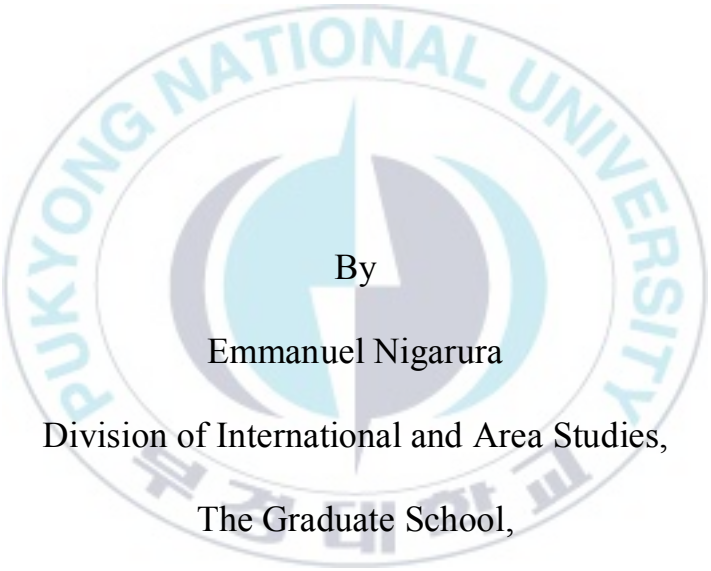
Thesis for the Degree of Master of Arts

The Impact of Climate Change on the Global Economy in 2050: The Case of the East African Community



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Division of International and Area Studies,

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Advisor: Prof. Dr. Jong-Hwan Ko

By

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in the Department of International and Area Studies

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기후 변화가 2050 년 세계 경제에 미칠 영향: 동아프리카

커뮤니티 사례를 중심으로

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The Impact of Climate Change on the Global Economy in 2050: The Case of the East African Community

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Abstract

Changes in agricultural sector production over time are driven by a combination of many factors; one of these factors is climate change. As the agricultural sector remains very important in the East Africa community countries' economies, any challenge faced by this sector, like climate change, will affect the whole economy through this sector. The purpose of this study is to introduce a common set of climate change data in economic models of the East African Community's agricultural sector for the year 2050, so that any divergence in economic effect could be understood in terms of differences in the structure and parameters of the economic models. Using the GTAP model and data from the projection model for climate change of the World in 2050; we assessed the impact of climate change in Eastern Africa countries' economy. Our results show that in all East Africa countries, climate change will have the negative impact on real GDP and agricultural output (qo). The price of agricultural products (ps) and agricultural consumption (pp) will increase; this will cause agricultural private consumption to decline. With climate change affecting farming of all EAC member countries, the EAC as a whole will have a similar negative trend in the agricultural output domestic market. However, we found that trade of agricultural commodities for each member will depend on world market' prices, Kenya's

exports will decrease by 4.52% and imports will increase by 7.9%. In Rwanda, exports will increase by 8.24% and imports will decline, in Tanzania exports will increase by 6.21% and imports will decline by 11.77%. In Uganda, exports will decline by 3.75% and imports will decline by 6.17%. In Rest of East Africa Community, the exports will increase by 5.76% and the imports will decline by 27.54%. Our study concludes that in the case of climate change in 2050 to avoid a low yield due to the negative impact of climate change on the agricultural sector, policymakers should mainstream to the agricultural technical plans.

Keywords: Climate change, EAC, CGE model, Quantitative Technical for Macroeconomic.

