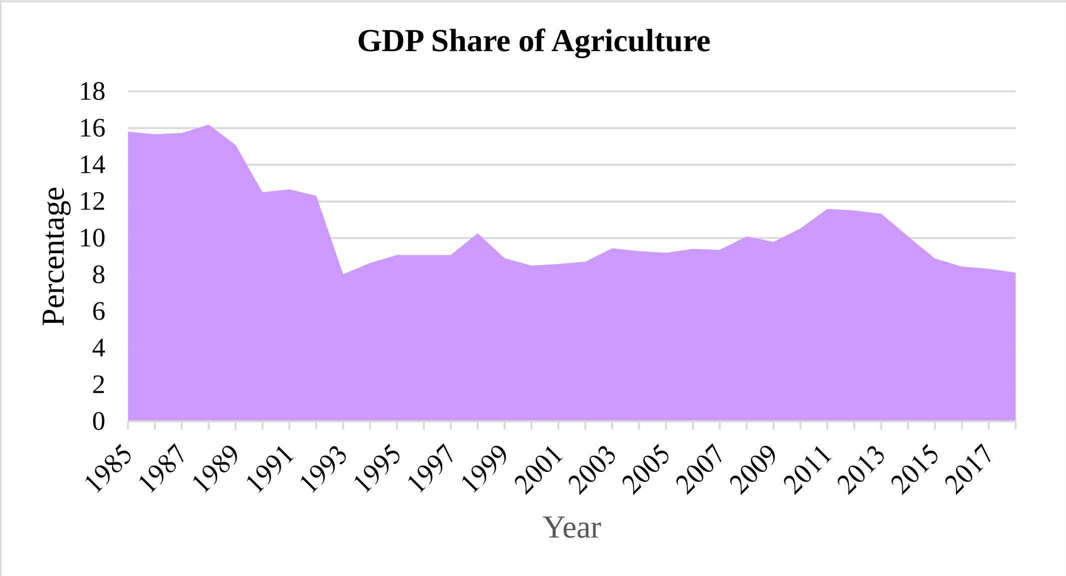


Figure 4: GDP share of agriculture in Thailand from 1985 to 2018.

(Source: TheGlobalEconomy.com, The World Bank)

The graph above shows the GDP share of agriculture in Thailand from 1985 to 2018. The country has an unstable trend which gains around 15.81% of GDP of agriculture yields and drops to only 8.12% at the end of year 2018. It is because of the unfavourable weather condition like drought which can affect and destroy the plantations, thus the growth of agriculture becomes slow down (Group, 2020). Thailand is the second lower of GDP share of agriculture sector among Malaysia, Indonesia, Philippines and Vietnam. Thailand acquires an average of 10.59% of GDP share from 1985 to 2018 with the highest percentage of 16.18% in 1998 and the lowest of 8.12% in 2018.

1.1.5 Vietnam

Vietnam is one of the selected ASEAN country as an important contributor of primary agriculture sector and famous to offer the cheap price of varieties products such as coffee beans, sugarcane, tea, rice, peanuts and cotton. It is the second highest of rice producer consisting of 19.6% farmland and another 69% for irrigated land. In recent years, aquaculture and fruit crops have significantly grown based on the export-oriented. Due to the increased demand of high quality and value of product, it leads to the consumption of domestic rising up and prompting the agricultural imports. The production of meat and its products can be produced rapidly, then following by the yields like rubber, animal feed grains, sugar and cotton. Netherlands and Vietnam are the long term partners in this sector.

As the graph below shown, it represents the GDP share of agriculture from 1985 to 2018. Among the selected ASEAN nations like Malaysia, Indonesia, Philippines and Thailand, Vietnam is the highest producer of agriculture sector which received approximately 40.17% of gross domestic share in 1985. Due to some reasons like failure regulations in production and environmental, poor capacity and information, poor human resources and other reasons (Giap, 2019), the GDP share of agriculture of Vietnam declines sharply to 14.57 at the end of 2018. The minimum value added of agriculture for Vietnam is 14.57 in the 2018 which the lowest and the maximum value is 40.56% in 1987 with an average of 25.79 from 1985 to 2018.

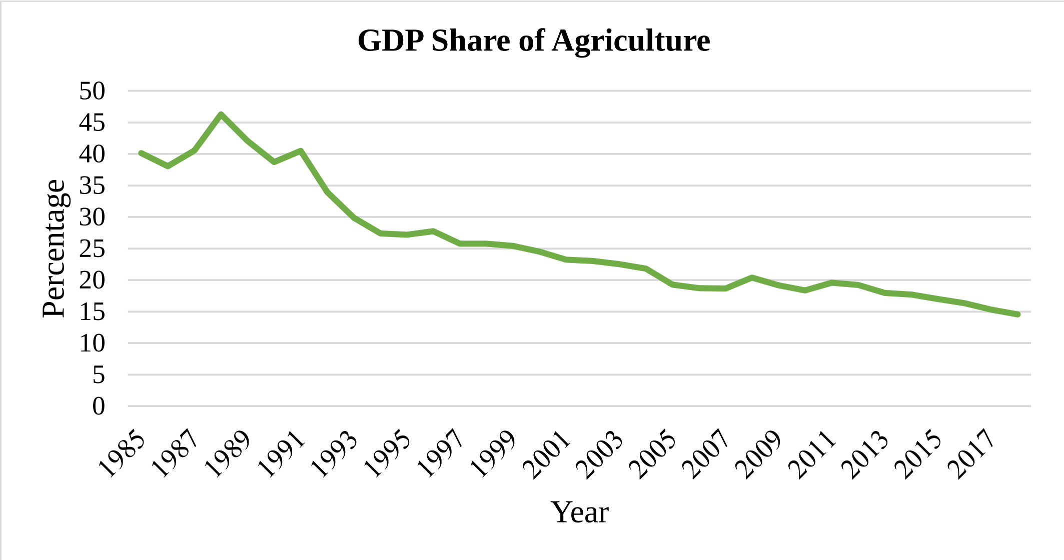


Figure 5: GDP share of agriculture in Vietnam from 1985 to 2018.

(Source: TheGlobalEconomy.com, The World Bank)

Even though the governments of Vietnam have tried to make significant progress on the productivity, output and exports of agriculture, but they are still encountering the issues like loss of farmers' welfare, poor quality and unsafe food because of inefficient and unsustainable resource utilization leading to the agriculture production decreased (Giap, 2019). It can be concluded that the farmers of Vietnam meet three main challenges in the sector of primary agriculture such as fail regulating production, environment, input and output in the marketplace by institutional, asymmetric information on weak ability to transparently generate and disseminate information and also poor human resources. It is because mostly of the populations are young generation and they are insufficient experience, education, skill and entrepreneur knowledge.

1.2 Climate Change and Primary Agriculture Sector

Primary agriculture sector can be influenced by the climate change in a wide range of methods such as temperature, precipitation, soil moisture, solar radiation, rainfall, sea level, carbon dioxide emissions and ice sheets. These factor determinants of climate changing will examine the agricultural productivity and its relationship. The current research study by Zoubi & Kadria (2016) confirmed that there is a direct and indirect impact of climate change on the agriculture production such as cereal, olive and citrus fruit in the long run relationship. For instances, if the temperature raises up by 1%, then the agriculture yields will become lower and vice versa. At the same time, the agriculture yields have an increasing trend if the precipitation rises up by 1% (Muhammad Iftikhar, Subramanian and Haider, 2018).

After that, the interaction between increasing temperature and rainfall change patterns will lead to the changes in soil moisture. It is because if the temperature keeps increasing, then the evaporation and precipitation in particular countries will follows to rise up the trend. According to Intergovernmental Panel on Climate Change report, they predict that the water availability and supply will increase due to the climate change reaching a high latitudes and several wet tropical region in the middle of 21st century. Besides, it also will make the diminished trend in some arid regions in the mid-latitudes and dry tropical (IPCC, 2007).

Rain is generally considered beneficial to agriculture productions and lands, even though somehow it is unpredictable and uncontrollable. It aims to determine the speed of production growth, but it may cause a serious problem from drowned crops to lower yields if the average rainfall is much higher or lower than the normal range. Thus, a good rainfall balance and proper irrigation can make the plantations growing faster, thereby shortening the germination time and the time between planting and harvesting (Sigfox, 2018).

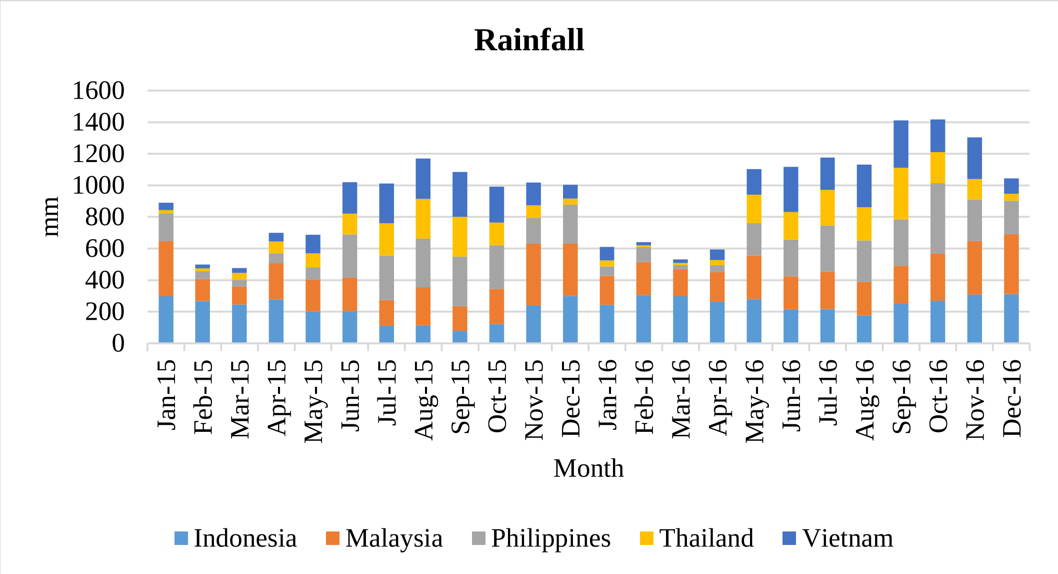


Figure 6: Rainfall (mm) in ASEAN selected countries from 2015 to 2016.

(Source: Climate Change Knowledge Portal, World Bank Group)

In addition, the graph shows monthly rainfall data from 2015 to 2016 for specific ASEAN countries such as Malaysia, Indonesia, the Philippines, Thailand and Vietnam. Among the specific ASEAN countries, Malaysia has the largest impact on rainfall, with an average of 236.94 mm. Thailand has the smallest impact, with an average of 121.79 mm. The second highest is Malaysia with an average rainfall of 233.04 mm, followed by the Philippines (196.42 mm) and Thailand (121.79 mm).

Next, agriculture land use plays an important role in influencing and determining the quantity of agriculture production of each country from time to time. It can be defined as the share of arable land under permanent crops and permanent pastures (Kanianska, 2016). Perhaps the population growth becomes rapidly and the food requirements from the consumer increase, then the land use will follow to accelerate in order to fulfil and achieve the demands from marketplace. Overtime, the issue of land scarcity occurs when the population growth along with the competitive land use and the wasteland begins to turn into agriculture and other uses like building construction, landmark and so forth.

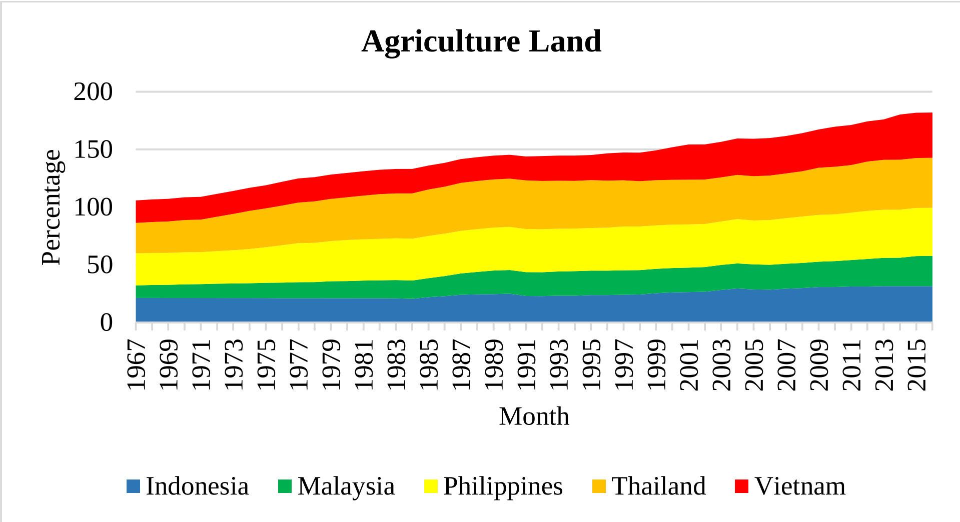


Figure 7: Agriculture land of selected ASEAN countries from 1967 to 2016.

(Source: World Development Indicators (WDI) of the World Bank)

The graph above indicates the agriculture land in percentage of selected ASEAN countries such as Malaysia, Indonesia, Philippines, Thailand and Vietnam monthly from 2015 to 2016. The highest agriculture land recorded is Thailand and the lowest is Malaysia, then following by Philippines, Vietnam and Indonesia. It can be seen that Thailand has spacious land for plantation comparing to other countries.

Apart from that, the increasing temperature and carbon dioxide concentration surrounding atmosphere provide a positive significant affect to the agriculture production like maize yields (WilfreyVuhSiahi, Yego and Bartilol, 2018). It can be through simulating the plant photosynthesis and decreasing the loss of water due to the plant respiration. The fertilization of carbon has a strong for C3 yield productions which is the most ordinary and efficient in the process of photosynthesis especially wet and cool climates with low photosynthesis efficiency such as rice, soybeans, fine grass, barley, tobacco, peanuts, oats and the others agriculture yields.

The release of carbon dioxide emissions (CO2) is mainly produced by burning carbonaceous fuels and wood decay caused by solid, liquid and gaseous fuels and burning natural gas. Under all conditions found naturally on Earth, carbon dioxide concentration is an invisible, odourless, non-toxic gas and colourless. It is considered one of the greenhouse gas emissions. Carbon dioxide emissions will cause climate change, which will affect potential ecological, physical and health impacts. Perhaps rising CO2 emissions will then affect the primary agricultural sector, disrupt food supplies, and reduce economic growth. Indonesia has a big problem with air pollution because, as shown in the figure below, the country's carbon dioxide emissions are 464,176.20 kilotons. Thailand is closely followed, with Thailand at 316,212.70 kilotons in second place, Malaysia (242,821.40 kilotons), Vietnam (166,910.80 tons) in third place, and the Philippines at 105,653.60 tons.

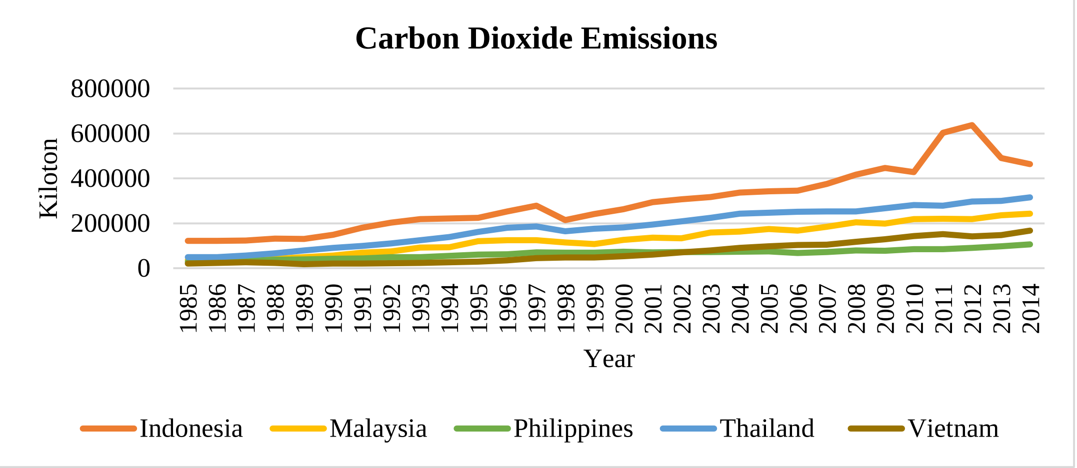


Figure 8: Carbon dioxide emissions of selected ASEAN countries from 1985 to 2014.

(Source: World Development Indicators (WDI) of the World Bank)

In addition to the temperature, rainfall and carbon dioxide concentration, the other ecological changes also bring the impact of climate change which will affect the productivity of agriculture. For instance, the patterns of pests and diseases leads to the reduction on the production of agriculture. As the world becomes warmer, that unusual warming has provoked many other changes in the Earth's climate through extreme weather and climate events such as extreme precipitation, hurricanes, tornadoes, wildfires, heat waves and droughts which are unexpected, unpredictable and unseasonal weather. The higher temperatures will make the evaporation rates rising up and reduce the productivity and production of agriculture. Although the precipitation in certain area does not declining, but the rising in surface evaporation and water loss through plant leaves will lead to dry soil.

1.3 Problem Statement

Uncertainty of rainfall is a critical challenges for all of the farmers in each country to deal with since the quantity, timeliness, distribution and duration of rainfall are totally different in each season and also the crop production depends entirely on highly unpredictable sporadic seasonal rainfall (Ndamani & Watanabe, 2014). Accordingly to the article reporting in India, the country faced a lot of unpredictable challenge recent year especially rainfall. In 2016, the agriculture productions such as wheat, barley and pulses affected by decreasing its quantity to lower 30% because of the shortage of rainfall which means no rainfall during the period (Punetha, 2016).

Besides, there has another real-life sad case in India reporting that the country encountered the issues of lower monsoon and erratic rains in 2019 (Rawat, 2019). At the beginning of the season, prolonged drought influenced the rainfall much lower than the average level, then the farmers force to delay the cultivations. By the end of

July, rivers flooded as a natural disaster damaged the crop productions such as soybean, rice, cotton, sugarcane and so forth due to heavy rainfall and leaded to expensive cultivation costs in pesticides. The farmers had no choice to spend a large amount of money in pest infestation and disease. Extreme rainfall variability affects rains and droughts which are uncontrollable making the farmers in India gained serious loss in 2019.

Globally, approximately three million hectares of agricultural land are lost each year due to soil erosion, degradation and become unusable when the soil composition moves from one location to another new location (Cunningham, 2013). One of the major problem that encounters by the population around the world is the loss of agricultural land due to human development and population growth. Over land use has measurable influences toward the climate change. Nowadays, the farmland is converted and used for roads, housing, infrastructures, factories and other urban needs in this era of technology advancement.

If this issue keeps continuing to appear and not well controlling, it will be complicated to produce food in order to meet the requirements and needs of growing population leading to out of stock for the products and inflation (Cunningham, 2013). Not only the buyers will be affected, but also the sellers since they need to spend a huge amount of money to take the goods from suppliers. For a real-life case example, it is reported that Penang, Malaysia faced the problem on lack of land for agriculture crop production and leaded to price hike of food items recently (Basyir, 2019). Deputy Minister of Agriculture and Agro-based Industry mentioned that less than one million hectares of land can be used to harvest the crop productions like fruits and vegetables, which is not enough to meet the demands of citizens, therefore the consumers are forced to pay more money to get the goods.

Initially, the scientists generally believe that the global climate change might be beneficial to the farmers in the short term. It is because the plantations need sufficient carbon dioxide in the atmosphere to carry out photosynthesis for producing food. The carbon dioxide emitted by human activities such as cars, factories and so forth will create new sources of plant nutrition and make some of the crop production growing faster. In contrast, it becomes a serious issue in the long term assumptions. The consequences of climate change like higher temperature. rising precipitation, nitrogen deposition in the soil and the other effects may reduce the plantation growth due to elevated atmospheric carbon dioxide (Shwartz, 2002).