기후 변화가 2050 년 세계 경제에 미칠 영향: 동아프리카 커뮤니티 사례를 중심으로

초록

Emmanuel Nigarura

시간이 지날수록 농업 부분 생산의 변화는 많은 요인들의 결합으로 발생한다. 그 요인들 중 하나는 기후 변화이다. 농업 부분이 동아프리카 커뮤니티에서 중요함에 따라 농업 부분이 기후변화가 경제에 미치는 것 때문에 여러 문제점에 직면한다. 이 연구의 목적은 동아프리카 커뮤니티와 설명하고 2050 년의 경제모델에서 농업 부분에 기후영향의 일련의 예시로 설명하고 그래서 경제 효과에 대한 다양한 의견들이 경제 모델의 구조와 변수에 따른 차이점을 소개하는 것이다. . GTAP CGE 모델과 결과를 사용하는 것은 2050 년의 세계의 기후변화의 프로젝션 모델로부터 온다. 우리는 동아프리카 커뮤니티에 미칠 영향을 확인했다. 우리의 결과는 동아프리카 나라들에 나쁜 변화는 것은 실제 GDP 와 농업생산량(QO), 부정적인 영향을 미칠 수 있고, 농업생산자가격과 농업소비자가격 둘 다 증가할 것이며 결국 농업가계소비를 감소를 불러올 것이다. 2050 년의 나쁜 변화는 EAC 커뮤니티 멤버 국가들이 농업 생산의 국내 시장에서의 그 기간의 비슷한 동향이 일어날 것이다. 그러나 우리는 각 멤버들에게 농업상품의 무역이 세계 시장 가격을 따를 것이며, 케냐의 수출은 4.52%감소할 것이고 7.9% 수입 증가할 것이며, 르완다에서는 8.24% 수출이 증가하며 수입은 감소할 것이다. 탄자니아에서는 수출은 6.21% 증가하고 수입은 11.77% 감소할 것이다. 우간다에서는 수출은 3.75% 증가하고 수입은 27.54% 감소할 것이다. 우리의 연구는 농업분야에서 낮은 생산량으로 인해 2050 년의 나쁜 기후의 경우에는 정책입안자는 농업 기술 계획에 주류에 편입시켜야 한다.

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Acronyms

CGE Computable General Equilibrium

CES Constant Elasticity for Substitution

CET Constant Elasticity of Transformation

EAC East African Community

GCM Global Climate Model

GDP Gross National Product

GTAP General Trade Analysis Project

IPCC Intergovernmental Panel on Climate change

NASA National Aeronautics and Space Administration

S.A.M Social Accounting Matrix

NIPA National Income

YDHH Household Disposable Income

YHKH Household Income from Rent of Factor Capital

YHLH Household Income from Rent of Factor Labor

YTHTRh Household Transfers Income Received

TDHH Indirect Tax Liable by Household

TRGOV,H Transfer Sent by Household to the Government

QGDP Real Gross Domestic Product

QO Percent Change in Quantity of Output

PS Percent Change of Supply Price

PP Percent Change in Consumer Price

QPD Percent Change of Quantity in Private Consumption

PXW Percent Change in World Price of Exported Goods

QXW Percent Change in Exported Quantity

QIW Percent Change in Import Quantity

PIW Percent Change in World Price of Imported Goods

US United States

WTO World Trade Organization

Dedication

To my brother Vincent Manirakiza

Acknowledgement

My special thanks to God almighty for the wisdom, knowledge, strength and abundant blessings He bestowed on me throughout my academic years. I express my sincere gratitude to my mentor and advisor Professor Dr. Jong-Hwan Ko, who has the substance of a genius. Thanks for your unfailing and endless support, guidance and your priceless time you devoted throughout this thesis. To the committee members: Thank you for your time, your insightful comments and your guidance. To the professors and the staff of the Department of International and Area Studies: Thanks for your help and co-operation throughout my study. A special gratitude goes to Mr Guide Nahayo, Gabin Nzohabonayo and all my family members: Thank you for your mental, physical and spiritual support. I would not forget to thank my friends, Mrs Cherine Arlette Ndayisenga, Mr. Geoffrey Musyoki Kitetu, Mrs Michele W. and many others for their discussions that helped me build this research

CHAPTER I. INTRODUCTION

1.1 Background

Regional integration is an important tool that countries can use to climb the ladder of economic development, and to achieve improved social welfare for their citizens. These assumptions, and other circumstances, have led in the past few decades to the growth of regional trade partnerships and multilateral trade organizations throughout the world. There are over 350 Regional Trade Agreements (RTA) in force, some fully operational while others are under ongoing negotiations (WTO, 2013).