According to a new National Aeronautics and Space Administration (NASA) study, an increase in the concentration of carbon dioxide surrounding the atmosphere can improve the water use efficiency of crop productions, but it reduces the agriculture yield losses affected by climate change. The effects of extreme temperatures and water shortages might be affected by increased emissions of carbon dioxide and other components of greenhouse gases. Consequently, the study stated that higher concentration of carbon dioxide may influence the crop production kept declining due to doubled carbon dioxide levels and become inefficiency (NASA, 2016).

Southeast Asia refers to the regions most affected by climate change in the world. Forecast rankings show that six of the world's twenty most vulnerable countries are Myanmar, Indonesia, Vietnam, Thailand, Malaysia, and Philippines. Climate change has led to increasing trend in the frequency of heat waves, precipitation, heavy rain, sea levels and intensity floods, tropical cyclones and droughts increased. Rising global temperatures and increasing food demand will pose huge risks to global food supply and security. For instance, the productions like wheat, rice and corn in the tropical and temperate areas, climate change is expected to affect the local temperatures negatively. Most subtropical arid regions have fewer renewable surface and groundwater resources and climate change has increased competition for water.

Caroline Rodriguez Billcott, Director of the FAO Liaison Office in Geneva mentioned that the country will face a total losses of 22% and natural disasters loss if they do not pay much attention on the issue of drought since the agriculture sector is damaged and destroyed. The environmental issue like climate change is the top concern and threat for the farmers especially staring at droughts, extreme rainfall, floods and storms which is unpredictable, so they have no choice to facing the challenge. For example in Indonesia, majority of 93% Indonesian farmers are small-scale farmers who are mainly engaged in food crops such as rice, corn, cassava, palm oil, rubber and other primary products.

Therefore, this research paper aims to study the impact of climate change which are rainfall, agriculture land and carbon dioxide emissions on primary agriculture sector in selected ASEAN countries such as Malaysia, Indonesia, Philippines, Thailand and Vietnam. The research questions are listed as below:

i. Do the primary agriculture sector in Malaysia, Indonesia, Philippines, Thailand and Vietnam influenced by rainfall, agriculture land and carbon dioxide emissions of climate change?

ii. What is the relationship between the primary agriculture sector and the climate variability such as rainfall, agriculture land and carbon dioxide emissions in Malaysia, Indonesia, Philippines, Thailand and Vietnam?

iii. Which selected ASEAN country has the highest impact by the rainfall, agriculture land and carbon dioxide emissions of climate change?

1.4 Research Objective

1.4.1 General Objective

Main scope of the study aims to investigate the relationship between primary agriculture sector and the climate variability such as rainfall, agriculture land and carbon dioxide emissions in Malaysia, Indonesia, Philippines, Thailand and Vietnam.

1.4.2 Specific Objectives

The specific objectives are stated as below:

i. To identify the impact of rainfall on the primary agriculture sector in Malaysia, Indonesia, Philippines, Thailand and Vietnam.

ii. To determine the primary agriculture sector when the agriculture land are varied year by year in Malaysia, Indonesia, Philippines, Thailand and Vietnam and Thailand.

iii. To investigate the relationship between the primary agriculture sector and the carbon dioxide emissions in selected ASEAN countries.

1.5 Significance of the Study

The ultimate contribution of this study is to study the impacts of rainfall, agriculture land and carbon dioxide emissions of climate change in Malaysia, Indonesia, Philippines, Thailand and Vietnam. Science has made tremendous progress in understanding climate change and its determinants. It is to provide and develop a strong and thorough understanding of the current and potential impact especially in primary agriculture sector that will bring negative externalities to the population, the new generation in future as well as the economic growth. It is because agriculture sector bears the important role as primary and basic food supply and the strategic character to boost the economic growth. If the agriculture sector is destroyed, the food chain and supply will follow to decrease, the income of people who focus on agriculture will diminish, the value added in the agriculture sector in percentage of GDP also decreases and lead to the economic growth declining.

Hence, it is also a crucial understanding since it enables decision makers or policymakers and government to place climate change in the context of other major challenges facing the country and the world. They can figure out the problem and give a good guideline and plan that will help the country to maintain and improve the climate change issues. Besides, the result of study may help the policymakers in Malaysia, Indonesia, Philippines, Thailand and Vietnam to be more concentrated eliminating the high quantity of rainfall, spacious agriculture land area and high level of carbon dioxide emissions that will influence the primary agriculture sector and economic growth. And also the government has to introduce and implement the appropriate policy to reduce the consequences of climate change especially in socio-economic development.

From the previous research paper, the researches attempts determine the factor determinants and the impacts on human health and vulnerability of climate change in different countries. It is less attention to study about the impacts of rainfall, agriculture land and carbon dioxide toward primary agriculture sector in Malaysia, Indonesia, Philippines, Thailand and Vietnam. Thus, this study is highly important and beneficial for other researchers in future to get more information and have a different perspectives regarding the climate variability on the primary agriculture sector.

Apart from that, this study can raise the awareness of public regarding the climate change crisis, so that they will start to take some actions in tackling the climate change issue for future even though it is just a small thing and contribution, but it makes a big difference to the world. For instance, the alternative ways to fight on climate change are using energy wisely, get charged up with renewable energy transitions, eat for a climate-stable planet, start a climate conversation and communicate with other people and so on. It is also very important and essential to give an early education regarding climate change to the children.

In addition, this research paper attempts to fill the gap to the literature and aims to provide empirical proof of investigating the impact of climate change on primary agriculture sector. It can help the government to monitor the progress of the ongoing strategies. In order to relate with the current climate crisis, it is recommended to adopt several policies to benefit the relevant government departments which will inevitably affect the economic growth in Malaysia, Indonesia, Philippines, Thailand and Vietnam. For example, the goal 13 of sustainable development goal (climate action) as one of the Paris Agreement with other 185 parties, they can make improvement to strengthen the resilience and adaptive of capacity related to climate-related hazards and natural disasters in all the countries.

1.6 Organization of the Study

This study is to investigate the relationship between primary agriculture sector and the climate variability such as rainfall, agriculture land and carbon dioxide concentration in Malaysia, Indonesia, Philippines, Thailand and Vietnam. It is organized by five chapter and will be discussing in further. Chapter 1 is about the introduction of this research consisting of the current climate change issue, background of primary agriculture sector and contribution in future. In this chapter two, it is regarding the reviews of selected previous studies about the primary agriculture sector including theoretical framework, empirical testing procedures, empirical evidence and summary of previous studies.

The chapter three will discuss about the data sample and various type of methodologies that apply in this study. The dependent variables is crop production index, whereas the independent variables are rainfall, and carbon dioxide emissions of climate change. The research methodologies of this study such as Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, Johansen and Juselius cointegration test, Vector Error Correction Model (VECM) test, variance decomposition, impulse response and diagnostic tests. Moreover, Chapter four is the section where the selected methodologies using to do analysis as mentioned in Chapter three, discusses and interprets the empirical result. Last but not least, the chapter five concludes the overall finding of this study and provides recommendation for further studies.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

The agriculture sector gives play on important roles as a basic source of food supply and strategic role in the performance of economic growth of a particular country (Macatta, 2016). It considers as a significant contribution of study to the economic prosperity in the particular nation. Meanwhile, the citizens who emphasize on the agriculture sector and other primary industries will get a lower real income per capita. Perhaps increasing in the agricultural production and income per capita in rural areas as well as industrialization and urbanization, it will have led to the increased demand for industrial production too.

Thus, the primary agriculture sector is always related to the economic growth. Recently, the demand for food like flour mills, rice, maize, tomato and miscellaneous organic food are increasing with a rapid rate due to the high pressure of population and the effects of climate change such as drought, flood, global warming, unstable temperature and so on. The shortage of agricultural vegetables and fruits upon the industrial production will increase the price level in the marketplace and highly impede the economic growth in the country (Macatta, 2016).

This section includes a review of the theoretical framework, testing procedures and empirical evidence on the impacts of climate change on primary agriculture sector and other macroeconomic consequences in order to have a better understanding. Section 2.1 is about the theoretical framework, Section 2.2 is discussing on the empirical evidence and findings, Section 2.3 is the research gap and also Section 2.4 is the concluding remarks.

2.1 Theoretical Framework

From the prior studies, there are some theories mentioned by researchers to explain the relationship between the primary agriculture sector and the climate variability such as rainfall, agriculture land and climate change. For instance, the theories such as the Ricardian approach, climate-smart agriculture (CSA) approach and the production function approach.

2.1.1 Ricardian Approach

The Ricardian method measures the impact of climate on arable land productivity by returning net income or arable land value to the climate. Ricardian analysis is performed in each space examining whether the net income or market value of the farms under different climates are similar or different. By using net income to measure impact, the Ricardian method can directly measure impact. Since no cross-section analysis is performed in a controlled environment like a laboratory, the Ricardian model must also include a few other independent variables in the regression which can be explained net income or cultivated land value such as access to markets, soil, geographic areas quantity. If these control variables are associated with climate and land productivity excluding them from the regression will lead to climate coefficient bias.

The Ricardian model can be derived by assuming that competitive farmers are agents that maximize profits (Mendelsohn, Nordhaus and Shaw 1994). Each farmer chooses outputs and inputs that maximize farm profits based on external variables that the farmer has no control over such as climate, market prices, and distance from the nearest market. Relying on these external variables, farmers can choose the number of crops and each input like fertilizer, pesticide, machinery, irrigation to maximize profits and increase the revenue. If exogenous variables such as climate are different, then farmers will choose different crops and may choose different inputs.

In multiple climates, the people tend to choose different crops and use different inputs in each climate. Given possible external variables, the result of profit maximization defines the relationship between maximum net income and external variables. The Ricardian model estimates this relationship. Assuming that farmers optimize their choices given the exogenous variables, it means that the Ricardian model includes adaptability. Farmers' choices, including farm inputs (fertilizers, pesticides), technology (machinery and seeds), and yield choices (what crops are grown), should not be included in the Ricardian regression as independent variables because they are endogenous. Including these choices in the regression may bias the model.

2.1.2 Climate-smart Agriculture (CSA) Approach

The Food and Agriculture Organization (FAO) has designed a "Climate Smart Agriculture (CSA)" approach for the purpose to control food security of agriculture properly during global warming (FAO 2010). There are three goals of the CSA approach consisting of continuously rising up the trend of agricultural productivity to encourage equitable growth of salary for employee, food supply and security, improving the adaptive capacity and withstanding multi-level shocks from farm to country and diminishing the harmful greenhouse gas emissions where possible and increase carbon sequestration.

CSA aims to achieve the sustainable food production when the greenhouse gas emissions can be reduced and make an improvement on the climate adaptability of agricultural systems. Lipper et al. (2014) mentioned CSA as a strategy to transform and adjust agro-ecosystems producing the food production under climate change scenarios. CSA defines as an emerging method to raise up the agriculture yield, quality of environmental, biodiversity, agro-ecosystem resilience, livelihoods and development of economic when addressing the impacts of climate change.

The priorities of CSA each target are varied by the location like small and low educational farmers have to place greater concern and attention on the productivity and adaptability of agriculture. Because of its ability to increase agricultural productivity and adaptability to agro-ecosystems while reducing greenhouse gas emissions, CSA has received increasing attention from the public.

2.1.3 Production Function Approach

The approach of production function is a breakthrough method for analysing the relationship between primary agriculture sector and climate change. The method is depending on an empirical production function in which environmental variables including rainfall and temperature are entered. The climatic variables in this production function approach change to estimate the impact of climate change on agriculture sector. These output changes are then incorporated into economic models to predict changes in welfare affected by climate change (Mendelsohn et al., 1994).

One of the advantage of the production function method is to provide an estimation of the climate impact without bias since the factors of agricultural production are unpredicted and out of the control of farmers such as soil quality

(Deschenes & Greenstone, 2007). Moreover, due to controlled experiments, the method can better predict the impact of climate change like rainfall, precipitation, temperature and carbon dioxide emissions on the agricultural.

However, this method has some shortcomings. Firstly, the production function approach does not include the measurement of adaption policy taken by the farmers to face the climate change issue. They can launch a new agriculture production policy or replace the yields with livestock. Lacking of adaptation measures has led to an overestimation of losses due to climate change (Mendelsohn et al., 1994). Apart from that, Deressa (2007) points out that this method is very expensive due to the need for controlled experiments. This may explain why this method is rarely used in the world and is used in some crops, mainly grains. Therefore, this method will be of a little value in summarizing and testing the results.

2.2 Empirical Evidence

2.2.1 Review of the Climate Change Impact in Asia Countries

First and foremost, a research study regarding the determinants of affecting the efficiency of Indonesia's cocoa farms had investigated in order to help rising the income or salary in rural Indonesia (Effendy, 2019). The researcher conducted a questionnaire survey using cross-section data in 2016 to obtain the relevant information such as production of coca, land, chemical fertilizer, labour, cost of pesticide, cost of pruning and cost of sanitation. OLS method, Tobit analysis and non-parametric approach are used. Through Tobit model, the result shows that all of the variables are positive and have significant relationship to rise agriculture output.

According to Ibrahim (2019), the researcher studied the consequences of CO_2 toward cereal yield in Sudan (North Eastern Africa) from 1961 until 2016 using annual data analysis. He obtained the data of cereal production (kg per hectare) as dependent variable, carbon dioxide concentration (kt), and the agriculture value added (in GDP) as independent variables from National Oceanic and Atmospheric Administration (NOAA), earth System Research Laboratory (ESRK) and Global Carbon Project using PP unit root test, ECM specification and ARDL bound test. Simply to say, there is a positive relationship among cereal yield and carbon dioxide concentration. It has greater positive effect in short run period compared to long run period.

Next, Sangkaphan and Shu (2019) found that the economic performance of Thailand can be affected by rainfall negatively, but the temperature does not influence the economic growth at the provincial level. From their research paper, they did the research on the gross provincial product (GPP), population growth rate, average rainfall and temperature from 1995 to 2015. The data of the variables took from Thai Meteorological Department, National Economic and Social Development Board of Thailand and Department of Provincial Administration and applied the research methodologies which are FGLS and OLS test.

An analysis of determinants affecting agricultural productivity had done in Philippines (Urrutia, 2018). The data were obtained from Bureau of Agricultural Statistics from 1980 to 2013. There were a few methods that used in this research study such as Pearson correlation test, individual significance test, granger causality test, Paired-T test, RAMSEY test and Chow-Breakpoint test. As the results, all of the variables are significant at 0.01 level of significance. A strong and positive correlation between real gross value added and all of the variables except agriculture raw material export was found. Through Ramsey RESET test, no specification problem occurs.

Indonesia is one of the Asian country. Busnita, Oktaviani and Novianti (2017) mentioned that the production of Indonesian paddy and price volatility of rice as influenced by the temperature. The price volatility of rice was from the E-Views calculation, rice price (Rp/Kg) and paddy production (Quintal) from Indonesia Central Statistical Bureau (BPS) and also the data of temperature from Climate Prediction Center for the duration of January 2007 to December 2014 which is the monthly analysis. The researchers applied ARGH-GARCH model specification, ADF unit root test, JJ co-integration test, VAR and variance decomposition. A negative relationship is tested between the paddy production and temperature in both short run and long run. Rice price production can be affected by temperature positively.

A case study of the impact of climate change on the agriculture sector was studied by Dumrul and Kilicarslan (2017) in Turkey from 1961 till 2013 using ADF and PP unit root test and ARDL co-integration test for the both short run and long run estimate. The GDP of agriculture value added in percentage is the dependent variable and the independent variables which are temperature (℃) and rainfall (mm). After testing, there are two relationship found among the agriculture GDP and the climate changes positively and negatively. If the agriculture GDP increase by 1%, then the precipitation will increase too. However, if the agriculture GDP decreases by 1%, then the temperature will raise up the trend.

A research paper regarding the rice market and climate change was studied by Le (2016) from 1975 to 2014 in Vietnam using unit root test, JJ co-integration, Lagrange multiplier test, rice market model, parameterization and EDM model. The production of rice (metrics tons per hectare), maximum and minimum temperature and precipitation were acquired from general statistics office of Vietnam, U.S. Department of agriculture and Climate Research Unit. As a result, ice yield can be affected by the temperature and precipitation in the spring and autumn production.

Previous research have emphasized the consequence of climate variability toward China's main rice production from 1979 to 2011 yearly applying panel data (Wang and Wang, 2016). There are a few methodologies that the researchers use to test the empirical result such as Cobb-Douglas function, regression model, pooled OLS technique, time and entity FE. In this scenario, the rice production considers as dependent variable and the temperatures data like minimum, maximum and difference obtained from China Meteorological Data Sharing Service System (CMDSSS), China Statistical Yearbook, China Agricultural Statistical Abstracts, China Agriculture Development Report and also National Bureau of Statistics of the People's Republic of China. As a result, temperature difference, minimum temperature and precipitation have positive impacts toward rice production. Rice production can be affected by the climate change negatively.

After that, Vaghefi et al. (2016) used the different methods from other researchers such as DSSAT model including calibration and validation and system dynamics model to study the effect of climate change towards food security in Malaysia and suggested the policy adjustments for improvement of rice industry. There are two periods of study which are the year from 2013 to 2030 for daily projected and 1998 to 2011 for annual. All of the variables collected from Research Centre for Tropical Climate Change System in MMD, DOA, DOS, MOA and LPP.

For example, the data of minimum and maximum temperature, rainfall, solar radiation, population growth rate, average human lifetime including birth rate and death rate, rice stock, rice consumption (per capita), rice supply and import of rice. As a result, the increased temperatures and diminished rainfall as expected influence the rice production the most.

The researcher, Tripathi (2010) wrote a thesis related to the total factor productivity in the agriculture of India. He look for the data through National Account Statistics (NAS) published from Central Statistical Organization, Government of India and Agricultural Statistics published from Directorate of Economics and Statistics and the data period were from 1969 to 2005. Three methodologies had used such as Cobb-Douglas production function, ordinary least square and ridge regression. It can be found that agricultural growth almost entirely depends on rising trend of conventional factors, whilst productivity growth is negative. Only in the initial stage of reform, the growth of total factor productivity in agriculture was positive.

In addition, Zhai and Zhuang (2009) provided an evidence of climate change that tended to affect the electricity consumption in Malaysia for the duration of 25 years from 1991 to 2015. They collected the annual data from World Bank Indicator for electric power consumption, rainfall, temperature, CO_2, forest area and arable land in percentage. Several techniques were used in this study such as ADF unit root test, granger causality. Error correction method and VAR. There is a long run impacts among the electricity power consumption and the independent variables such as average rain, temperature, carbon dioxide emissions and arable land. The dependent variable like electricity consumption and the independent variables which are CO_2

have granger causality causes to average rainfall and average temperature respectively. If the electricity power consumption increases by 1%, it will lead to diminish of land area and rise up the forest area trend.

2.2.2 Review of the Climate Change Impact in Non-Asia Countries

Most early studies as well as current research paper emphasizing on the climate change. Dogru et al. (2019) acquired the data of tourism receipts, GDP, vulnerabilities to climate change and resilience to climate change from World Bank and ND-GAIN online for the year of 1995 until 2014. The research paper aims to determine the relationship among tourism activities and the climate change indicators using multivariate analyses, instrumental validity and serial correlation test. Overall, the tourism industry and entire economy have high numbers of vulnerable to climate change compared to resilience to climate change.