Climate however, is rarely factored into economic integration, especially in economic development. Climate is the composite or generally prevailing weather conditions of a region, as temperature, air pressure, humidity, precipitation, sunshine, cloudiness, and winds, throughout the year, averaged over a series of years.

According to the Solarimpulse Foundation the average temperature of the planet has increased by 0.8º Celsius (33.4° Fahrenheit) compared to the end of the 19th century. In recent decades the atmosphere and ocean have warmed, the quantities of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased" (IPCC, 2013). The agricultural sector is highly dependent on the climate, the more change of climate and rainfall the more lead to a considerable change in crop production.

While a lot debate on climate change has examined the natural scientific aspects of the issue, and rightfully so, there are relatively few works that deal with the macroeconomic aspect. The aim of

this research is to introduce a common set of climate change and agricultural sector yield inputs into economic models. In this way, any divergences in economic responses can be understood in terms of differences in the structure and parameters of the economic models. Since the agricultural sector is generally the main driver of East Africa's economy, to focus the impact of climate change on this sector is very important. The formal reports of the United Nations Intergovernmental Panel on Climate Change represent the consensus among the world's leading climate scientists on what the causes, likely effects, and possible solutions to global warming are.

To assess the impact of climate change East Africa community's economy in 2050 we will use a Computable General Equilibrium Model (CGE). The CGE model can be defined as a system of non-linear simultaneous equations representing the constrained optimization of behaviors of economic agents that produce, consume, export, import, save, invest, and govern. In order to consider this study, we used economic inputs from biophysical projection. Biophysical projection uses statistical or mechanical and output projected within the Global Climate Model (GCM) to simulate the impacts of projected climate change on biological and physical processes and systems such as water supply, crop yields, and human health and productivity.

1.2 Statement of Problem

Changes in agricultural sector production over time are driven by a combination of many factors; one of these factors is climate change. As the agricultural sector remains very important in the Eastern Africa countries' economy, deterioration due to climate change reduces the yield in the economy.

1.3 Research Objective

The aim of this research is to introduce a common set of climate change and agricultural sector yield inputs into economic models. In this way, we will assess show how climate change affect the economy through agricultural sector.

1.4 Research Question

How will the East Africa community's economy through agricultural sector in 2050 be affected by climate change?

1.5 Organization of the Study

This study aims the impact of climate change on East Africa community in 2050 using CGE analysis. It is organized as follows: the first chapter deals with introduction of the study; the second part portrays the climate change on the global economy, the third part presents the empirical literature. The fourth chapter the research methodology, the fifth chapter presents the shock, results discussion and we conclude our study by policies recommendations followed by references.

CHAPTER II. CLIMATE CHANGE AND THE GLOBAL ECONOMY

2.1 Climate Change

In recent years scientists have reached a consensus that the earth is experiencing climate change due to natural causes and the consequences of human activities. Climate change has significant impacts on biodiversity which, in turn, impacts humanity

2.1.1 Climatic Classification

According the German scientist Köppen (1918) the classification of the climates is based on the temperature and rainfall. He distinguishes five main climate zones, with the tropical climate zone being the warmest and the polar climate the coldest. To make things easier internationally, each climate has been assigned a letter from A to E

1. Tropical climate

The tropical climate zone is located at the equator. In a tropical climate the average temperature of the coldest month is greater than 18 degrees. It is warm all year

2. Desert climate

The desert climate is characterized by a lack of rainfall. As a result, fewer plants grow there. There are however zones where it can rain. Big differences between the average temperatures during the day and the night are characteristic of climates. With few clouds, no obstacles block

the sun's rays during the day, while the heat is not retained at night under cloud cover. Thus, it is hot during the day and cold at night.