For the non-Asia country, Muhammad Iftikhar, Subramanian and Haider (2018) had conducted the research of the effect on agriculture sector across 60 countries in Asia, Africa, Europe, South America, North America and Oceania using the methods such as descriptive statistics, panel unit root test, regression to identify the mechanism, two stage least squares and also the robustness check from 1999 to 2011. In this study, the yearly value added of agriculture considered as dependent variable (current US dollars), fertilizer consumption, land area of agriculture, total of population as the control variables collected from the World Bank Development Indicators. For the climate variables like average temperature and precipitation are acquired from Climate Research Unit from University of East Anglia with Hadley Centre. As a result, the variables such as temperature and precipitation have negative and positive impacts respectively to value added of agriculture. If the temperature increases by 1%, then the agriculture yields become lower and vice versa. As the precipitation increases by 1% and it will lead to increasing trend in agriculture yields.

In addition, WilfreyVuhSiahi, Yego and Bartilol (2018) studied the relationship between maize productivity and climate change in Kenya using ADF unit root test, Johansen cointegration test, normalized equation, error correction model, Test for serial correlation and heteroskedasticity from 1961 to 2015. The data of all the variables such as maize production, rainfall, temperature and carbon dioxide were obtained from FOASTAT and African Climate Change Portal. As a result, temperature and carbon dioxide are positive significant affect the maize production. However, only rainfall has a negative and not significant impact toward maize output.

Not only climate change leads to declining in agriculture sector, but also the gross domestic product may influence by the temperature, rainfall and other climate variabilities. Shafinah Rahim and Tay (2017) investigated the effect of climate change on Malaysian economy from 1983 to 2013 using ADF unit root test, DF-GLS unit root test, JJ co-integration test, VECM model, VDC test and IRF test. The dependent variable was gross domestic product (current LCU) and the independent variables such as precipitation (mm), temperature ((˚C) and the arable land (% of land used). As a conclusion, the independent variables of temperature and arable land are significant at 5% of significance level, but they have a negative impact towards climate change.

Apart from that, Howard, Cakan and Upadhyaya (2016) stated that the total output of wheat production can be influenced by the climate variables such as temperature (℉) and precipitation (inches) in Kansas, USA. Not only the climate change's impact to the production of wheat, but also the wheat price and oat price. All of the annual data were obtained from National Agricultural Statistics Service and National Climatic Data Center from 1949-2014. They applied the research methods such as ADF and PP unit root test, JJ co-integration test, cointegrated vector normalized and error correction model. Perhaps the temperature in UAS increases, then it will positively affect the production of wheat in short run. Whereas there is a positive effect to wheat production in short run, but it brings negative impact in the long run.

As has been previously reported in the literature, Kahsay and Hansen (2014) estimated the impact of climate change and adapted the climate change policy on the production of agricultural from 1983 to 2014 based on Eastern Africa countries such as Burundi, Djibouti, Kenya, Rwanda, Somalia, Tanzania, Uganda, Sudan and Ethiopia using parameter estimates and predicted future climate change scenarios. They obtained the data of output production index (millions of USD), labor (person, land (hectare), machinery, livestock including head count millions of cattle, sheep and goats), fertilizer (tonnes, nutrients), irrigation (hectares), mean temperature, mean precipitation and the variability among temperature and precipitation from Food and Agricultural Organizational (FAO) and Climate Research Unit (CRU). The researchers predicted and found that impacts of seasoning temperature and precipitation as well as within growing season variance of precipitation. Based on the climate scenarios, it is forecasted to gain a negative output as impact of climate change.

The effect of climate change toward the agriculture sector has also been explored in prior study by Blanc (2012). The scholar focused the crop yields in Sub-Saharan Africa and acquired the data of carbon dioxide concentration, cassava yield, millet yield, sorghum yield, land area, precipitation, drought, flood, temperature and evapotranspiration from FOASTAT, CRU TS 2.1 dataset, Mauna Loa Observatory Hawaii and satellite-derived land cover data. He applied the ADF unit root test, co-integration test, diagnostic test, T-P and ET-SPI regressions to test the variables from 1961 to 2011. From the result, there is a significant result of weather affecting on both yields, whilst there is a significant result among crops yield and the climate change which are temperature and precipitation. Rainfall has big impact of changes in the production of millet and sorghum in LFAC countries compare to non-LFAC countries.

Next, some of the authors like Oseni and Masarirambi (2011) also suggested that the agriculture sector focusing in maize production can be influenced by climate change such as rainfall and precipitation. They collected the all the data for each variables in Malkerns Research Station, Malkerns and Swaziland Ministry of Agriculture and Manzini Regional Office from 1990 to 2009 annually using analysis of variance (ANOVA) and regression analysis. As a result, the average rainfall and growing season rainfall have significant differences in the production of maize. Maize production can be influenced negatively by the declining trend in both mean and planting season precipitation.

Previous research showed that the climate change affected the agricultural factor productivity in United States by McCarl, Villavicencio and Wu (2009) using panel unit root tests, panel ci-integration test and the panel ECM tested the year of 1970 to 1990. In this case, agriculture TFP acts as the dependent variable and the independent variables such as mean temperature (℉), precipitation (inches), public agricultural research capital (RPUB), share of SAES budget coming from federal formula funds, budget coming share from federal grants and contracts, stock of public extension capital, public agriculture research spill-in stock and also the private agricultural research capital from Economic Research Service of US Department of Agriculture and National Oceanic and Atmospheric Administration. The inclusion of climate variables such as temperature, amount and intensity of precipitation and also the evaluation and correction of problems due to non-stationary of some of the variables.

The researcher, Dogan (2018) conducted a research paper of the relationship between agriculture, gross domestic product, population and climate change in Eurasian countries and Turkey from 1993 to 2016. For instance, the Eurasian countries such as Armenia, Belarus, Georgia, Hyrgyzstan, Uzbekistan, Russia, Ukraine, Azerbaijian and so forth. Carbon dioxide emissions as the dependent variable, whereas the independent variables such as share of agricultural fields, value added of agriculture, GDP per capita in US dollars and population from World Bank Indicators. The methodologies to test the variables which are ADF unit root test, ARDL test and VECM. All of the variables have rising up trend to the carbon dioxide emissions in the long run. Population affects the most on carbon dioxide level especially in Turkey. There is a linear relationship among agriculture share and carbon dioxide in Eurasian, but it becomes negative in Turkey side.

Last but not least, Oussama Zouabi and Mohamed Kadria (2016) mentioned that there is a direct and indirect climate change impact on the production yield such as cereal, olive and citrus fruit in Tunisia for long run period. Both of them took the data of agricultural production of governorates, average temperature and precipitation from NIS, IEQ, ONAGRI and National Institute of Meteorology and Micro-disaggregated database using SAR model, SDM model, robustness checks, unit root test, co-integration test and FMOLS estimation.

Abidoye and Odusola (2015) did an econometric analysis regarding the climate variability and economic development in Africa (34 African countries) from 1901 to 2009 using the simple correlation and descriptive analysis, simulation diagnostic, multivariate regression, 5-year intervals and with-or-without analysis. The data such as temperature including mean, maximum and minimum data, human capital investment, FDI, GDP growth rate, population, initial net primary and secondary school enrolment from CRU, EM-DAT international disaster database and Africa Development Indicators. The countries have the highest swings in temperature variability which are Sudan, Botswana and Niger changing more than 2 degree Celsius for 49 years. As a result, climate change brings negative effect towards economic growth of Africa because as an increase of 1 degree Celsius in temperature, then the GDP will drop by 0.67%.

Furthermore, Huo et al. (2013) investigated on how the reference and aridity index can be affected by climate change from 1955 to 2008 monthly in China. The data sources were from National Climate Centre (NCC) of China Meteorological Administration for the climatic variables such as temperature, wind speed, precipitation, relative humidity, sunshine hours, aridity index and evapotranspiration. He applied the techniques of FAO Penman-Monteith method, Mann-Kendall test, change-point analysis, sensitivity analyses and sensitivity coefficients and quantitative estimation of the influence of climate variables change on ET_0In the previous 50 years, the annual temperature, precipitation and humidity have a significant relationship toward evapotranspiration and aridity. However, the time, wind speed and solar radiation have a declining trends. The result shows that the annual temperature, relative humidity and precipitation get significant uptrends and diminishing trends for wind speed.

Dell, Jones and Olken (2012) determined the relationship between temperature shocks and economic development in hot country, poor country and agricultural country from 1900 to 2006 using robustness check (Penn World Tables Version 6.2), models with lags, nonlinear temperature effects and panel specifications. For instance, the variables such mean temperature, precipitation, GDP per capita, growth in investment and political economy effects from the sources of Terrestrial Air Temperature and Perception, World Bank database and global rural-urban mapping project. Simply to say, the temperature has a fluctuation towards economic growth especially in the poor countries. As the temperature increase 1 degree Celsius, then the economic growth will decline by 1.3% on average.

Zhang and Wang (2010) applied the techniques such as Mann-Kendall test and Thornthwaite memorial model to examine the relationship between corn yield and the climate changes which are temperature and precipitation in Mongalia, China from 1951 to 2010. They took the data from National Climate Center and Agricultural and Animal Husbandry Department, Inner Mongolia. There is a significant relationship between corn yield and temperature. Although the precipitation does not give a significant result, but it still changes dramatically in 60 years.

A research about the impact of climate change toward the air quality in North America, Europe and Asia was investigated by Jacob and Winner (2008) based on two periods which are 1980 to 1999 and projection of 2080 to 2099 acquiring from 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). The variables used such as temperature, regional stagnation, wind speed, relative humidity, cloud over, precipitation and particular matter (PM) applying CTMs, GCMs and GCM-CTM studies. The highest impacts Baof climate change which are precipitation frequency and mixing depth. After applying GCM-CTM approaches, PM concentrations of particular matters in polluted environments by $\pm$0.1-1 μ gm^{-3}.

Marshall and Randhir (2008) studied the impact of climate change like precipitation and temperature on the watershed system consisting of water yield, sediment loading and nutrient loading in Connecticut River, New England from 1960 to 2000 monthly. The sources data were from NOAA and NCDC and used the methods of simulation model and SWAT. From the result, climate change has a significant affect towards the water quantity and quality in the watershed. Watershed is influenced by the snowmelt and evaporation since as a decreased in annual stream flow, increased in winter and spring runoff, then the annual sediment loading will also increase.

Moreover, Grum (2006) identified the relationship among urban drainage and climate change in Denmark from 1979 to 1996 and forecasted 2071 to 2100. He collected the data of precipitation, rain gauge and hourly rainfall from Hadley-Centr, DMI and IDA using HIR-HAM model, measurement of extreme statistics and water aspects modelling framework. It can be said that the extreme precipitation events influencing the urban drainage and lead to flooding becomes more frequent as one of the result of climate change. A halving of the return periods for hourly intensity extreme events is recommended in this study.

Hamilton et al. (2005) investigated on how the international tourism can be affected by the carbon dioxide emissions. They applied the research methodologies which are SRES scenarios analysis, GCMs, scenario A1B and sensitivity analysis for the projection period from 2005 to 2075. The data sources were from World Tourism Organization, Central Statistical Office Poland, World Resources Institute and Central Intelligence Agency for the variables such as international arrivals, temperature, length of coastline, income per capita, land borders, population density, economic growth, international trips per person and the carbon dioxide emissions emitted by tourism. With climate change, the upward trend has slowed slightly, mainly because frequent travellers from North and West Europe are often close to home. Climate change will cause tourism destinations to gradually shift to the poles and mountains. Declining international tourism will reduce the international travellers and greenhouse gas emissions.

Besides, Chen, McCarl and Schimmelpfennig (2004) also conducted the research on the impact of climate change toward yield variability in United State through statistical investigation. They obtained the yearly data from 1973 to 1997 of temperature, precipitation, rainfall, acreage harvested, carbon dioxide fertilization and the state level productions like corn, cotton, sorghum, soybeans and wheat from USDA-NASS Agricultural Statistics and NOAA Internet homepage. Several techniques to test the variables were used such as panel unit root tests, fixed or random effects, tests of model adequacy, linear and Cobb-Douglas functional forms, serial correlation, range of normality statistics and LM-bar test statistics. In the yield of corn, more rainfall leads to increase in corn yield, while diminishing yield variance and the effect of temperature towards corn yield is reverse effects. Higher temperature will make sorghum yield and yield variability reducing. If the rainfall rises up, the sorghum yield and yield variability will increase too.

Besides, Barrios et al. (2003) mentioned that the growth performance of Africa may be influenced by the rainfall, thus they decided to study the relationship among the variables from 1901 to 1998 using OLS regression techniques and fixed effects for robustness checking. In this study, they examined the climatic variables such as rainfall, rate of real gross domestic product per capita, investment of GDP in percentage, population growth rate, openness government expenditure, agricultural production index and energy production acquired from IPCC, WPT 6.1, FAO database and UN Energy Statistics database. This study found that rainfall has impact on the economic development in sub-Saharan Africa, rather than developing countries.

Hanratty and Stefan (1998) also conducted the impact of climate changing on the agriculture watershed in Minnesota, United State from 1967 to 1992 to test the variables such as suspended sediment concentrations, total phosphorus, nitrate/nitrite, ammonia/organic nitrogen, potential stream bed degradation, flow velocity, inflow to channel, precipitation, temperature solar radiation, relative humidity and wind speed. The data were obtained from USGS Eros Data Center, USDA Natural Resources Conservation Service STATSGO database and Minnesota Pollution Control Agency. They applied scientific techniques which are SWAT96 and evaporation sub model. Overused land and land management practices have more effects on water quality compared to climate change. The relationship of climate change and land management practices on stream flow, stream water quality and ultimately aquatic ecosystem has related with each other.

2.3 Concluding Remark

Depending on the previous analysis and study paper from the different researchers in different countries regarding the impact of climate change on agriculture sector and other fields like international tourism, soil management, the performance of economic development and so on. The literature review is categorized into two groups based on Asia countries and non-Asia countries. There are several similarities and differences comparing both of the Asia and non-Asia countries. Some of them used modelling and econometric analysis to make the study like unit root test, co-integration test through times series and panel analysis. Whilst some of them applied the scientific methods to investigate the consequences of climate change like general circulation model, sensitivity analysis and make the projection in future.

In short, chapter two is related to the previous literatures regarding on the impact of temperature, rainfall and carbon dioxide emissions toward the primary agriculture sector in different countries such as Africa, United State, Turkey, China, Swaziland, Malaysia, Indonesia and the other countries. From the previous studies, the researchers are prompted to study and investigate the impacts of climate change to minimize the risks of the environmental issues nowadays. Before studying the impacts of climate change in further, therefore the previous studies have to be studied before proceed with estimation analysis. Below are the summary table of all the literature review that have been reviewed from the pass case studies.

Table 2.3.1: The summary table of literature review on Asia countries.

Author(s)	**Sources/Variables**	**Data/Country**	**Methodology**	**Findings**
Effendy. Et. Al (2019)	Source: • Questionnaire survey (cross-section data) Variables: • Production of cocoa • Land • Chemical fertilizer • Labor • Cost of pesticide • Cost of pruning • Cost of sanitation	Country: Indonesia Period: 2016	• OLS method • Tobit analysis • Non-parametric approach	• Through Tobit model, the result shows that all of the variables are positive and have significant relationship to rise agriculture output.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Data/Country	Methodology	Findings
Ibrahim, A. O. (2019)	Source: • National Oceanic and Atmospheric Administration (NOAA) • Earth System Research Laboratory (ESRK) • Global Carbon Project Variables: • CO_2 emission levels • Yield of cereal crops • Valued added of agriculture sector to GDP	Period: 1961-2016 (Annual) Country: Sudan	• PP unit root test • ECM specification • ARDL bound test for cointegration analysis	• There is a positive relationship among cereal yield and CO_2 concentration. • CO_2 get a greater positive effect in the short run period compared to the long run period.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Sangkhaphan, S. & Shu, Y. (2019)	Source: • Thai Meteorological Department • National Economic and Social Development Board of Thailand • Department of Provincial Administration Variables: • Gross provincial product (GPP) • Population growth rate • Average rainfall • Average temperature	Country: Thailand Period: 1995 to 2015 (Annual)	• Feasible Generalized Least Squares (FGLS) • Ordinary least squares (OLS)	• Briefly, the economic performance of Thailand can be affected by rainfall negatively, but the temperature does not influence the economic growth at the provincial level.
Urrutia, J. D. (2018)	Source: • The World Bank Indicator • Bureau of Agricultural Statistics Variables: • Real gross value added • Agricultural land area • Government expenditure on agriculture • Employment on agriculture • Agriculture raw material export • Electric consumption per capita	Country: Philippines Period: 1980 to 2013 (Annual)	• Pearson Correlation test • Individual significance test • Granger causality test • Paired-T test • Ramsey RESET • Chow-Breakpoint test	• All of the variables are significant at 0.01 level of significance. • There is a strong and positive correlation between real gross value added and all of the variables except agriculture raw material export. • Through Ramsey RESET test, no specification problem occurs. • Stable parameters are tested using Chow-Breakpoint test.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Busnita, S. S., Oktaviani, R. & Novianti, T. (2017)	Source: • Author calculation using E-Views 8 • Central Statistical Bureau (BPS) • Climate Prediction Center (CPC) Variables: • Rice price volatility • Domestic rice price (Rp/Kg) • Paddy production (Quintal) • Temperature (ENSO Index)	Country: Indonesia Period: January 2007-December 2014 (Monthly)	• ARGH-GARCH model specification • ADF unit root test • Johansen Co-integration test • Vector Auto Regression (VAR/VECM) • Variance decomposition	• There is a negative relationship between the paddy production and temperature in both short run and long run. Rice price production can be affected by temperature positively.
Dumrul, Y. & Kilicarslan, Z. (2017)	Source: • World Bank, World Development Indicator database Variables: • Value added agricultural GDP (% of GDP) • Temperature (℃) • Rainfall (mm)	Period: 1961-2013 (Annual) Country: Turkey	• Unit root test (ADF and PP) • ARDL cointegration test (long run and short run estimate)	• There are two relationship among the agriculture GDP and the climate changes positively and negatively. • If the agriculture GDP increase by 1%, then the precipitation will increase too. • However, if the agriculture GDP decreases by 1%, then the temperature will raise up the trend.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Le, T. T. H. (2016)	Source: • General Statistics Office of Vietnam • U.S. Department of Agriculture • Climate Research Unit (University of East Anglia) Variables: • Rice yield (metric tons per hectare) • Maximum and minimum temperature • Precipitation	Period: 1975-2014 (Annual) Country: Vietnam	• Unit root test • Johansen cointegration test • Lagrange multiplier test for serial correlation • Vietnam rice market model • Parameterization EDM model	• Rice yield can be affected by the temperature and precipitation in the spring and autumn production.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Wang, D., Huo, Y. & Wang, J. (2016)	Source: • China Meteorological Data Sharing Service System (CMDSSS) • China Statistical Yearbook • China Agricultural Statistical Abstracts • China Agriculture Development Report • National Bureau of Statistics of the People's Republic of China Variables: • Annual rice production • Minimum temperature • Maximum temperature • Temperature difference • Precipitation • Sunshine hours • Ratio of paddy area • Quantity of fertilizers • Omissions or apparent errors • Average wage	Country: China Period: 1979-2011 (Monthly)	• Cobb-Douglas function • Regression model • Pooled OLS technique Time and entity FE	• As a result, temperature difference, minimum temperature and precipitation have positive impacts toward rice production. • Climate change has a negative impact towards rice production.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Vaghefi, N. et al. (2016)	Source: • Research Centre for Tropical Climate Change System in National University of Malaysia • Malaysian Meteorological Department (MMD) • Department of Agriculture (DOA) • Department of Statistics (DOS) • Ministry of Agriculture (MOA) • Farmers' Organization Authority (LPP) Variables: • Minimum and maximum temperature • Rainfall • Solar radiation • Population growth rate • Average human lifetime (birth rate and death rate) • Rice stock • Rice consumption (per capita) • Rice supply • Import of rice	Country: Malaysia Period: • 2013-2030 (Daily projected) • 1998-2011 (Annual)	• DSSAT model • Calibration and validation of DSSAT model • System dynamics model • Validation of system dynamics model	• As a result, the increased temperatures and diminished rainfall as expected influence the rice production the most.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Tripathi, A. (2010)	Source: • National Account Statistics (NAS) published from Central Statistical Organization, Government of India • Agricultural Statistics published from Directorate of Economics and Statistics Variables: • Total factor productivity (TFP) index • Total value of agricultural production (GVAO) • Agricultural outputs (farming, livestock, forestry and fisheries) • Conventional inputs (land, capital	Country: Indian Period: 1969 to 2005	• Cobb-Douglas production function • OLS • Ridge regression	• Agricultural growth almost entirely depends on rising trend of conventional factors, whilst productivity growth is negative. • Only in the initial stage of reform, the growth of total factor productivity in agriculture was positive.