3. Maritime Climate

The maritime climate zone is characterized by moderate temperatures. The temperature average of the coldest month is not less than -3 ° C, and that of the hottest month oscillates between 10 and 18 ° C. Precipitations are sufficient throughout the year.

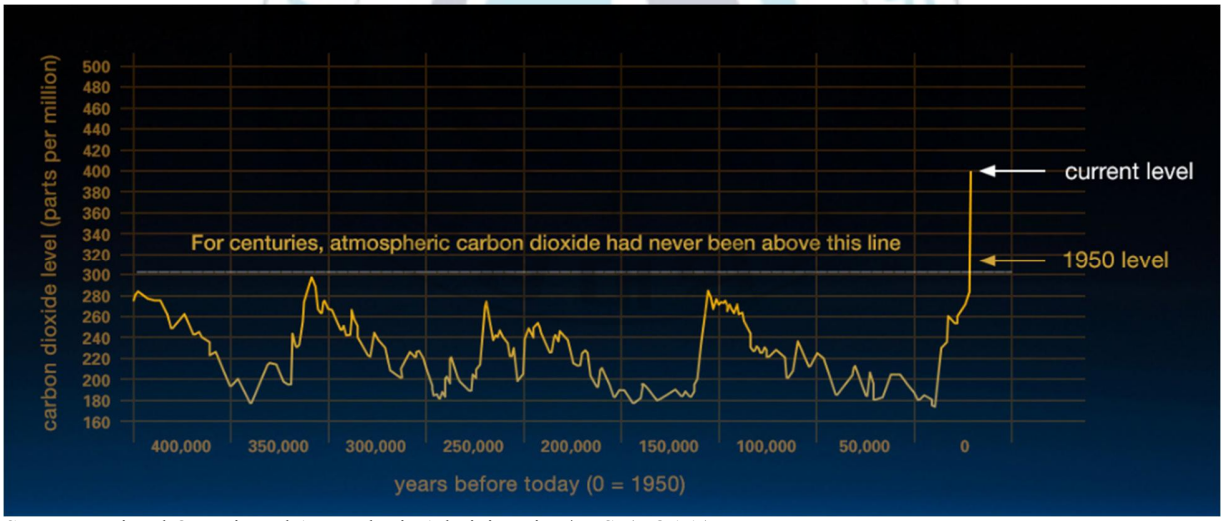
4. Continental Climate

The continental climate is characterized by great differences between summer and winter. Summers are often short and hot, while winters are long, cold and characterized by snow.

5. Polar Climate

In a polar climate, the temperature never exceeds 10 degrees Celsius.

Figure 2. 1 The World Climate Variation



Source: National Oceanic and Atmospheric Administration | U.S. (NOAA)

This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO2 has increased since the

Industrial Revolution. (Credit: Vostok ice core data/J.R. Petit et al.; NOAA Mauna Loa CO2 record.)

The earth's climate has changed over the last millennia. Since 7000 BC, according to a NASA report, there have been seven cycles of glacial advance and retreat, with the abrupt end of the last ice age about 7,000 years ago marking the beginning of the modern climate era — and an increase in human impact on the environment and climate. Most of this change attributed to very small variations in Earth's orbit that change the amount of solar energy our planet receives".But more recent change is due to both natural and human causes. The rapid rate of recent change is attributed primarily to human causes.

The global sea decreased about 8 inches in the last century. The industrialization revolution increased the acidity of surface ocean waters about 30 percent. The carbon dioxide which are absorbed by the upper layer of the oceans is increasing every year by 2 billion tons

2.1.2 The Causes of Climate Change

The primarily cause of climate change is the global warming which is the increase of the average temperature in the earth's atmosphere. One of the primary causes of this warming is increased emission in the atmosphere from the burning of fossils fuel, a human activity. This releases gases, including carbon dioxide that disturbs the natural systems which regulate the climate.