Table 2.3.1: The summary table of literature review on Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Zhai, F. & Zhuang, J. (2009)	Source: • World Development Indicator of World Bank Variables: • Electric power consumption (Kilo watt hour KWh per capita) • Average rainfall (mm) • Average temperature (℃) • Carbon dioxide emission (total emission) • Forest area (% of land are) • Arable land (% or land area)	Country: Malaysia Period: 1991-2015 (Annual)	• ADF unit root test • Granger causality • Error correction method • Vector autoregressive model (VAR)	• There is a long run impacts among the electricity power consumption and the independent variables such as average rain, temperature, carbon dioxide emission and arable land. • The dependent variable like electricity consumption and the independent variables which are CO_2 have granger causality causes to average rainfall and average temperature respectively. • If the electricity power consumption increases by 1%, it will lead to diminish of land area and rise up the forest area trend.

Table 2.3.2: The summary table of literature review on non-Asia countries.

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Dogru, T. et al. (2019)	Source: • World Bank database online • Notre Dame Global Adaption Institute (ND-GAIN) online Variables: • Tourism receipts (TR) • Real gross domestic product (GDP) • Vulnerabilities to climate change • Resilience to climate change	Country: Global Period: 1995-2014 (Annual)	• Multivariate analyses • Instrumental validity • Serial correlation test	• When the tourism receipts as dependent variable, the result shows that the vulnerabilities of climate change such as human habitat, food, health and so forth have the high impact comparing resilience of climate change. • Same as the GDP as dependent variable, the vulnerabilities of climate change also affect the entire economy more than resilience to climate change. • Comparing both of the tourism industry and entire economy, tourism industry has the high impact towards climate change.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Muhammad Iftikhar, U. H., Subramanian, A. & Haider, A. (2018)	Source: • World Bank, World Development Indicator database • Climate Research Unit, University of East Anglia with Hadley Centre Variables: • Agriculture value added (current US dollars) • Temperature • Precipitation • Fertilizer consumption • Agriculture input imports • Population • Arable land/agriculture land area	Country: 60 countries Period: 1999-2011 (Annual)	• Descriptive statistics • Panel unit root tests • Regression to identify the mechanism • Two stage least squares • Robustness	• The variables such as temperature and precipitation have negative and positive impacts respectively to agriculture value addition. • If the temperature increases by 1%, then the agriculture yields become lower and vice versa. • As the precipitation increases by 1% and it will lead to increasing trend in agriculture yields.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
WilfreyVuhSiahi, Yego, H. K. & Bartilol, M. K. (2018)	Source: • Food and Agriculture Organization database (FAOSTAT) • African Climate Change Portal Variables: • Maize output • Rainfall • Temperature • Carbon dioxide	Country: Kenya Period: 1961-2015 (Annual)	• ADF unit root test • Johansen cointegration test • Normalized equation • Error correction model • Test for serial correlation • Test for heteroskedasticity	• As a result, temperature and carbon dioxide are positive significant affect the maize production. • However, only rainfall has a negative and not significant impact toward maize output.
Shafinah Rahim & Tay, G. P. (2017)	Source: World Bank Indicators Variables: • Precipitation (mm) • Temperature (˚C) • Arable land (% of land used) • Gross domestic product (current LCU)	Country: Malaysia Period: 1983-2013 (Annual)	• ADF unit root test • Dickey-Fuller GLS (DF-GLS) unit root test • Johansen-Juselius Cointegration test • VECM model • Variance decomposition (VDC) test • Impulse response function (IRF) test	• As a conclusion, the independent variables of temperature and arable land are significant at 5% of significance level, but they have a negative impact towards climate change.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Howard, J. C., Cakan, E. & Upadhyaya, K. P. (2016)	Source: • National Agricultural Statistics Service • National Climatic Data Center Variables: • Total output of wheat production (in bushels) • Oat production (in bushels) • Price of wheat in real terms • Price of oats in real terms • Average yearly temperature (in Fahrenheit) • Average yearly precipitation (in inches)	Country: Kansas, USA Period: 1949-2014 (Annual)	• ADF unit root test • PP unit root test • Johansen cointegration test • Cointegrated vector normalized • Error correction model	• Perhaps the temperature in USA increases, then it will positively impact on the wheat production in the short. • Whereas there is a positive effect to the wheat production in the short run, but it brings negative impact in the long run.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Kahsay, G. A. & Hansen, L. G. (2014)	Source: • Food and Agricultural Organization (FAO) • Climate Research Unit (CRU) Variables: • Net production index or output (in millions of international US dollars) • Labor (1000 person) • Land (1000 hectares) • Machinery • Livestock (head count of cattle, sheep and goats in millions) • Fertilizer (1000 tonnes nutrients) • Irrigation (1000 hectares) • Mean temperature • Mean precipitation • Precipitation and temperature variability	Country: Eastern Africa (9 countries) Period: 1983-2014 (Annual)	• Parameter estimates • Predicted future climate change scenarios	• The researchers predicted and found that impacts of mean season temperature and precipitation as well as within growing season variance of precipitation. • Based on the climate scenarios, it is forecasted to gain a negative output impact of climate change.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Blanc, E. (2012)	Source: • FAOSTAT • CRU TS 2.1 dataset • Mauna Loa Observatory, Hawaii • Satellite-derived land cover data Variables: • Carbon dioxide concentration (CO_2) • Cassava yield (tonnes/Ha) • Maize yield (tonnes/Ha) • Millet yield (tonnes/Ha) • Sorghum yield (tonnes/Ha) • Land area (ha) • Precipitation (mm) • Drought • Flood • Temperature • ET_0 (mm/day)	Country: Sub-Saharan Africa (SSA) Period: 1961-2011 (Annual)	• ADF unit root test • Cointegration test • Diagnostic test • T-P and ET-SPI regressions	• There is a significant impact of weather on yields. • There is a significant result among crops yield and the climate change which are temperature and precipitation. • Rainfall has big impact of changes in millet and sorghum yields in LFAC countries compare to non-LFAC countries.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Oseni, T. O. & Masarirambi (2011)	Source: • Malkerns Research Station • Malkerns and Swaziland Ministry of Agriculture • Manzini Regional office Variables: • Average monthly and annual rainfall • Precipitation • Average annual output per hectare of maize • Maize production (tonnes)	Country: Swaziland Period: 1990-2009 (Annual)	• Analysis of variance (ANOVA) • Regression analysis	• As a result, a significant differences in average rainfall and growing season rainfall on maize production. • Maize production can be influenced negatively by the reduction in both mean annual and planting season precipitation.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
McCarl, B., Villavicencio, X. & Wu, X. (2009)	Source: • Economic Research Service (ERS) of US Department of Agriculture (USDA) • National Oceanic and Atmospheric Administration (NOAA) Variables: • Mean annual temperature (℉) • Total precipitation (inches) • Agriculture TFP • Public agricultural research capital (RPUB) • Share of SAES budget coming from federal formula funds (SFF) • Share of SAES budget from federal grants and contracts (GR) • Stock of public extension capital (EXT) • Public agriculture research spill-in stock (RPUBSPILL) • Private agricultural research capital (RPRI)	Country: United States Period: 1970-1990 (Annual)	• Panel unit root tests • Panel cointegration tests • Panel error correction model	• The inclusion of climate variables such as temperature, amount and intensity of precipitation and also the evaluation and correction of problems due to non-stationary of some of the variables.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Dogan, H. G. (2018)	Source: • World Bank Variables: • CO_2 (million tones) • Share of agricultural fields within total area (% of land area) • Agriculture added value (current US$) • GDP per capita (current US$) • Population (total number of people)	Country: Eurasia (12 countries) and Turkey Period: 1993-2016 (Annual)	• ADF unit root test • Autoregressive distributed lag bound test (ARDL) • Vector error correction model	• All of the variables have rising up trend to the carbon dioxide emissions in the long run. • Population affects the most on carbon dioxide level especially in Turkey. • There is a linear relationship among agriculture share and carbon dioxide in Eurasian, but it becomes negative in Turkey side.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Oussama Zouabi & Mohamed Kadria (2016)	Source: • National Institute of Statistics (NIS) • Institute of Quantitative (IEQ) • Statistical yearbooks of Tunisia • National Observatory of Agriculture (ONAGRI) • National Institute of Meteorology • Micro-disaggregated database Variables: • Agricultural production of governorates • Average temperature • Precipitation	Country: Tunisia Period: 1980-2012 (Annual)	• Spatial autocorrelation tests (global and local) • Multiplier tests of Lagrange • Spatial autoregressive model (SAR) • Spatial Durbin model (SDM) • Robustness checks • Unit root test panel • Cointegration test • FMOLS estimation (micro-spatial effect)	• There is a direct and indirect climate change impact on the production yield such as cereal, olive and citrus fruit in the long run. • It can be considered a serious issue in Tunisia due to climate change effects on food production.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Abidoye, B. O. & Odusola, A. D. (2015)	Source: • Climate Research Unit (CRU) • EM-DAT international disaster database • Africa Development Indicators Variables: • Monthly mean temperature data • Maximum and minimum temperature • Human capital investment • Foreign direct investments • Annual percentage growth rate of GDP • Population • Initial net primary school enrolment • Initial secondary school enrolment	Country: Africa Period: 1901-2009 (Annual)	• Simple correlation and descriptive analysis • Simulation diagnostic • Multivariate regression • 5-year intervals • With-or-without analysis	• The countries have the highest swings in temperature variability which are Sudan, Botswana and Niger changing more than 2 degree Celsius for 49 years. • There is a negative effect of climate change towards economic growth in Africa because as an increase of 1 degree Celsius in temperature, then the GDP will drop by 0.67%.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Huo, Z. et al. (2013)	Source: • National Climate Centre (NCC) of China Meteorological Administration Variables: • Mean minimum air temperature • Mean maximum air temperature • Mean human relative humidity • Mean wind speed at 2m • Bright sunshine hours • Precipitation • Aridity index • Evapotranspiration	Country: China Period: 1955-2008 (Monthly)	• FAO Penman-Monteith method • Mann-Kendall test • Change-point analysis • Sensitivity analyses and sensitivity coefficients • Quantitative estimation of the influence of climate variables change on ET_0	• In the past 50 years, the annual temperature, humidity and precipitation have a significant relationship toward evapotranspiration and aridity. • However, the time, wind speed and radiation have a decreasing trends. • The result shows that the annual temperature, humidity and precipitation get significant uptrends and diminishing trends for wind speed and radiation due to varies of seasonal trend.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Dell, M., Jones, B. F. & Olken, B. A. (2012)	Source: • Terrestrial Air Temperature and Perception • World Development Indicators (World Bank) • Global Rural-Urban Mapping Project Variables: • Monthly mean temperature • Precipitation • GDP per capita • Growth in agriculture value added • Growth in investment • Political economy effects	Country: Global Period: 1900-2006 (Annual)	• Robustness check (Penn World Tables Version 6.2) • Models with lags • Nonlinear temperature effects • Panel specifications	• The temperature has a fluctuation towards economic growth especially in the poor countries. • As the temperature increase 1 degree Celsius, then the economic growth will decline by 1.3% on average.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Zhang, B. & Wang, Z. (2010)	Source: • National Climate Center • Agriculture and Animal Husbandry Department, Inner Mongolia Variables: • Temperature • Precipitation • Corn yield • Climate productivity •	Country: Mongolia, China Period: 1951-2010 (Annual)	• Mann-Kendall test • Thornthwaite memorial model	• There is a significant relationship between corn yield and temperature. • Although the precipitation does not give a significant result, but it still changes dramatically in 60 years.
Jacob, D. J. & Winner, D. A. (2008)	Source: • 4^{th} Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) Variables: • Temperature • Regional stagnation • Wind speed • Humidity • Cloud over • Precipitation Particular matter (PM)	Period: • 1980-1999 (Annual) • 2080-2099 (Annual) Country: North America, Europe and Asia	• Chemical transport models (CTMs) • General circulation models (GCMs) • GCM-CTM studies	• The most important impacts of climate change which are precipitation frequency and mixing depth. • After applying GCM-CTM approaches, PM concentrations of particular matters in polluted environments by $\underline{+}0.1$-1 μgm^{-3}.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Marshall, R. & Randhir, T. (2008)	Source: • National Oceanic and Atmospheric Association (NOAA) • National Climatic Data Center (NCDC) Variables: • Precipitation • Maximum and minimum temperature • Water yield • Sediment loading • Nutrient loading	Country: Connecticut River, New England Period: 1960-2000 (Monthly)	• Simulation model • Soil and Water Assessment Tool (SWAT)	• From the result, climate change has a significant affect towards the water quantity and quality in the watershed. • Watershed is influenced by the snowmelt and evaporation since as a decreased in annual stream flow, increased in winter and spring runoff, then the annual sediment loading will also increase.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Grum, M. et al. (2006)	Source: • Hadley-Centre • Danish Meteorological Institute (DMI) • Danish Engineering Society (IDA) • Danish rainfall KMD Variables: • Average precipitation • Rain gauge • Hourly rainfall	Country: Denmark Period: • 1979-1996 (Annual) • 2071-2100 (Annual)	• HIR-HAM model • Measurement extreme statistics • Water Aspects modelling framework	• It can be said that the extreme precipitation events influencing the urban drainage and lead to flooding becomes more frequent as one of the result of climate change. • A halving of the return periods for hourly intensity extreme events is recommended in this study.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Hamilton, J. M. et al. (2005)	Source: • World Tourism Organization • Central Statistical Office Poland • World Resources Institute • Central Intelligence Agency Variables: • Number of international arrivals • Annual average temperature • Length of coastline • Income per capita • Number of land borders • Population density • Economic growth • Number of international trips per person • Total CO_2 emitted by international tourism	Country: Global Period: 2005-2075 (Annual)	• SRES scenarios analysis • Circulation models (GCMs) • Scenario A1B • Sensitivity Analysis (simulation mode)	• With climate change, the upward trend has slowed slightly, mainly because frequent travellers from North and West Europe are often close to home. • Climate change will cause tourism destinations to gradually shift to the poles and mountains. • Declining international tourism will reduce the international travellers and greenhouse gas emissions.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Chen, C. C., McCarl, B. A. & Schimmelpfennig, D. E. (2004)	Source: • USDA-NASS Agricultural Statistics • NOAA Internet home page Variables: • Temperature • Precipitation • Rainfall • Acreage harvested • CO_2 fertilization State-level yields (corn, cotton, sorghum, soybeans, wheat)	Country: United State Period: 1973-1997 (Annual)	• Panel unit root tests • Fixed or random effects • Tests of model adequacy • Linear and Cobb-Douglas functional forms • Serial correlation • Range of normality statistics • LM-bar test statistic	• In the yield of corn, more rainfall leads to increase in corn yield, while diminishing yield variance and the effect of temperature towards corn yield is reverse effects. • Higher temperature will make sorghum yield and yield variability reducing. • If the rainfall rises up, the sorghum yield and yield variability will increase too.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Barrios, S. et al. (2003)	Source: • Intergovernmental Panel on Climate Change (IPCC) • World Penn Tables (WPT) 6.1 • FAO database • UN Energy Statistics database Variables: • Average annual rainfall • Real GDP per capita growth rate • Investment (% of GDP) • Population growth rate • Openness • Government expenditure (% of GDP) • Agricultural production index • Energy production	Country: Global Period: 1901-1998 (Annual)	• OLS regression techniques • Fixed effects (robustness)	• The study found that rainfall has impact on the economic growth in sub-Saharan Africa, rather than developing countries.

Table 2.3.2: The summary table of literature review on non-Asia countries (continued).

Author(s)	Sources/Variables	Country/Period	Methodology	Findings
Hanratty, M. P. & Stefan, H. G. (1998)	Source: • U.S. Geological Survey (USGS) Eros Data Center • U.S. Department of Agriculture (USDA) Natural Resources Conservation Service STATSGO database • Minnesota Pollution Control Agency Variables: • Suspended sediment concentrations • Total phosphorus • Nitrate/nitrite • Ammonia/organic nitrogen • Potential stream bed degradation • Flow velocity • Inflow to channel • Precipitation • Temperature solar radiation • Relative humidity • Wind speed	Country: United State Period: 1967-1992 (Annual)	• Soil and water assessment tool, 1996 version (SWAT96) • Evaporation submodel	• Overused land and land management practices have more effects on water quality compared to climate change. • The relationship of climate change and land management practices on stream flow, stream water quality and ultimately aquatic ecosystem has related with each other.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

This research paper aims to examine the relationship between the primary agriculture sector and the climate change such as rainfall, agriculture land and carbon dioxide emissions in selected ASEAN countries. In Chapter 3, the different research methodologies will be applied to carry out the empirical analysis. Firstly, Section 3.1 is about the research design and the following sections explaining the research methodologies. For instance, the tests such as Augmented Dickey-Fuller (ADF) test, Phillips-Perron (PP) test, Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test, Johansen and Juselius cointegration test, Vector Error Correction Model (VECM) tests for normalized equation and granger causality, variance decomposition, impulse response and diagnostic tests are employed using E-Views 10.0 software.

3.1 Research Design

The purpose of conducting this research study is to identify the impact of rainfall, agriculture land and carbon dioxide emissions toward the primary agriculture sector in Malaysia, Indonesia, Philippines, Thailand and Vietnam. Besides, it is to examine the relationship between crop production index and climate change variability whether they are significant or insignificant positively or negatively. The causality study is carried out to investigate the cause, direction and effect relationship among primary agriculture sector and the rainfall, agriculture land and carbon dioxide emissions in selected ASEAN countries. Moreover, it is to study the stability of primary agriculture sector and the climate change such as rainfall, agriculture land and carbon dioxide in

Malaysia, Indonesia, Philippines, Thailand and Vietnam that have never been studied before.

3.1.1 Data Description

In this research study, all of the dependent variable (primary agriculture sector) and independent variables (rainfall, agriculture land as control variable and carbon dioxide as proxy of climate change) are applied the secondary data for 35 years from year 1980 to 2014. For dependent variable, the annual GDP share of agriculture in percentage was obtained from theGlobalEconomy.com, The World Bank. Whilst for the independent variables, the monthly rainfall (mm) were collected from Climate Change Knowledge Portal, World Bank Gorup. After acquiring the monthly mean data for temperature and rainfall, the simple calculations have to conduct in order to get the average annual rainfall which are added up all of the mean monthly temperature and rainfall from January to December of the year, then divide by 12 months.

In addition, the data of share of agriculture land area in percentage and carbon dioxide emission (kiloton) was obtained from World Development Indicators (WDI) of the World Bank data. Logarithm is applied on the variables which the log transformation compressing the scales in the measured variable to reduce the heteroscedasticity and difference among the variables (Gujarati, 1995). The time series analysis is used in this study.

3.1.2 Theoretical Model

Based on the study, a few variables are applied such as rainfall, agriculture land and carbon dioxide of climate change to study the relationship between primary agriculture sector and the climate change. The econometric model is written as below:

$$CRO_i = f\,(RAI_i, AGR_i, CO2_i)$$

While *i* represent Malaysia (MYS), Indonesia (IND), Philippine (PHL), Thailand (THA) and Vietnam (VNM).

Thus, the model specification of the log-linear primary agriculture sector in Malaysia, Indonesia, Philippines, Thailand and Vietnam are expressed as below:

$$LGCROM_t = \beta_0 + \beta_t LGRAI_t + \beta_{2t} LGAGR_t + \beta_{3t} LGCO2_t + \varepsilon_t \tag{1}$$

$$LGCROI_t = \beta_0 + \beta_t LGRAI_t + \beta_{2t} LGAGR_t + \beta_{3t} LGCO2_t + \varepsilon_t \tag{2}$$

$$LGCROP_t = \beta_0 + \beta_t LGRAI_t + \beta_{2t} LGAGR_t + \beta_{3t} LGCO2_t + \varepsilon_t \tag{3}$$

$$LGCROT_t = \beta_0 + \beta_t LGRAI_t + \beta_{2t} LGAGR_t + \beta_{3t} LGCO2_t + \varepsilon_t \tag{4}$$

$$LGCROV_t = \beta_0 + \beta_t LGRAI_t + \beta_{2t} LGAGR_t + \beta_{3t} LGCO2_t + \varepsilon_t \tag{5}$$

$LGCROM_t$= Logarithm of crop production index of Malaysia for period of *t*

$LGCROI_t$= Logarithm of crop production index of Indonesia for period of *t*

$LGCROP_t$= Logarithm of crop production index of Philippines for period of *t*

$LGCROT_t$= Logarithm of crop production index of Thailand for period of *t*

$LGCROV_t$= Logarithm of crop production index of Vietnam for period of *t*

$LGRAI_t$= Logarithm of rainfall for period of *t*

$LGAGR_t$= Logarithm of agriculture land for period of *t*

$LGCO2_t$= Logarithm of carbon dioxide emissions for period of *t*

β_i= Coefficient of variables, *i* = 1, 2, 3

ε_t= Error Term

The expected sign of coefficients for the explanatory variables based on the theory are interpreted as below:

$$\beta_1 LGRAI > 0;\ \beta_2 LGAGR < 0;\ \beta_3 LGCO2, < \text{or} > 0$$

Where $\beta_1 LGRAI$ can be positive sign or negative sign. From the previous studies, it is forecasted to get positive and negative sign since Chen, McCarl and Schimmelpfennig (2004) and Sangkaphan and Shu (2019) shows the result that the rainfall has a positive and negative relationship respectively. Next, Urrutia (2018) tested that the temperature has a positive and significant relationship in the study. Besides, $\beta_3 LGCO2$ expects to get negative sign in the long run because of the previous research paper from Ibrahim (2019).

Diagrammatically, the model framework of this study can be expressed as below:

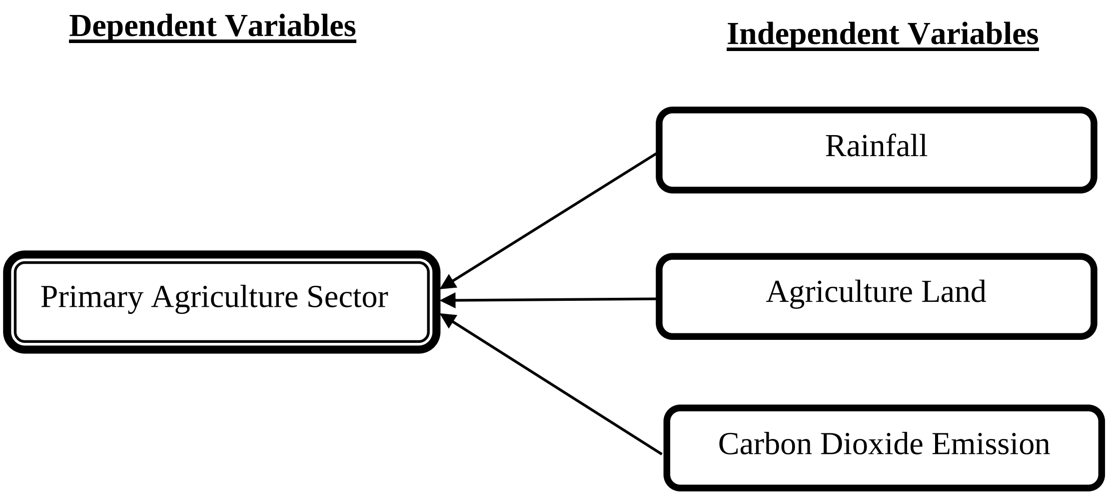


Figure 8: The model framework of the impact of climate change on primary agriculture sector.

From the figure above, it illustrates that the model framework of this research study which the primary agriculture sector can be influenced by the climate change such as rainfall, agriculture land and the carbon dioxide emissions in selected ASEAN countries such as Malaysia, Indonesia, Philippines, Thailand and Vietnam.

3.1.3 Data Analyzing Method

In order to determine the relationship between the primary agriculture sector and the climate change such as rainfall, agriculture land and carbon dioxide emissions, there are five types of research methodologies are applied in this study. Firstly, the unit root test which are Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests are used to identify the presence of unit roots for each variable, whilst Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test uses to confirm the results of both ADF and PP tests. They are used to test the variables whether they are stationary or non-stationary.

After testing unit root tests, the independent variables are stationary in the first difference which implies that they are integrated of order one and also called $I(1)$ series. Therefore, a cointegration test is necessary to perform for establishing a long run relationship between primary agriculture sector and the climate change such as temperature, rainfall and carbon dioxide emissions. Assumed that a long run relationship in the model despite the fact that the series are drifting apart or trending either upward or downward. In this case, a Johansen cointegration test is applied as a prominent cointegration tests for the series.

Thirdly, the vector error correction model (VECM) test is applied in this study. There are two types of the model such as normalized equation and granger causality test. For normalized equation, it is to determine the independent variables whether they are significant or insignificant, whilst the casual direction on the impact of climate change toward agriculture sector can be identified through granger causality test based on the vector error correction model. Next, variance decomposition and impulse response function also are applied in this study to test the primary agriculture and the climate change whether they are exogenous or endogenous and the forecast trend in future as long as 50 years. The last is diagnostics tests to check the relevancy of the primary agriculture sector.

3.2 Unit Root Tests

Accordingly to Gujarati and Porter (2009), the unit root test is a common, popular and widely used empirical time series method to test the variables whether they are stationary or non-stationary. It is very important for the researchers to know perhaps the stocks have permanent or transitory effect and forecasting on the process of attractor. Varies stationary and trend stationary models tend to have different predictions in the same time series. There are only a few types of unit root tests will be applied in this study such as Augmented Dickey Fuller (ADF) test, the Phillips-Perron (PP) test and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test.

3.2.1 Augmented Dickey-Fuller (ADF) Test

Augmented Dickey Fuller (ADF) test is an augmented statistical version test of original Dickey-Fuller test which came from David Dickey, Wayne Fuller and also Said and Dickey for a larger set of time series models to identify the stationary series and apply with serial correlation. The ADF test constructs a parametric correction for higher-order correlation by assuming that the series follows an AR (*p*) process and adding *p*-lagged difference terms of the dependent variable to the right-hand side of the test regression:

$$\Delta Y_t = \alpha_0 + \delta Y_{t-1} + \sum_{i=2}^{P} \beta_i \Delta\, Y_{t-i+1} ++ \varepsilon_t \tag{6}$$

This augmented specification is then used to test the hypothesis using t-ratio. The symbols of Δ is the change or difference, *p* represents lag value, ε indicates adjustment of error and X are the variables under this study. The null and alternative hypothesis are written as following:

$$H_0 : \alpha = 0 \text{ (The variables is non-stationary)}$$

$$H_1 : \alpha < 0 \text{ (The variable is stationary)}$$

Perhaps there has a non-stationary variable in level, then the first difference can continue when the coefficient of α_1 is zero and ensure that the all of the variables are stationary at the first difference. The data will integrate without unit root in order one or called *I*(1) series.

3.2.2 Phillips-Perron (PP) Test

Moreover, Phillips-Perron (PP) test is slightly a difference from ADF test since PP test is focused on how to deal with serial correlation and heteroscedasticity in the errors. Below are the null hypothesis and alternative hypothesis of PP test:

$$H_0 : \delta = 0 \text{ (The variables is non-stationary)}$$

$$H_1 : \delta < 0 \text{ (The variable is stationary)}$$

The decision rule of PP test is that the alternative hypothesis can be rejected if the probability is smaller than 0.01, 0.05 and 0.1 at the significance level of 1%, 5% and 10% respectively. It implies that the variables are stationary and unit root does not exist. Conversely, perhaps the probability exceeds the significance level, the null hypothesis is fail to reject and there is unit root exist or non-stationary. The regression model of PP are as below:

$$X_t = \mu + \beta x_{t-1} + \mu_t \qquad (t = 1, 2, 3, \ldots T) \tag{7}$$

Where μ refers to the innovation term. In order to test the unit root, the regression t-statistic for the null hypothesis ($H_0 : \beta = 1$) represents by t_β which is adjusted non-parametrically for the possible serial correlation in μ_t.

3.2.3 Kwiatkowski-Phillips-Schmidt-Shin (KPSS) Test

The KPSS test is the most commonly used fixed test. The KPSS test is much more stable than the ADF and PP tests. Compared with the KPSS test, the ADF and PP tests are not very helpful in distinguishing the unit root and the close unit root. The weakness of ADF and PP tests is that they consume less power at small sample sizes. In the KPSS test, univariate sequences can be divided into the sum of deterministic trends, random walks, and stationary I (0) disturbances (Kwiatkowski et al., 1992). In addition, it is based on the Lagrangian multiplier principle. This test has opposite null hypotheses and alternative hypotheses for the ADF and PP tests.

The decision rule of KPSS is different with ADF test and PP test which is expressed as below;

$H_0 : \delta < 0$ (Unit root does not exist/ Shock will die off / Stationary)

$H_1 : \delta = 0$ (Unit root exist/ Shock will persist / Non-stationary)

3.3 Johansen and Juselius Cointegration Test

Cointegrationis refers to the essential property in time series analysis to test the long term equilibrium of the variables. It prefers more than one cointegrating relationship and to be cointegrated if two or more series are non-stationary but a linear combination of them is stationary. In this study, Johansen and Juselius (1990) approach will be use is to measure the long term relationship that may occur in the selective variables. Therefore, the hypothesis can be stated as below;

H_0: There is no cointegrating equation.

H_1: There is cointegrating equation.

There are two types of Johansen test which is trace and max-Eigen and the inferences was different. The null hypothesis for the trace test is number of cointegration vectors ($r = r^* < k$) while the alternative hypothesis is $r = k$. Whereas the null hypothesis for the max-Eigen test is similar as the null hypothesis of trace, however, the alternative hypothesis is $r = r^* + 1$ (Hjalmarsson and Osterholm, 2007). The movements of long run relationship is at below:

$$\Delta Z_t = \prod Z_1 + \sum_{i=1}^{k-1} \prod_i \Delta Z_{t-i} + \mu_t + \varepsilon_t \quad (8)$$

Where, Z_t is the (n x 1) vector of the *I(1)* variables:; of a ($\times$) coefficient matrixes, and a ($\times$1) constant vector; $\prod$ and $\prod_t$ is where (i=1, …, k-1) of a (n x n) coefficient matrixes and (n x 1) is the constant vector, ε_t represents independent, normally distributed (mean=0) with the covariance matrix of Ω, k is the lag length and Δ implies the changes operator. is the length and Δ is the difference operator.

3.4 Vector Error Correction Model (VECM) Tests

Vector Error Correction Model (VECM) was applied in conducting the test to prevent the problems of misspecification (Clarke, 2006). VECM is a restricted vector autoregression (VAR) that can be utilized for non-stationary series when the series are cointegrated. The VECM has cointegration built into its specification to restrict the long runrelationhsip of endogenous variables. The restriction is required to converge the cointegrating relationships and enable short-run adjustment dynamics. The Error Correction Term (ECT) is the cointegration term because through the series of partial short-run adjustments, the deviations from the long-run equilibrium are corrected gradually.

3.4.1 Normalized Equation

Normalized Equation in VECM will be used to investigate which terms are prevalent in given situations. Moreover, the normalization considerably simplifies the expressions which is very useful in dimensionless units (Aquino, 2005). The normalized equation model is expressed as below:

$$LGCRO_t = \beta_0 + \beta_t LGTEM_t + \beta_{2t} LGRAI_t + \beta_{3t} LGCO2_t + \varepsilon_t \qquad (9)$$

Where, LGCRO represent the crop production index of primary agriculture, LGTEM refers to temperature, LGRAI is the rainfall and also LGCO2 indicates the carbon dioxide emissions. Through normalized equation, the result of significant or significant and the relationship between primary agriculture and climate change in Malaysia, Indonesia, Philippines, Thailand and Vietnam positively or negatively will be discussing in further.

3.4.2 Granger Causality Test

Furthermore, VECM Granger Causality test will be used in this study in determining the short-run relationship and the direction among each variables. Granger Causality is a statistical hypothesis test which used to verify whether one time series is to be say useful in forecasting another. The causality relationship was based on two principles, which are the cause happens prior to its effect and the cause has unique information about the future values of its effect. The cointegration testbased on VECM is described below:

$$\Delta LGCRO_t = \phi_0 + \sum_k \phi_1 \Delta LGTEM_{t-k} + \lambda_1 e_{t-1} + V_t \quad (10)$$

3.4.3 Variance Decomposition

Variance decomposition defines as a classical statistical method in multivariate analysis to uncover the simplify structures in a large set of variables. In the time series analysis, variance decomposition or know as forecast error variance decomposition (FEVD) is used to aid in the interpretation of the vector autoregression (VAR) model once it has been fitted. It indicates the amount of information each variable contributes to the other variables in the autoregression. Besides, it also measures the number of the forecast error variance of each of the variables can be explained by exogenous shocks to the other variables (Lutkepohl, 2010).

3.4.4 Impulse Response Function

In addition, the impulse response also known as impulse response function (IRF) will be used in this study to describes the reaction of the system as a function of time or other independent variable that parameterizes the dynamic behavior of the system. It is a signal processing of a dynamic system when presented with a brief input signal (impulse). In generally, Impulses that treated as exogenous in this study are the temperature, rainfall and carbon dioxide emissions. These impulse response is reaction to any dynamic system responding to the external changes. It is because the impulse function contains all of the frequencies and refers to the response of a liner time invariant system for all frequencies (Lutkepohl, 2010).

3.5 Diagnostics Tests

3.5.1 Normality Tests

The normality test proves the histogram and descriptive statistics of the residuals. If the residuals are normally distributed, the histogram is represented in a bell shape and Jarque-Bera's statistics are trivial. The hypothesis testing for normality test is as followed:

H_0: Residuals are normally distributed

H_1: Residuals are not normally distributed

3.5.2 Auto-Regressive Conditional Heteroscedasticity (ARCH) Test

According to Engle (2001), in order to analyse and forecast volatility, ARCH and Generalized ARCH (GARCH) have become useful tools in the analysis of time series data. Besides that, from the perspective of econometric inference, ignoring ARCH may lead to arbitrarily large loss in asymptotic efficiency and will cause over rejection of standard tests for serial correlation in conditional mean (Hong & Shehadeh, 1999). In addition, as from Bera and Higgins (1993), the ARCH model is practical as it not only catches useful facts, and also applications to numerous and diverse areas.

Not only in their study, it has been implemented in asset pricing to test the I-CAPM, the CAAPM, the APT, and the CCAPM. Moreover, according to Wang et al. (2005), ARCH-type model is a nonlinear model which takes into account of the past variances in the explanation for the future variances. This type of model can produce a more accurate forecast of future volatility, especially over a short horizon. ARCH-type models take into account excess kurtosis, which is common in hydrologic processes therefore they might come in handy for hydrologic time series modelling (Wang et al., 2005).

There is the evidence to reject the null hypothesis if the test statistic is higher than the critical value from a chi-square distribution with q degrees of freedom as compared with the null hypothesis of no existence of ARCH error versus the alternative hypothesis which that the conditional error variance is given by an ARCH (q) process. The test hypothesis for heteroscedasticity test is:

H_0: Variance of residuals are constant or homocedasticity

H_1: Variance of residuals are unequal or heteroscedasticity

3.5.3 Breusch-Godfrey LM Test

According to Baum, Schaffer, and Stillman (2007), Breusch and Godfrey proposed that the LM test can be applied to ordinary least square (OLS) regressions. According to Gujarati and Dawn (2009), Durbin-Watson and Durbin's h test have the same features as Breusch-Godfrey LM test do, but LM test marks an important note that the lagged dependent variables and serial correlation have to be in higher level. Breusch-Godfrey Serial Correlation LM test imply to find out autocorrelation problem.

Null hypothesis will be free from autocorrelation problem whereas, alternative hypothesis will be stated to have an autocorrelation problem. If result shows the p-value is less than the significant level, the null hypothesis will be rejecting and can conclude that model consists of autocorrelation problem. When autocorrelation problem occurred, it means that the estimated parameter tends to be unbiased, inefficient and consistent therefore, no longer Best Linear Unbiased Estimators (BLUE). The test hypothesis for BG LM test is:

H_0: There is no serial correlation

H_1: There is serial correlation

CHAPTER FOUR

EMPIRICAL RESULTS AND INTERPRETATIONS

4.0 Introduction

Throughout the chapter four, the empirical results and interpretations of the impact of rainfall, agriculture land and carbon dioxide toward primary agriculture in five selected ASEAN countries which are Malaysia, Indonesia, Philippines, Thailand and Vietnam will be discussing. The time series data for 35 years from 1980 to 2014 are used to analyse the relationship between primary agriculture output and climate change and transformed into logarithm. Crop production index for five selected ASEAN countries are chosen as dependent variables and the independent and control variables such as rainfall, agriculture land and carbon dioxide.

Firstly, unit root tests such as Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests are used to examine the order of integration of the variables. Secondly, Johansen and Juselius cointegration test applies to investigate the long run relationship between primary agriculture and climate change in selected ASEAN countries. Thirdly, the section is regarding the results of Error Correction Model (VECM) and granger causality test which refers to the long and short run causal relationship between the variables respectively. The fourth and fifth section indicates the results of variance decomposition and impulse response to forecast the effects of shocks in the period of 50 years. Last but not least, section six discusses the results of diagnostic tests such as Jarque Bera normality test, Breusch-Godfrey serial correlation Lagrange Multiplier (AR) test and Autoregressive

Conditional Heteroscedasticity (ARCH) test in order to check the superiority of the models.

4.1 Unit Root Tests Results

4.1.1 ADF Unit Root Test

Table 3: Result of ADF test.