2.1.3 The Effects of Global Warming

Scientists have found "clear and irrefutable evidence that the average global temperature is much higher and is rising faster than hitherto seen in modern civilization. According to scientists, this warming trend can only be explained by human activities, including greenhouse gas emissions into the atmosphere. Due to the greenhouse gases produced by human activities, climate scientists agree, temperatures will continue to rise. According the Intergovernmental Panel on Climate Change (IPCC) which is included more than 1300 scientists from the United States and other countries, the earth's temperature will rise between 2 and 10 degrees Celsius in the coming century.

2.1.4 Future Effects

The magnitude of climate change in the next decade will depend on the amount of heat-trapping gases which are emitted globally. These future effects are the following

2.1.4.1 Irregular Rising of Temperature

Temperature will rise but not in a way that is uniform among or within countries or over time

2.1.4.2 Season Irregularity

The length of seasons will change an effect that has already been observed in some countries for several decades. This will affect the growing seasons of agricultural plants; as well as broader ecosystems.

Figure 2. 2 Arable Land

Source: National Oceanic and Atmospheric Administration | U.S. (NOAA)

2.1.4.3 Changes in Precipitation Patterns

In recent years, data collected some regions of the world; including the United States indicate rising average of precipitation rates, it suggested that in the future the precipitation will continue to increase.

2.1.4.4 More Droughts and Heat Waves

In other regions of the world climate has produced measurably less rainfall and has led to droughts.

Figure 2. 3 Droughts

Source: http://www.climatechallenge.be

According the Intergovernmental Panel on Climate Change in world regions where rainfall has decreased, droughts and the heat waves are projected to become intensive, summer temperature and duration are projected to rise, and soil moisture will likely reduce. According models, in two decades some warmer regions of the world will experience extremely hot temperatures.

2.1.5 The Impact of the Global Warming

Most climate scientists, agree that the main cause of global warming on climate is human activities

Responsible human activity

Figure 2. 4 Burning of Fossil Fuel

Source: http://www.climatechallenge.be

The high concentrations of CO_2 in atmosphere come from the burning of fossil fuel. Over two hundred years of; ever-increasing reliance on fossil fuel coupled with demographic and economic growth has led to increased overall global energy use. From 2000 to 2010 global energy use increased by 3.2 %. The world region where fossil fuel energy use has increased the most is Asia (data from the Global Carbon Project, www.globalcarbonproject.org). Aside from

fossil fuel use, there are also other causes for the increases of CO_2 concentration in the atmosphere.

2.1.6 The Climate Change and Social Issues

The consequences of climate change beyond borders will increasingly affect trade and economies, including import and export prices, and supply chains. According US climate report: "Climate change is going to affect US infrastructure and goods more and more negatively, and economic growth in this century."

Climate change is already affecting the global economy and its negative consequences will only worsen if drastic measures are not taken to reduce greenhouse gas emissions. By the middle of this century, annual losses in the United States related to climate change are project to reach hundreds of billions of dollars, "according to the latest National Climate Assessment "an" assessment mandated by the US Congress and drafted by more than 300 scientists.

Within both developed counties like US and less developed countries like Mozambique weather related disasters, such as hurricanes, floods, mudslides and fires have become frequent and have caused infrastructural damage

Figure 2. 5 Colorado 2012

Source:

NOAA National Weather Service

Figure 2. 6 Mozambique, after the passage of Cyclone Idai, 20 March

The flooded streets of Buzi, central Mozambique, after the passage of Cyclone Idai, 20 March 2019. Photograph: Adrien Barbier/AFP/Getty Images

Eighteen teams of researchers analyzed the causes of 12 exceptionally intense weather events that occurred in 2012. These included droughts from Hurricane Sandy in the United States, the melting of Arctic ice, and torrential rains in Great Britain. In Australia, northern China and Japan, according to the American Meteorological Society (AMS), "natural weather mechanisms and normal climate fluctuations played a key role in these phenomena". The AMS concluded “in some cases, the analysis clearly reveal that climate change induced by emissions of greenhouse gases resulting from human activities has contributed to these phenomena".