	Level		First Difference	
Variables	**Trend and Intercept**	**Intercept**	**Trend and Intercept**	**Intercept**
Malaysia (1980-2014)				
LGCROP	-2.8506(0)	-0.8744(0)	-7.8271(0)**	-7.8658(0)**
LGRAI	-2.6876(3)	-2.0245(3)	-6.2901(1)**	-6.4111(1)**
LGAGR	-2.2473(1)	-1.6621(1)	-3.0604 (2)**	-2.4190(0)**
LGCO2	-1.3294(0)	-1.3187(0)	-6.4690(0)**	-6.3518(0)**
Indonesia (1980-2014)				
LGCROP	-2.4156(0)	-0.5670(0)	-6.5914(0) **	-6.7014(0) **
LGRAI	-2.8188(3)	-1.7011(4)	-7.3519(1)**	-7.4777(1)**
LGAGR	-2.0927(0)	-0.3932(0)	-4.7684(0)**	-4.8553(0)**
LGCO2	-2.9884(0)	-1.0467(0)	-5.4536(1)**	-5.5705(1)**
Philippines (1980-2014)				
LGCROP	-2.1210(3)	-0.6847(0)	-5.5247(1)**	-5.6170(1)**
LGRAI	-2.6490(4)	-1.6528(4)	-6.3697(2)**	-6.5432(2)**
LGAGR	-0.8845(0)	0.6234(0)	-4.6864(0)**	-4.6173(0)**
LGCO2	-1.9979(0)	0.2810(0)	-4.5301(0)**	-4.5827(0)**
Thailand (1980-2014)				
LGCROP	-2.2674(3)	0.1317(2)	-7.3631(1)**	-7.4932(1)**
LGRAI	-2.7920(4)	-2.2058(3)	-8.7637(0)**	-8.9317(0)**
LGAGR	-2.3076(3)	-2.4414(3)	-3.4357(0)**	-3.4910(0)**
LGCO2	-0.2632(0)	-1.6686(0)	-4.2824(0)**	-3.7338(0)**
Vietnam (1980-2014)				
LGCROP	-1.9486(5)	-0.8799(0)	-6.4443(0)**	-6.3950(0)**
LGRAI	-2.6036(4)	-1.5648(5)	-5.0274(4)**	-5.0896(4)**
LGAGR	-2.005(1)	0.9890(1)	-3.8780(0)**	-3.4437(0)**
LGCO2	-1.9256(0)	0.4046(0)	-5.0836(0)**	-5.0476(0)**

Notes: ** denotes rejection at 5% significance level. Number in parentheses is the number of lag length.

Based on the table, it implies that the result of ADF test in Malaysia, Indonesia, Philippines, Thailand and Indonesia. The maximum lag lengths are automatically determine following the Schwartz Information Criteria (SIC). All of the variables are non-stationary and unit roots exist at level since the probabilities are lower than 0.05 at 5% significance level, so the null hypotheses are failed to reject. After the first difference conducting, all of the variables become stationary and there are no unit roots existing because the null hypotheses can be rejected at 5% of significance level if the probabilities exceed the critical value of 0.05. In other words, it means that the variables are integrated at order one or called $I(1)$.

4.1.2 PP Unit Root Test

Table 4.1.2.1: Result of PP test.

	Level		First Difference	
Variables	**Trend and Intercept**	**Intercept**	**Trend and Intercept**	**Intercept**
Malaysia (1980-2014)				
LGCROP	-2.7979(2)	-0.9434(5)	-7.9314(1)**	-8.1324(2)**
LGRAI	-4.2947(5)	-3.7955(3)	-6.6806(0)**	-6.7971(0)**
LGAGR	-1.9180(3)	-2.0524(3)	-2.5402(1)**	-2.5684(2)**
LGCO2	-1.3459(2)	-1.3755(1)	-6.4366(2)**	-6.3227(2)**
Indonesia (1980-2014)				
LGCROP	-2.4449(3)	-0.5910(3)	-6.7084(2)**	-6.8287(2)**
LGRAI	-5.6600(3)	-5.3758(3)	-8.5989(0)**	-8.7426(0)**
LGAGR	-2.2662(1)	-0.4466(1)	-4.7247(3)**	-4.8170(3)**
LGCO2	-2.7530(5)	-1.0575(3)	-5.6207(2)**	-5.7290(3)**
Philippines (1980-2014)				
LGCROP	-3.1820(6)	-0.5741(4)	-6.0626(1)**	-6.1717(1)**
LGRAI	-4.6434(4)	-4.1080(4)	-9.3213(3)**	-9.5253(3)**
LGAGR	-1.0532(2)	0.6234(0)	-4.6931(1)**	-4.6173(0)**
LGCO2	-2.2675(3)	0.0389(3)	-4.5290(1)**	-4.5790(1)**
Thailand (1980-2014)				
LGCROP	-3.6119(4)	-0.0792(3)	-5.8857(1)**	-5.9921(1)**
LGRAI	-5.3221(5)	-4.8394(5)	-9.4513(2)**	-9.6505(2)**
LGAGR	-1.7456(4)	-1.7516(4)	-3.6029(6)**	-3.4636(3)**
LGCO2	-0.6234(2)	-1.4498(2)	-4.2627(4)**	-3.7592(4)**
Vietnam (1980-2014)				
LGCROP	-1.2421(1)	-0.9585(3)	-6.4443(0)**	-6.3950(0)**
LGRAI	-5.4695(5)	-5.3714(5)	-8.8629(2)**	-9.0668(2)**
LGAGR	-1.8774(1)	1.2000(1)	-3.8794(4)**	-3.3135(3)**
LGCO2	-1.9724(1)	0.3903(2)	-5.0501(3)**	-5.0259(2)**

Notes: ** denotes rejection at 5% significance level. Number in parentheses is the number of lag length.

The decision rule of PP test are similar as ADF test. The table above clearly shows the results of PP test. At the level, the probabilities of the variables do not exceeded the critical value of 0.05 at the significance level of 5%, so the null hypotheses can be accepted representing that the variables are non-stationary and unit root exist at the level. However, all of the variables are stationary and there are no unit roots occurred after the first difference. It is because the critical value of 0.05 are smaller than the probabilities, therefore the null hypotheses can be rejected at first difference.

4.1.3 KPSS Unit Root Test

Table 5: Result of KPSS test.

	Level		First Difference	
Variables	**Trend and Intercept**	**Intercept**	**Trend and Intercept**	**Intercept**
Malaysia (1980-2014)				
LGCROP	0.1686(13)**	0.6880(5)**	0.0988(6)	0.1295(6)
LGRAI	0.0976(6)**	0.4501(3)**	0.0891(5)	0.0889(5)
LGAGR	0.1577(4)**	0.6826(4)**	0.1306(3)	0.2462(4)
LGCO2	0.1629(4)**	0.6725(5)**	0.0727(1)	0.2040(2)
Indonesia (1980-2014)				
LGCROP	0.2959(0)**	0.6957(5)**	0.0854(3)	0.0902(3)
LGRAI	0.1461(10)**	0.4712(32)**	0.0573(2)	0.0627(2)
LGAGR	0.1634(1)**	0.6635(5)**	0.0552(2)	0.0614(2)
LGCO2	0.1532(12)**	0.6827(5)**	0.0686(3)	0.1118(3)
Philippines (1980-2014)				
LGCROP	0.1653(10)**	0.6776(5)**	0.0859(3)	0.0889(3)
LGRAI	0.1507(12)**	0.5390(1)**	0.0330(1)	0.0332(1)
LGAGR	0.1606(4)**	0.6283(5)**	0.1109(0)	0.2185(2)
LGCO2	0.1940(1)**	0.6429(5)**	0.1124(3)	0.1339(3)
Thailand (1980-2014)				
LGCROP	0.1933(0)**	0.6954(5)**	0.0500(2)	0.0561(2)
LGRAI	0.1532(11)**	0.4720(32)**	0.1225(5)	0.1245(5)
LGAGR	0.4211(0)**	0.4867(20)**	0.1400(7)	0.1813(4)
LGCO2	0.1911(4)**	0.6578(5)**	0.1258(1)	0.2808(3)
Vietnam (1980-2014)				
LGCROP	0.4039(0)**	0.6943(5)**	0.1320(3)	0.1871(2)
LGRAI	0.1516(10)**	0.4717(2)**	0.0667(3)	0.0724(3)
LGAGR	0.1477(4)**	0.6446(5)**	0.1332(0)	0.3994(2)
LGCO2	0.1503(4)**	0.6658(5)**	0.1045(2)	0.1882(1)

Notes: ** denotes rejection at 5% significance level. Number in parentheses is the number of lag length.

KPSS test is varied from ADF and PP tests. The unit root only exists at the level due to the rejection of null hypothesis. It can be seen from the table above and shows that the variables are non-stationary at level. The null hypotheses of the variables are rejected because the t-statistics is greater than the critical value off 1.96 at 5%

significance level. After the first difference, all of the variables become stationary and there are no unit roots exist due to the acceptance of null hypotheses.

4.2 Johansen and Juselius Cointegration Test

Table 6: Result of JJ test.

		λmax		Trace	
Null	**Alternative**	**Unadjusted**	**95% C.V**	**Unadjusted**	**95% C.V**
		Malaysia (1980-2014) k=2, r=1			
R=0	R=1	30.8341*	27.5843	55.4221*	47.8561
R≤1	R=2	12.4445	21.1316	24.5881	29.7971
R≤2	R=3	10.8715	14.2646	12.1436	15.4947
R≤3	R=4	1.2721	3.8415	1.2721	3.8415
		Indonesia (1980-2014) k=4, r=2			
R=0	R=1	48.6271*	27.5843	76.7163*	47.8561
R≤1	R=2	21.5151*	21.1316	28.0892	29.7971
R≤2	R=3	5.6501	14.2646	6.5741	15.4947
R≤3	R=4	0.9241	3.8415	0.9241	3.8415
		Philippines (1980-2014) k=4, r=2			
R=0	R=1	47.1915*	27.5843	85.0680*	47.8561
R≤1	R=2	25.2514*	21.1316	37.8765*	29.7971
R≤2	R=3	10.0803	14.2646	12.6251	15.4947
R≤3	R=4	2.5448	3.8415	2.5448	3.8415
		Thailand (1980-2014) k=2, r=2			
R=0	R=1	30.6707*	27.5843	61.7985*	47.8561
R≤1	R=2	24.0143*	21.1316	31.1278*	29.7971
R≤2	R=3	7.0540	14.2646	7.1135	15.4947
R≤3	R=4	0.0595	3.8415	0.0595	3.8415
		Vietnam (1980-2014) k=5, r=4			
R=0	R=1	27.6174*	27.5843	50.6160*	47.8561
R≤1	R=2	13.2828	21.1316	23.0986	29.7971
R≤2	R=3	7.4500	14.2646	9.8158	15.4947
R≤3	R=4	2.3658	3.8415	2.3658	3.8415

Notes: Asterisks (*) denote statistically significant at 5% significance level. The k is the lag length and r is the cointegrating vector(s). Chosen r: number of cointegrating vectors that are significant under both tests.

After conducting the unit root tests, all of the variables are stationary in the first difference which implies that they are integrated of order one and also called $I(1)$ series. Therefore, a cointegration test is necessary to perform for establishing a long run relationship between the primary agriculture and climate change in five selected ASEAN countries. Assumed that a long run relationship in the model despite the fact that the series are drifting apart or trending either upward or downward. In this case, a Johansen cointegration test is applied as a prominent cointegration tests for the series.

From the table above, it indicates the result of JJ test. The decision rule of JJ test is rejected the null hypothesis if the value of Trace and max-Eigen statistics are greater than the critical value at the 5% of significance level, otherwise, it is fail to reject. The different countries apply different number of lag numbers to determine the long run relationship of variables. It can be concluded that there are one cointegrating vectors in the model of Malaysia and Vietnam and also two cointegrating vectors in the model of Indonesia, Philippines and Thailand.

4.3 Vector Error Correction Model (VECM)

4.3.1 VECM Normalized Equation

Through the result of Eviews 10, the equation of log crop production index is expressed by the following:

Table 7: Normalized equation of VECM.

Malaysia (1980-2014):	
LGCROP =	-13.6400 + 2.5804 LGRAI + 3.5512 LGAGR – 1.3621 LGCO2 + ε
	(-4.8432) (-4.8832) (8.3693)
Indonesia (1980-2014):	
LGCROP =	0.9210 + 0.6750 LGRAI - 2.1248 LGAGR - 0.1678 LGCO2 + ε
	(-4.0236) (13.1345) (4.8091)
Philippines (1980-2014):	
LGCROP =	5.3125 + 4.1017 LGRAI – 7.0670 LGAGR – 0.5398 LGCO2 + ε
	(-3.6544) (1.6769) (1.3155)

Thailand (1980-2014):				
LGCROP =	-9.5600 + 1.8172 LGRAI + 0.6157 LGAGR – 0.5024 LGCO2 + ε			
		(-3.5451)	(-0.8200)	(11.6349)

Vietnam (1980-2014):				
LGCROP =	-5.0164 + 1.4044 LGRAI – 1.1746 LGAGR – 0.2281 LGCO2 + ε			
		(-9.8024)	(6.9425)	(4.7462)

Note: The value in parentheses refers to *t*-statistics.

According to the table above, it shows the normalized equation of VECM. Crop production index as dependent variable represents the output of primary agriculture, whereas the independent variables and control variable are rainfall, carbon dioxide and agriculture land respectively. For Malaysia, all of the variables are significant. The model specification indicates if the LGCROP increases by 1%, LGRAI and LGAGR will increase by 2.5804 and 3.5512 respectively, but LGCO2 will decline by 1.3621 with constant of negative 13.6400.

Next, all of the variables for Indonesia are significant. Perhaps LGCROP raises up by 1%, LGRAI will increase by 0.6750, but LGAGR and LGCO2 will decrease by 2.1248 and 0.1678 respectively holding other constant (0.9210). For Philippines, only LGRAI is significant meaning that if LGCROP increases by 1%, LGRAI will increases by 4.1017, but LGAGR and LGCO2 will decrease by 7.0670 and 0.5398 with the constant of 5.3125. Moreover, LGRAI and LGCO2 are significant in the model specification of Thailand. If LGCROP rises by 1%, LGRAI and LGAGR will also increase by 1.8172 and 0.6157, only LGCO2 will decline by 0.5024 holding other constant (-9.5600). Last but not least, all of the variables are significant in the model specification of Vietnam. Perhaps LGCROP increase by 1%, LGRAI will increase by 1.4044, but the other independent variables like LGRAI and LGCO2 will follow to diminish by 1.1746 and 0.2281 respectively holding other constant (-5.0164).

4.3.2 VECM Granger Causality

Table 8: Summary result of VECM granger causality test with ECT.

Dependent Variables	Independent Variable				
	ΔLGCROP	ΔLGRAI	ΔLGAGR	ΔLGCO2	ECT
			χ^2-statistics (p value)		Coefficient (t-statistic)
Malaysia (1985-2014)					
ΔLGCROP	-	5.7943** (0.0161)	1.5499 (0.2131)	0.3938 (0.5303)	-0.0351 [-0.9368]
ΔLGRAI	4.0522** (0.0441)	-	2.9879* (0.0839)	0.5396 (0.4626)	-0.2788 [-3.2608]**
ΔLGAGR	0.7123 (0.3987)	0.2783 (0.5978)	-	4.9131 (0.0267)	0.0035 [0.3069]
ΔLGCO2	0.1982 (0.6562)	3.7946* (0.0514)	2.6820 (0.1015)	-	0.2066 [2.8471]
Indonesia (1985-2014)					
ΔLGCROP	-	5.4620 (0.2431)	7.8298* (0.0980)	2.3726 (0.6676)	-0.4334 [-2.2777]**
ΔLGRAI	3.0452 (0.5503)	-	2.8949 (0.5756)	2.9749 (0.5620)	-0.5372 [-0.6542]
ΔLGAGR	0.7479 (0.9453)	5.0107 (0.2862)	-	2.7242 (0.6050)	0.2733 [1.2482]
ΔLGCO2	2.8632 (0.5810)	13.2254** (0.0102)	9.4995** (0.0498)	-	-1.8711 [-2.6823]
Philippines (1985-2014)					
ΔLGCROP	-	1.0437 (0.3070)	1.6202 (0.2031)	2.7765 (0.0957)	0.0016 [0.0683]
ΔLGRAI	5.5988** (0.0180)	-	0.0621 (0.8032)	0.8083 (0.3686)	-0.1872 [-2.9436]**
ΔLGAGR	0.1559 (0.6930)	0.4915 (0.4833)	-	1.0278 (0.3107)	-0.0004 [-0.0782]
ΔLGCO2	5.4544** (0.0195)	0.0313 (0.8595)	0.0377 (0.8460)	-	-0.0227 [-0.6822]
Thailand (1985-2014)					
ΔLGCROP	-	7.2174*** (0.0072)	0.2050 (0.6507)	0.0078 (0.9298)	-0.0330 [-0.4985]
ΔLGRAI	0.0174 (0.8950)	-	7.2082*** (0.0073)	0.8555 (0.3550)	-0.4603 [-3.8317]**
ΔLGAGR	2.2475 (0.1338)	0.3046 (0.5810)	-	3.5862* (0.0583)	0.0398 [2.6125]
ΔLGCO2	0.3658 (0.5453)	1.9680 (0.1607)	0.1291 (0.7194)	-	0.0191 [0.2459]
Vietnam (1985-2014)					
ΔLGCROP	-	9.9326** (0.0416)	5.1947 (0.2679)	2.8162 (0.5890)	0.1727 [1.7674]
ΔLGRAI	2.3957 (0.6634)	-	1.5641 (0.8152)	1.4781 (0.8305)	-0.6873 [-1.0691]**
ΔLGAGR	20.3138***	50.2038***	-	13.8293***	0.4446

	(0.0004)	(0.0000)		(0.0079)	[6.4849]
ΔLGCO2	6.0438	4.3483	4.2779	-	-0.4507
	(0.1959)	(0.3609)	(0.3697)		[-1.0753]**

Notes: The χ^2-statistics test the joint significant of the lagged values of the independent variables and the significance of the error correction terms(s). Δ is the first different operator. Asterisks (*), (**) and (***) denote the rejection of the hypothesis at the 10%, 5% and 1% of significance level.

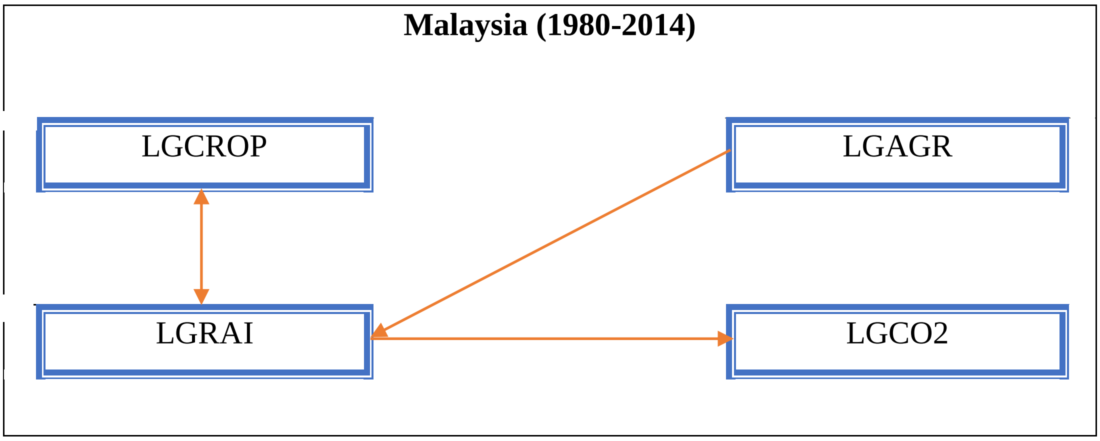
Furthermore, the table above shows the summary result of VECM granger causality test with ECT. It is applied to investigate the direction of causality effect among the variables such as crop production index, rainfall, carbon dioxide emission and agriculture land in five selected ASEAN countries. The probabilities value of the dependent variable of VECM represent the short run casual effect, whilst the coefficient and t-statistics in error correction term (ECT) refer to a stable long run relationship and speed of adjustment towards long run equilibrium.

The ECT coefficient indicates the speed of adjustment to long-run equilibrium. There are three conditions of ECT which are negative value, less than one and statistically significant as per cointegration results. In the model of Malaysia, LGRAI has a speed of adjustment to the long run equilibrium which equals to 0.2788. The coefficient of ECT indicates that LGRAI will complete 27.88% of the adjustment in a year. Thus, 3.59 years are required to achieve 100% or bring back the other variables to the long run equilibrium. Next, Indonesia gets 0.4334 or 43.34% of speed of adjustment and it will takes around 2.31 years to adjust to long run equilibrium.

For the country of Philippines, the speed of adjustment is 0.1872 or 18.72% for LGRAI implying that the variable takes 5.34 years to adjust to long run equilibrium. In addition, Thailand has a different speed of adjustment which is LGAGR consisting of 0.4603 or 46.03%. The duration required by LGAGR to adjust the speed is 2.17 years. At the same time, the speed of adjustment for Vietnam is 0.6873 (LGRAI) which is equivalent to 68.73% taking the period of 1.45 years to adjust to the long run equilibrium.

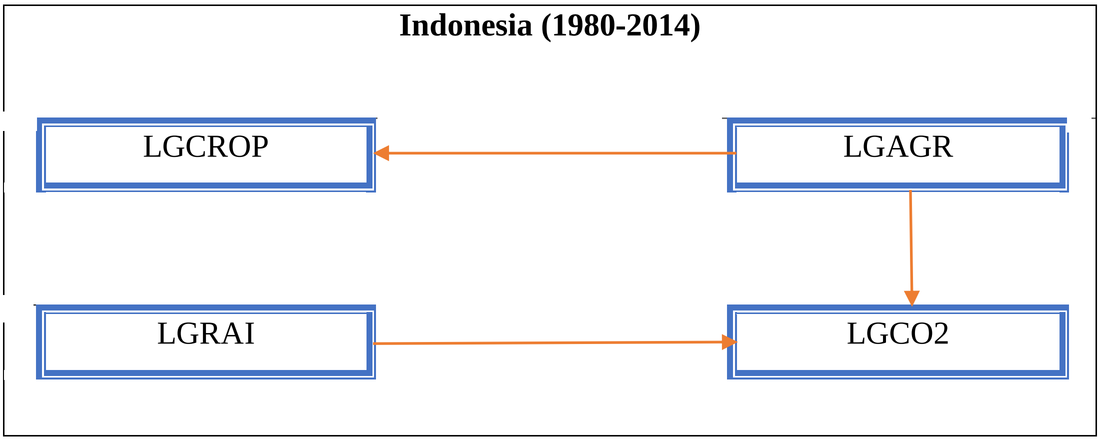
The finding of causality based on VECM is presented in the table above. The decision rule is that the null hypothesis can be rejected if the probability is smaller than the critical value at 1% (0.01), 5% (0.05) and 10% (0.1) of significance level meaning that there has a granger causality relationship. The granger causality of the variables such as crop production index, rainfall, agriculture land and carbon dioxide emission in Malaysia, Indonesia, Philippines, Thailand and Vietnam will be illustrated by following.

Figure 10: Granger causality relationship of Malaysia.



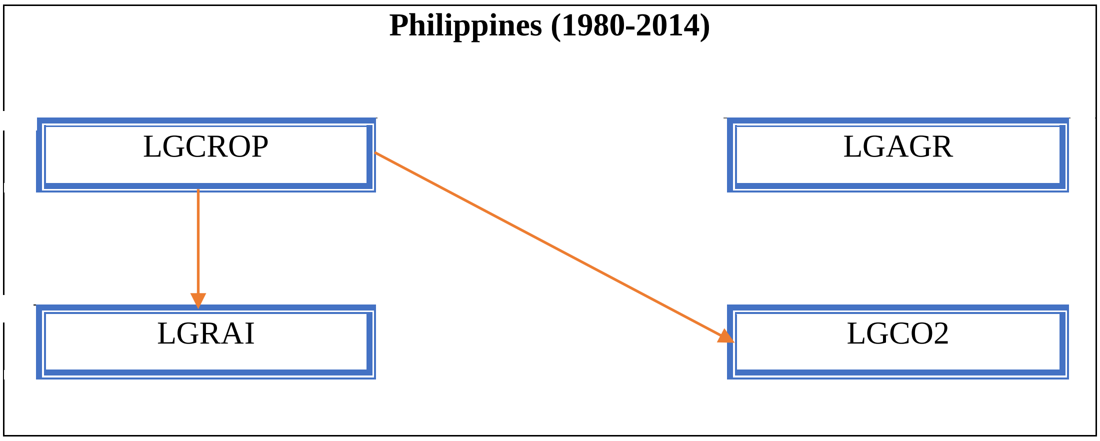
The granger causality test shows that there exist casual relationships among the variables at 1%, 5% and 10% significance level. There are only one bidirectional causality and two unidirectional causalities in the figure illustrated above. Simply to say, the bi-direction indicates that LGCROP and LGRAI will cause and influence each other at the moment. While the other two uni-direction means that LGAGR can affect LGRAI and LGRAI may cause LGCO2.

Figure 11: Granger causality relationship of Indonesia.



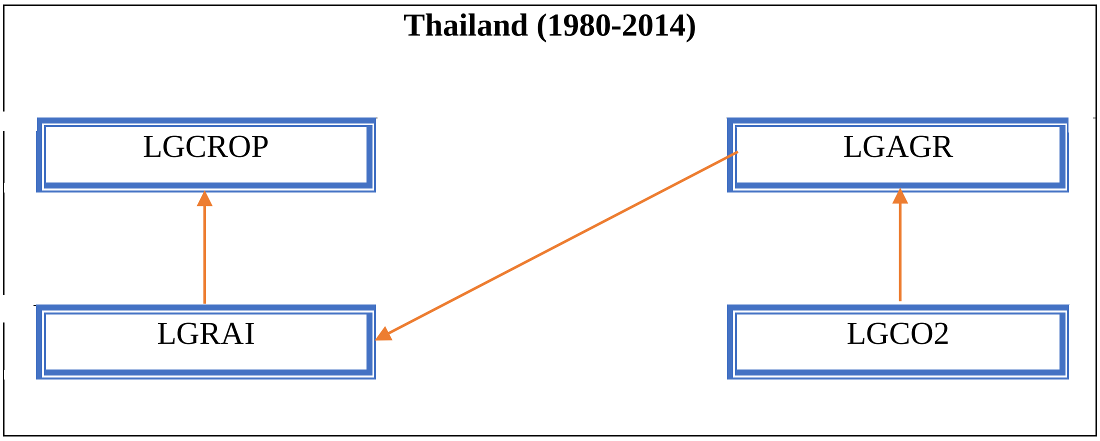
The granger causality test shows that there exist casual relationships among the variables at 1%, 5% and 10% significance level. From the figure above, all of the casual relationships among the variables are unidirectional causalities. It implies that LGAGR can cause and influence LGCROP and LCO2, but LGCO2 is caused by LGRAI. Therefore, there are three uni-direction granger casual relationship in Indonesia.

Figure 12: Granger causality relationship of Philippines.



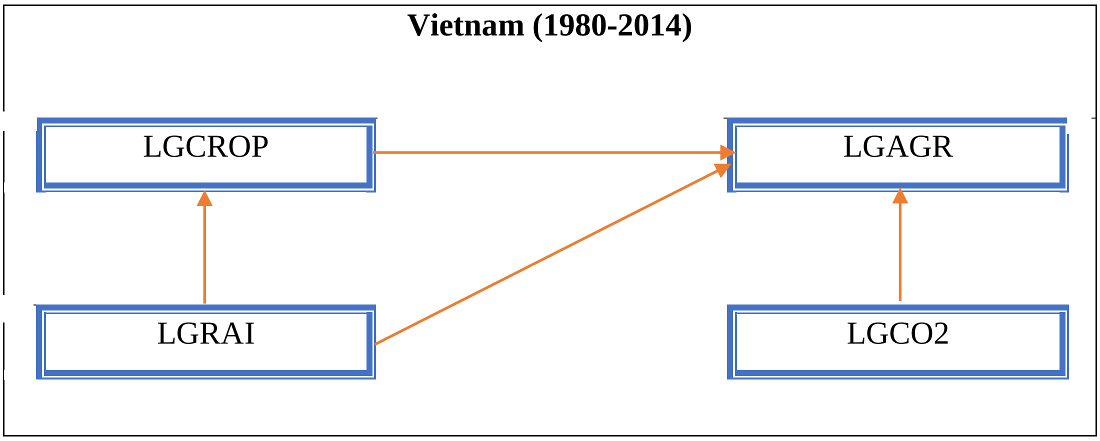
The granger casual relationships among the variables such as LGCROP, LGRAI, LGAGR and LGCO2 exist due to the rejection of null hypothesis at the significance level of 1%, 5% and 10%. The result shows that there are two unidirectional casual relationships between LGCRP and LGRAI and also LGCROP and CO2. It means that the crop production index may cause and affect the rainfall and carbon dioxide emission changing.

Figure 13: Granger causality relationship of Thailand.



At the significance level of 1%, 5% and 10%, the casual relationships among the variables will appear since the null hypothesis can be rejected if the critical value is greater than the probabilities. The figure above shows the granger causality relationship of Thailand. It can be concluded that there are three causalities among between LGRAI and LGCROP, LGAGR and LGRAI and also LGCO2 and LGAGR. The three unidirectional causalities represent that LGRAI can cause LGCROP, LGAGR may affect LGRAI and also LGCO2 will influence LGAGR.

Figure 14: Granger causality relationship of Vietnam.



Based on the figure above, the granger causality relationship of Vietnam is illustrated as above. All of the casual relationships among the variables are unidirectional causalities. At the first, both of the variables like LGCROP and LGRAI have the impacts toward LGAGR. Next is that LGRAI may affect LGCROP. Last but not least, LGCO2 has the cause effect on LGAGR. Hence, there are four uni-direction causality relationships in the model of Vietnam.

4.4 Variance Decomposition (VDCS)

4.4.1 Variance Decomposition of Malaysia

Table 9: Result of forecast error variance decomposition.

Horizon (Years)	Due to Innovation in:				Cumulative
	ΔLGCROP	**ΔLGRAI**	**ΔLGAGR**	**ΔLGCO2**	
Malaysia (1980-2014)					
Quarterly Relative Variance in ΔLGCROP					
1	**100.0000**	0.0000	0.0000	0.0000	0.0000
10	**94.2658**	2.8078	2.3248	0.6016	5.7342
20	**95.4123**	2.2647	1.5531	0.7699	4.5877
30	**95.8217**	2.0702	1.2783	0.8298	4.1783
40	**96.0316**	1.9705	1.1374	0.8605	3.9684
50	**96.1594**	1.9098	1.0516	0.8792	3.8406
Quarterly Relative Variance in ΔLGRAI					
1	2.3285	**97.6715**	0.0000	0.0000	2.3285
10	5.3594	**52.7817**	27.4093	14.4497	47.2184
20	3.9879	**44.7932**	35.6164	15.6025	55.2068
30	3.5698	**42.3569**	38.1200	15.9533	57.6431
40	3.3672	**41.1765**	39.3331	16.1233	58.8236
50	3.2476	**40.4798**	40.0490	16.2236	59.5202
Quarterly Relative Variance in ΔLGAGR					
1	0.0156	0.0183	**99.9661**	0.0000	0.0339
10	0.5024	2.4210	**93.9067**	3.1699	6.0933
20	0.5703	3.0270	**93.3125**	3.0903	6.6876
30	0.5887	3.1906	**93.1520**	3.0687	6.8480
40	0.5973	3.2667	**93.0773**	3.0587	6.9227
50	0.6022	3.3107	**93.0342**	3.0529	6.9658
Quarterly Relative Variance in ΔLGCO2					
1	2.1653	18.8179	0.7086	**78.3082**	21.6918
10	1.1878	61.9564	4.0235	**32.8323**	67.1677
20	1.1114	63.4264	5.8035	**29.6587**	70.3413
30	1.0853	63.9368	6.4270	**28.5508**	71.4491
40	1.0720	64.1969	6.7446	**27.9864**	72.0135
50	1.0640	64.3546	6.9372	**27.6443**	72.3558

Through the VECM Granger Causality result, it is not possible to determine the relative strength of the degree of exogeneity among the variables. Hence, the variance decomposition technique is applied to distinguish the relative endogeneity or exogeneity of the variables. The variable which mostly explained by its own shock is considered as the exogenous variable, whilst the variable which least explained by its own stock can be considered as the endogenous variable and vice versa in cumulative.

From the table above, it indicates the result of forecast error variance decomposition of Malaysia in the estimation period of 50 years. It can be said that 96.16% of forecast variance can be explained by its own shock whereas 3.84% can be explained by others variables such as LGRAI (1.91%), LGAGR (1.05%) and LGCO2 (0.88%) at the end of 50 years horizon when there is a shock happened in crop production index. Next, approximately 59.52% of the forecast error variance in rainfall can be described by 3.25% of LGCROP, 40.05% of LGAGR and 16.22% of LGCO2 at the end of 50 years horizon. There are three variables explained the forecast error variance of 6.97% when the shock occurs in agriculture land comprising 0.60% of LGCROP, 3.31% of LGRAI and 3.05% of LGCO2 along the estimation period of 50 years.

Moreover, around 72.36% can be explained by 1.06% of LGCROP, 64.35% of LGRAI and 6.94% of LGAGR during its own shock at the end of 50 year horizon. Simply to say, the overall result shows that LGCROP is the most exogenous variable since there has nearly 96.16% of the variation is explained by its own shocks. However, the most endogenous variables is LGCO2 with only 27.64% of variation which is the lowest range among the other variables when it shocks itself. Besides, the cumulative result shows that the most endogenous variable is LGCO2 (72.36%) and the most exogenous variable is LGCROP (3.84%). The concept of endogenous and exogenous variables are varied during own shocks and cumulative.

4.4.2 Variance Decomposition of Indonesia

Table 10: Result of forecast error variance decomposition.

Horizon (Years)	Due to Innovation in:				Cumulative
	ΔLGCROP	**ΔLGRAI**	**ΔLGAGR**	**ΔLGCO2**	
Indonesia (1980-2014)					
Quarterly Relative Variance in ΔLGCROP					
1	**100.0000**	0.0000	0.0000	0.0000	0.0000
10	**52.3818**	3.6003	40.3364	3.6815	47.6182
20	**54.3360**	3.8456	38.8488	2.9695	45.6639
30	**54.2771**	3.8846	38.8940	2.9442	45.7228
40	**54.3123**	3.9002	38.9446	2.8429	45.6877
50	**54.5998**	3.9055	38.7444	2.7503	45.4002
Quarterly Relative Variance in ΔLGRAI					
1	14.2025	**85.7975**	0.0000	0.0000	14.2025
10	10.6293	**57.8978**	20.3279	11.1450	42.1022
20	8.0559	**57.2031**	20.2224	14.5187	42.7970
30	6.6825	**58.7349**	19.6212	14.9614	41.2651
40	5.7258	**59.1948**	19.2063	15.8731	40.8052
50	5.0497	**58.6925**	19.4954	16.7624	41.3075
Quarterly Relative Variance in ΔLGAGR					
1	48.7801	0.0108	**51.2091**	0.0000	48.7909
10	68.4574	5.1684	**15.8052**	10.5691	84.1949
20	69.0400	5.1001	**15.7114**	10.1485	84.2886
30	71.8427	5.8454	**12.1024**	10.2095	87.8976
40	72.4286	6.3450	**9.9543**	11.2721	90.0457
50	73.1212	6.7042	**9.0383**	11.1363	90.9617
Quarterly Relative Variance in ΔLGCO2					
1	18.4400	7.2722	4.1290	**70.1589**	29.8412
10	7.9815	4.7088	47.9169	**39.3928**	60.6072
20	4.3528	3.0155	53.9954	**38.6364**	61.3637
30	3.0665	2.2519	56.1248	**38.5568**	61.4432
40	2.2691	1.7418	57.2653	**38.7238**	61.2762
50	1.8804	1.4970	58.1859	**38.4368**	61.5633

As it can be seen the table above, forecast error variance decomposition is carried out to estimate the trend of the variables whether they are upward or downward in Indonesia for 50 years. The result shows almost 45.40% of the forecast error variance can be explained by LGRAI (3.91%), LGAGR (38.74%) and LGCO2 (2.75%)

at the end of the 50 years horizon when LGCROP is shocked. Besides that, nearly 41.31% of the forecast error variance can be described by LGCROP (5.05%), LGAGR (19.50%) and LGCO2 (16.76%) at the end of the 50 years horizon when there has a shock happened in LGRAI. Furthermore, about 90.96% of the forecast error variance can be explained by LGCROP (73.12%), LGRAI (6.70%) and LGCO2 (11.14%) at the end of the 50 years beyond the sample when LGAGR is shocked.

There are also three variables explained the forecast error variance of 61.56% when the shock appears in carbon dioxide emission consisting of LGCROP (1.88%), LGRAI (1.50%) and LGAGR (58.19%) along the estimation period of 50 years. Briefly, exogenous variable is the variable that is mostly explained by its own shocks, whilst endogenous variable is the variable that is least explained by its own shocks. The result indicates that LGRAI is the most exogenous variable since there has about 58.70% of the variation in LGRAI explained by its own shocks. Besides, the most endogenous variable can be observed from this result is LGAGR because it has only 9.04% of the variation in LGAGR explained by its own shock. Conversely, the concept of endogenous and exogenous are slightly different in cumulative. When the variables shock itself in cumulative, LGAGR is the most endogenous variable with 90.96%, while LGRAI is the most exogenous variable with 41.31%.

4.4.3 Variance Decomposition of Philippines

Table 11: Result of forecast error variance decomposition.

Horizon (Years)	Due to Innovation in:				Cumulative
	ΔLGCROP	**ΔLGRAI**	**ΔLGAGR**	**ΔLGCO2**	
			Philippines (1980-2014)		
Quarterly Relative Variance in ΔLGCROP					
1	**100.0000**	0.0000	0.0000	0.0000	0.0000
10	**84.3734**	1.8414	6.2564	7.5288	15.6266
20	**83.6115**	1.7146	6.7925	7.8814	16.3885
30	**83.3386**	1.6694	6.9843	8.0076	16.6613
40	**83.1983**	1.6462	7.0830	8.0726	16.8018
50	**83.1127**	1.6320	7.1431	8.1121	16.8872
Quarterly Relative Variance in ΔLGRAI					
1	21.6244	**78.3756**	0.0000	0.0000	21.6244
10	25.9767	**54.4111**	15.4409	4.1713	45.5889
20	22.0736	**46.4609**	25.9287	5.5368	53.5391
30	19.1945	**40.5949**	33.6709	6.5397	59.4051
40	16.9798	**36.0826**	39.6265	7.3111	63.9174
50	15.2233	**32.5038**	44.3499	7.9230	67.4962
Quarterly Relative Variance in ΔLGAGR					
1	3.4869	0.2448	**96.2683**	0.0000	3.7317
10	2.5152	1.1856	**92.8701**	3.4291	7.1299
20	2.2235	1.1062	**93.0558**	3.6146	6.9443
30	2.1297	1.0805	**93.1156**	3.6742	6.8844
40	2.0834	1.0678	**93.1451**	3.7037	6.8549
50	2.0558	1.0602	**93.1627**	3.7213	6.8373
Quarterly Relative Variance in ΔLGCO2					
1	1.2496	3.2274	0.0427	**95.4804**	4.5197
10	17.7018	9.5615	0.3119	**72.4249**	27.5752
20	18.2168	10.0003	0.3559	**71.4270**	28.573
30	18.3842	10.1440	0.3702	**71.1016**	28.8984
40	18.4672	10.2153	0.3773	**70.9402**	29.0598
50	18.5169	10.2578	0.3816	**70.8438**	29.1563

In order to strengthen the empirical evidence from the granger causality analysis, the dynamic analysis of the variables are examined such as crop production index (LGCROP), rainfall (LGRAI), agriculture land (LGAGR) and carbon dioxide emissions (LGCO2). The table above provides the decomposition of the forecast error variables up to 50 years horizon. The result implies that about 16.89% of the forecast error variance in LGCROP can be explained by LGRAI (1.63%), LGAGR (7.14%) and 8.11% (LGCO2) at the end of 50 years horizon. Next, when LGRAI shocks itself, approximately 67.50% can be explained by 15.22% of LGCROP, 44.35% of LGAGR and 7.92% of LGCO2 in 50 years horizon.