According to the report, the human impact on the climate may be partly responsible for the exceptional rainfall in Australia, the unprecedented winter drought in southern Europe and the drought in East Africa

2.2. Climate Change in the East African Community

The East African Community is a multilateral organization that integrates six countries located in the African Great Lakes region and eastern Africa: Burundi, Kenya, Rwanda, South Sudan, Tanzania, and Uganda. According to Mutharika (1972), in the most economic sense, integration refers to the coordination of economic activities to foster the development of countries.

2.2.1 History

The East African community, although recently revived, is well over 50 years old, extending back to the colonial period (1887-1960). Its three original members (Tanzania, Kenya, and Uganda did not share a common vision. The community failed to cohere and finally collapsed. In 1977 the treaty guiding the community was repealed. The main cause the collapse was ‘lack of stakeholder political will. In addition the organization did not consider of the private sector and civil society, in its activities, shared the benefits of the community in a disproportionate way based on member countries’ level of the development and the lacked adequate policy to resolve all these problems.

In spite of these problems, the East African Community was able to recover in the 1990s, and in 1993 put in place in a `tripartite committee 'charged with ensuring the coordination of the economic, social, cultural, security and political questions among East African countries .

In their goal of achieving rapid and balanced regional development, EAC countries (Kenya, Uganda, and Tanzania) have decided to create an environment to attract investment and create opportunities for the private sector and civil society to play key roles. They have given

considerable attention the implementation of these objectives, so as not to fall into the same mistakes of the past.

2.2.2 Geographic Coverage

The EAC is composed by of six Partner States: The Republics of Burundi, Kenya, Rwanda, Uganda, the United Republic of Tanzania and south Sudan (New country in EAC: no data). The population of region was about 164 million in (2018.). The total land area is 1,832,782 square kilometers (EAC Facts and Figures, 2014). Among the five state, Tanzania accounts for slightly over half (51.7 percent) of the total surface area while both Burundi and Rwanda their share for each is 1.5 percent of the surface area`. The share of Kenya and Uganda are 32.1 and 13.3 percent, respectively. This region is characterized by a great diversity of culture, language, history, geography, ethnic and religious identity. The rich social-economic diversity among the partner states carries attributes that provide an opportunity for an integrated and competitive East Africa in a rapidly globalizing world

Figure 2. 7 EAC map

A map of the East African Community (Domestic Tourism Safaris Home)

2.2.3 Social and Economic Indicators of the East African Community

The EAC has 163711369 citizens, more than 22% of whom rural dwellers. With the combined gross domestic product of US $165.534 billion (EAC statistics for 2017), the region has great strategic and geopolitical importance.

Table 2. 1 Social and Economic Indicators of the EAC member countries

Social economic indicators	Burundi	Kenya	Uganda	Rwanda	Tanzania	EAC
Population 2018	11 759 805	46,050,302	39 612 378	12 089 721	54 199 163	163711369
Population growth(%per year)	3.24	2.52	3.28	2.44	3.11	2.89
Area	27 834	591,971	241 551	26 338	945 088	1832782
Density habitat/km	422.50	77.79	163.99	459.02	57.35	200.41
GDP 2017 $ billion	3.478	74.938	25.891	9.137	52.090	165.534
GDP growth per year 2017	0.50	4.90	4.00	6.10	7.10	4.48
GDP per capita 2017 in $	320	1,508	604	748	936	1169.17
Life expectancy 2016 years old	58.50	61.58	63.30	66.60	62.20	62.61
Birth-rate ‰ per year 2016	37.90	34.64	44.50	31.89	36.00	36.33
Fertility 2014 children / woman	5.50	4.33	5.80	4.20	4.83	4.84
Mortality ‰ per year 2014	11.31	8.26	11.26	7.05	4.83	8.41
Child ‰ per year mortality 2015	47.00	35.50	53.00	32.00	41.20	42.72
Literacy % per year 2015	87.62	77.97	72.20	85.03	87.31	81
Official languages	French, Kirundi, English	English, Swahili	Swahili, English	Kinyarwanda, French, English	English, Swahili	
Currency	Burundian Franc BIF)	Kenya Shilling (KES)	Ugandan shilling(UGX)	Rwandan Franc (RWF)	Tanzanian shilling (TZS)	
HDI 2017	0.417 / 1	0.590/ 1	0.516 / 1	0.524 / 1	0,538 / 1	0.5145/1
Regime	Republic. Presidential regime	Republic. Presidential regime	Republic (police state, close to a dictatorship)	Republic (authoritarian)	Federal Republic	