Furthermore, almost 6.84% of the forecast error variance can be described by LGAGR (2.06%), LGRAI (1.06%) and LGCO2 (3.72%) at the end of the 50 years horizon when there has a shock happened in LGAGR. When LGCO2 shocks itself at the end of 50 years horizon, nearly 29.16% of the forecast error variance can be explained by LGCROP (18.52%), LGRAI (10.26%) and LGAGR (0.38%). As a summary, it is proven that LGAGR is the most exogenous variable since it is mostly explained by its own shock about 93.16% of the variation in LGAGR. Besides, LGRAI is the most endogenous variable because it is least explained by its own shock and only 32.50% of the variation in LGRAI. However, the cumulative result shows that the most endogenous variable is LGAGR since it mostly explained by its own shock, whilst the most exogenous variable is LGRAI due to least explained by its own shock.

4.4.4 Variance Decomposition of Thailand

Table 12: Result of forecast error variance decomposition.

Horizon (Years)	Due to Innovation in:				Cumulative
	ΔLGCROP	**ΔLGRAI**	**ΔLGAGR**	**ΔLGCO2**	
Thailand (1980-2014)					
Quarterly Relative Variance in ΔLGCROP					
1	**100.0000**	0.0000	0.0000	0.0000	0.0000
10	**96.3712**	1.6276	1.1498	0.8514	3.6288
20	**95.9480**	1.1136	0.8314	2.1070	4.0520
30	**95.7327**	0.9285	0.7137	2.6251	4.2673
40	**95.6199**	0.8322	0.6524	2.8955	4.3801
50	**95.5507**	0.7732	0.6149	3.0612	4.4493
Quarterly Relative Variance in ΔLGRAI					
1	18.3136	**81.6864**	0.0000	0.0000	18.3136
10	31.1105	**43.3627**	10.1891	15.3377	56.6373
20	34.3728	**25.6328**	6.3373	33.6572	74.3673
30	35.5476	**18.4501**	4.7769	41.2253	81.5498
40	36.1699	**14.6364**	3.9485	45.2453	85.3637
50	36.5555	**12.2724**	3.4349	47.7372	87.7276
Quarterly Relative Variance in ΔLGAGR					
1	0.9751	1.7458	**97.2792**	0.0000	2.7209
10	0.9975	17.7289	**39.2019**	42.0717	60.7981
20	1.3327	17.3823	**32.4696**	48.8154	67.5304
30	1.4233	17.2716	**30.7254**	50.5797	69.2746
40	1.4639	17.2217	**29.9437**	51.3706	70.0562
50	1.4870	17.1935	**29.5005**	51.8191	70.4996
Quarterly Relative Variance in ΔLGCO2					
1	0.3733	0.7359	5.0073	**93.8834**	6.1165
10	0.1510	6.2063	12.0536	**81.5891**	18.4109
20	0.1059	7.0161	13.1516	**79.7265**	20.2736
30	0.0904	7.2953	13.5212	**79.0931**	20.9069
40	0.0828	7.4331	13.7034	**78.7808**	21.2193
50	0.0783	7.5150	13.8118	**78.5949**	21.4051

Variance decomposition of the variables such as crop production index, rainfall, agriculture land and carbon dioxide emissions are examined to strengthen the empirical evidence from the causality analysis. The results which are pertaining to 50 year periods after the shock are only discussed. From the table above, it can be said that the crop production index (95.55%) is the exogenous variable because it is mostly explained around when it shocks itself in 50 years horizon. However, since the rainfall (12.27%) is least explained itself in the estimated period of 50 years, so it is considered as endogenous variable. During cumulative, LGRAI is the exogenous variable with 87.73%, while LGCROP is recognized as endogenous variable with 4.45 percent.

For the further information, approximately 4.45% of the forecast error variance can be explained by LGRAI (0.77%), LGAGR (0.61%) and LGCO2 (3.06%) when there has a shock occurred in crop production index in 50 years horizon. Next, there are three variables explained the forecast error variance of 87.73% when LGRAI shocks itself along the estimation period of 50 years including LGCROP (36.56%), LGAGR (3.43%) and LGCO2 (47.74%). The result also shows that around 70.50% of the forecast error variance can be described by LGCROP (1.49%), LGRAI (17.19%) and LGCO2 (51.82%) when LGAGR is shocked. Last but not least, almost 21.41% of the forecast error variance can be explained by LGCROP (0.08%), LGRAI (7.52%) and LGAGR (13.81%) at the end of 50 years beyond the sample when LGCO2 is shocked.

4.4.5 Variance Decomposition of Vietnam

Table 13: Result of forecast error variance decomposition.

Horizon (Years)	Due to Innovation in:				Cumulative
	ΔLGCROP	ΔLGRAI	ΔLGAGR	ΔLGCO2	
Vietnam (1980-2014)					
Quarterly Relative Variance in ΔLGCROP					
1	**100.0000**	0.0000	0.0000	0.0000	0.0000
10	**95.0075**	1.1873	0.6554	3.1498	4.9925
20	**94.6612**	0.8960	0.8133	3.6296	5.3389
30	**92.0081**	1.2139	1.1744	5.6036	7.9919
40	**84.3512**	2.4936	2.4213	10.7340	15.6489
50	**73.3539**	4.1213	4.1391	18.3858	26.6462
Quarterly Relative Variance in ΔLGRAI					
1	14.7457	**85.2543**	0.0000	0.0000	14.7457
10	35.1398	**57.9642**	4.1544	2.7417	42.0359
20	47.5596	**44.3029**	3.0731	5.0644	55.6971
30	53.0610	**33.6530**	3.8686	9.4174	66.3471
40	60.1587	**20.3009**	5.1925	14.3479	79.6991
50	62.0113	**11.8394**	6.0398	20.1096	88.1607
Quarterly Relative Variance in ΔLGAGR					
1	4.6974	19.6133	**75.6894**	0.0000	24.3107
10	60.9629	33.8857	**2.9083**	2.2431	97.0917
20	69.2635	26.6153	**1.4589**	2.6622	98.5410
30	69.3922	23.6206	**1.6447**	5.3426	98.3554
40	70.8569	18.6212	**2.6870**	7.8348	97.3129
50	68.4258	14.6649	**3.8147**	13.0947	96.1854
Quarterly Relative Variance in ΔLGCO2					
1	25.1116	8.4659	25.7294	**40.6931**	59.3069
10	59.9714	22.9600	5.9099	**11.1587**	88.8413
20	71.0608	17.9661	5.1220	**5.8511**	94.1489
30	72.4709	16.3215	5.2383	**5.9694**	94.0307
40	72.8252	13.9867	5.5860	**7.6021**	92.3979
50	68.5944	11.9759	5.6665	**13.7632**	86.2368

Variance decomposition (VDC) as one of the dynamic analysis is applied to examine the variables whether they are exogenous or endogenous variables and also determine the casual relationship among the dependent and independent variables. Table 4.4.5 indicates the result of forest error variance decomposition of each variable up to 50 years horizon. Approximately 26.65% of the forecast error variance can be explained by LGRAI (4.12%), LGAGR (4.14%) and LGCO2 (18.39%) when crop production index shocks itself at the end of 50 years horizon. In relative variance in LGRAI, almost 88.16% can be described by 62.01% of LGCROP, 6.04% of LGAGR and 20.11% of LGCO2 in the years of 50 periods. There are also three variables explained the forecast error variance of 96.19% when the shock appears in agriculture land consisting of 68.43 % of LGCROP, 14.66% of LGRAI and 13.09% of LGCO2 along the estimation period of 50 years. Furthermore, around 86.24% can be explained by % of LG, % of LG and % of LG during its own shock at the end of 50 years horizon.

From the results, exogenous and endogenous variables can be classified clearly. The most exogenous variable is the most explained by its own shock, whilst the variables that is least explained by its own shock is deemed to be the most endogenous variable and vice versa during cumulative. The variable of crop production index is considered as exogenous variable with 73.35% variation, while agriculture land (3.81%) is recognised as the endogenous variable when they shock themselves. In contrast, LGAGR is the most exogenous variable since it is most explained itself with the variation of 96.19% and LGCROP is the least explained its own shock with only 26.65% during cumulative in 50 years horizon.

4.5 Impulse Response

Impulse response function analysis is conducted to illustrate the beyond sample dynamic relationship and aim to show the response of a variable towards the shock itself or the other variables in the system over time. It is carried out for 50 years horizon and the graphs can be found in the appendix. From the analysis of Malaysia as shown in Appendix Figure 1, it can be said that the response of LGCROP to LGAGR and the response of LGCROP to LGCO2 are positive and stable, while the response of LGCROP to LGRAI becomes negative when LGCROP shocks itself. Next, in the response of rainfall, LGRAI and LGCO2 have positive trends, only agriculture land has negative trend.

However, there are two negative trends occurred when agriculture trend shocks itself which are LGRAI and LGCO2, whilst LGCROP keeps remaining its trend in 50 years horizon. All of the variables such as LGCROP, LGRAI and LGAGR get positive trends when carbon dioxide emission shocked. In Indonesia and Vietnam (figure 2 and 3 in appendix, the trends of all the variables are unstable because it suddenly keep increasing and decreasing at the different periods throughout 50 years horizon. In contrast, the trends of Philippines and Thailand (figure 4 and 5 in appendix) are quite stable since all of the variables are mostly performed well, even they have slightly upward and downward in the estimation duration.

4.6 Diagnostic Tests

Table 14: Summary Results of Diagnostic Tests

Diagnostic Tests	*F*-statistics (*p*-value)
Malaysia (1980-2014)	
JB	4.4374 (0.1088)
BG	20.9843 (0.0956)
ARCH	2.4771 (0.0692)
Indonesia (1980-2014)	
JB	0.1462 (0.9295)
BG	2.3669 (0.0694)
ARCH	0.1343 (0.7062)
Philippines (1980-2014)	
JB	1.5769 (0.4546)
BG	2.6939 (0.0545)
ARCH	0.3958 (0.5193)
Thailand (1980-2014)	
JB	1.5989 (0.4496)
BG	6.0825 (0.0526)
ARCH	2.3971 (0.0837)
Vietnam (1980-2014)	
JB	0.9875 (0.6103)
BG	2.6635 (0.0621)
ARCH	2.6446 (0.0620)

Notes: JB considers as Jarque-Bera normality test of the residuals. BG denotes Breusch-Godfrey serial correlation Lagrange Multiplier test. ARCH is autoregressive conditional heteroschedasticity test. These results are carried out from Eviews-10 software.

Besides the modelling methods, a few diagnostic tests are also conducted to support the superiority of crop production index model. The table above indicates the summary results of Jarque-Bera normality test, Breusch-Godfrey serial correlation Lagrange Multiplier tests for autocorrelation and autoregressive conditional heteroschedasticity test of five selected countries such as Malaysia, Indonesia, Philippines, Thailand and Vietnam from 1980 until 2014.

4.6.1 Jarque-Bera Normality Test

The decision rule for JB test is that the null hypothesis can be rejected if the *p*-value is higher than the critical value of 0.05 at the significance level of 5%. In other words, it means that the estimated model does not have the specification problem, therefore the error term is normally distributed. From the table above, the *p*-value of Malaysia is 0.1087 which is larger than 0.05 indicating that the country gets 10.88% of probability at 5% significance level.

Indonesia acquires 92.95% of probability which there is no specification problem occurred since the *p*-value (0.9295) is larger than 0.05. Moreover. Philippines also does not face any specification problem because of the probability value (0.4546) is larger than 0.05 at 5% significance level and gets 45.46% probability. Thailand is normally distributed since the *p*-value of the country is 0.4496 higher than critical value of 0.05 or approximately 44.96% at the significance level of 5%. Vietnam also considers as normally distributed and gets around 98.75% of probability since the *p*-value (0.6103) is larger than the critical value at 5% significance level.

4.6.2 Breusch-Godfrey (BG) Serial Correlation LM Test

According to the decision rule, the null hypothesis is rejected if the *p*-value is higher that the critical value at 5% significance level in BG-LM test. Once the alternative hypothesis can be accepted, it means that the estimated model does not have the autocorrelation problem and the error term does not exist serial correlation problem. Based on the result through Eviews-10 software, all of the five selected countries do not meet the serial correlation problem. It can be seen that the null hypothesis of Malaysia is rejected since the probability chi square (0.0956) is greater than 0.05 at the significance level of 5%. Besides, Indonesia (0.0694), Philippines (0.0545), Thailand (0.0526) and Vietnam (0.0621) are also higher and larger than the critical value of 0.05 at the significance level of 5%.

4.6.3 Autoregressive Conditional Heteroscedasticity (ARCH) Test

Last but not least, the decision rule of ARCH test is that there is enough evidence to reject the null hypothesis if the *p*-value is smaller than the critical value at the significance level of 5%. In this case, the null hypothesis of all of the five selected countries such as Malaysia (0.0692), Indonesia (0.7062), Philippines (0.5193), Thailand (0.0837) and Vietnam (0.0620) cannot be rejected because of the *p*-value is higher than the critical value at 5% significance level. This indicates that the result is not statistically insignificant and the estimated model does not have the heteroscedasticity problem. Thus, the variance or error term are constant and homoscedastic.

CHAPTER FIVE

CONCLUSION AND POLICY IMPLICATION

5.0 Conclusion

Overall, this research aims to investigate the impact of rainfall, agriculture land and carbon dioxide emission toward the primary agriculture in selected ASEAN countries such as Malaysia, Indonesia, Philippines, Thailand and Vietnam. In this study, the gap range of 35 years annual data are taken from 1980 until 2014. For the estimation model, crop production index acts as the dependent variable, whereas the independents variable are rainfall, agriculture land and carbon dioxide emission. Eviews 10 is utilised to run the data by each country and obtain the results.

There are a few tests been tested in this study such as unit root tests encompassing Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski-Phillips-Schmidt-Shin (KPSS), Johansen-Juselius cointegration test, Vector Error Correction Model (VECM) tests including normalized equation and granger causality test, variance decomposition, impulse response function and also diagnostics tests such as normality test, Auto-regressive Conditional Heteroscedasticity (ARCH) test and Breusch-Godfrey Lagrange Multiplier (LM) test.

First of all, the unit root tests are examined to test the stationary of variables using the time series data. ADF and PP unit root tests have the same decision rules. Even though all of the independent variables are non-stationary at the first level, but they become stationary after first difference. Besides, KPSS test is slightly different from ADF and PP unit root tests. It shows that all of the variables are integrated and stationary at order one or $I(1)$ after the first difference conducting.

Normalized equation also determine the relationship among the dependent and independent variables whether it is positive or negative. The results are slightly different as expected from the previous studies. LGRAI is forecasted to get positive or negative relationship, but the variable has significant relationship in the five selected countries. Selected ASEAN countries get positive and negative relationships, not as expected only positive relationship in the previous study. The variables of LGCO2 has negative effect on crop production rate which are expected signs showing that the models are relevant and consistent based on the theoretical framework. There are a few ECTs are found in VECM in the estimation model which bring the whole system into the strong and stable relationship and speed of adjustment towards long run equilibrium. Moreover, the granger causality test is applied to investigate the short run causal relationship between dependent variable and independent variables.

All of the variables in each countries have relationship and causes among each other. Variance decomposition also has used to distinguish the relative endogeneity and exogeneity of the variables throughout the years. Different countries might have different trends upward or downward in the forecasted 50 years. Last but not least, diagnostic tests are conducted to support the superiority and check the relevancy of crop production index function. The overall results prove a good result that there is no specification, autocorrelation and heteroscedasticity problem in this estimation model.

5.0 Policy Implication

Based on the empirical results, Malaysia has a good and high impact toward the independent variables such as rainfall, agriculture land and carbon dioxide emission comparing to other four selected ASEAN countries such as Indonesia, Philippines, Thailand and Vietnam. Perhaps the crop production index increases by 1% due to positive and significant relationship, the rainfall and agriculture land follow to raise up by 2.58% and 3.55% respectively, whilst decreasing in carbon dioxide emissions.

However, the worst impact on the independent variables is Indonesia because the agriculture land use reduces the most by 2.12% compared to other countries if the crop production index by 1%. There are two variables such as LGAGR and LGCO2 are not significant in Indonesia during this duration indicating that they are not so important. Simply to say, the forecasted trend of 50 years horizon in Malaysia, Philippines, and Thailand are considered as good and stable, but Indonesia and Vietnam are unstable since they are expected to change and fluctuate unequally from time to time.

Through this research study, the relationship among the primary agriculture sector and the independent variables such as rainfall, agriculture land and carbon dioxide emissions has examined and they have causality cause between each other. Sometime the climate change give contribution to the primary agriculture sector in the short term, but somehow it only creates threat and give bad implication in reducing the quantity of production and gross domestic product of each country. As a result of climate change, ASEAN meets the common challenges comprising of rising sea levels, mass migration, humanitarian crises and international conflicts.

Therefore, they have to jointly tackle the climate risks together by demonstrating their commitment to climate change mitigation by asking questions, sharing the relevant analysis and taking concrete actions to accomplish their nationally determined contributions. One of the recommendation on climate policy is make preparations for Development of Regional Contributions (RDC) in order to encourage ambitious ASEAN members giving some contributions. Secondly, it is to make sure that the current and future plans of ASEAN Energy Cooperation Action Plan (APAEC) are perform well and effectively as possible to confront the issue of greenhouse gas emission. And also the third one is to promote regional electricity trade by expanding the ASEAN power grid to better handle the intermittency of renewable energy (Wijaya, 2017).

Meanwhile, the low-carbon economies which is a fundamental shift and considers as a good step in confronting the climate change across ASEAN (Groff, 2016). There are two biggest chances to improve although the composition of each economy largely determines where it can be minimized such as reducing the rate of deforestation and utilizing the use of better technologies particularly carbon capture. According to the article news online, Singapore also lend a hand to assist ASEAN countries solving the climate change issue by launching a new programme under Climate Action Package (CAP). This programme aims to develop the capabilities in the fields such as climate science, flood management and long term mitigation, disaster risk reduction and also adaptation strategies (Loh, 2018).

At the same time, protection and sustainable management of natural resources like agriculture land is very essential to prevent, minimize and remedy the negative externalities on soil, land and air. ASEAN countries shall cooperate with each other and change the opinion to educate and encourage the population especially young generation in order to reduce unnecessary waste or trash, utilize environmentally friendly packaging like Tupperware, metal straw and so on and also lengthen product life cycle (Noi, 2018). These contributions may help to increase the efficiency of crop production if the soil is not contaminated. They also should plan and launch a few new programmes on the best management exercises for farming.

5.2 Limitation

The main limitation of this study is regarding the data obtained period. Not all of the latest data can be found especially in five selected countries. It is because some of the data collection has the current record until 2019, but some of the data has not update yet. Therefore, the data duration is restricted to only 35 years from 1980 till 2014 in this study and no latest or further research. Besides, a control variable is added in this study which is agriculture land. Apart from climate change variability such as rainfall, temperature, sea level and so forth, agriculture land use also might be influenced the crop production index. Referring to the prevailing view from the researchers, only a few researchers apply the variable of agriculture land use in their research studies. Although the crop production model is fitted with the theoretical concept, but it is hard to guarantee that the crop production index will be implemented successfully in the reality without strong empirical evidence.

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