2.2.4 Objectives of the East African Community

The East African Community's founding countries joined together in order to develop and carry out policies and programs aimed at widening and deepening the cooperation in domains of politics, the economy, social and cultural affairs, and research, technology, defense, and security, legal and judicial affairs.

Similarly, the Member States have undertaken to establish among them a customs union (in progress since 2010), a common market and later a monetary union. The ultimate goal of the EAC is to establish a political federation to strengthen and regulate their relations in the commercial, industrial, cultural, social and political sectors to promote accelerated, harmonious and balanced development and sustainable expansion of economic activities, the benefits of which will be shared equitably among themselves .

To reach these objectives, the community is committed giving certainty and the assurance to the Member States of:

- Achieve sustainable growth and development of the Member States by promoting a more balanced and harmonious development of their structures;

- reinforce and consolidate cooperation in agreed areas in order to achieve equitable economic development of the Member States with the consequent increase and improvement of the level and quality of life of the population; - Promote the sustainable use of Member States' natural resources and adopt measures that will protect the natural environment of the Member States;

- strengthen and consolidate associations and traditional political, economic, social and cultural links among the populations of the Member States in order to promote the mutual and people-centered development of these links and associations;

- take into account the gender dimension in all its facets and recognize the role of women in cultural, social, political, economic and technological development;

- promote peace, security, stability and good neighborliness among the Member States;

- Consolidate and strengthen partnership with the private sector and civil society to achieve sustainable socio-economic and political development;

- And any other activities aimed at achieving the Community objectives that the Member States may periodically decide to undertake jointly

According BALASSA (1962), the regional economic integration is a process consisting of a series of five steps, to achieve the objectives of any regional have to realize the following steps: the customs union, the common market, the economic union, the perfect economic integration:

2.2.4.1 Free trade

Free Trade is characterized by the formal abolition of tariffs and quantitative restrictions between articipating countries, but each maintains its tariffs with non-member countries. The aim is to liberalize trade between the signatory countries. The construction of a free trade zone

presupposes the disappearance of impediments on the exchange of goods between the member countries

2.2.4.2 Customs union

A customs union harmonizes tariffs in trade with foreign countries through the establishment of a common tariff applied to any product imported outside the customs union. In addition to the removal of discrimination concerning the movement of goods within the union, the transition from the free trade area to the customs union requires member countries to put in place the same single customs law for all countries.

2.2.4.3 The common market

A common market leads to full integration, since the abolition of barriers no longer only affects trade in products (as in the customs union) but also movements of the factors of production. A common market is a customs union; to which are added certain characteristics such as the free movement of capital and workers within this market. This stage of integration is reflected in the free movement of all factors of production (goods, labor, capital) between the member countries. (Common Market = Customs Union + Capital Factor + Labor Factor)

2.2.4.4 The economic union

Economic union requires harmonization of economic policies in order to eliminate discrimination due to disparities that may arise from liberalization policies. The harmonization measures concern the areas of monetary, financial, commercial and social policies. The economic union therefore adds to the characteristics of the common market that of common policies. All the countries of the economic space seeking only the common interest which is henceforth privileged to the individual interest

2.2.4.5 Perfect economic integration

This step corresponds to the adoption of a single currency that facilitates trade and promotes stability within this economic area. Using a single currency puts an end to currency risks between the currencies of the member countries and allows the application of the common monetary policy. As we can see, the limits of a step in regional integration according to this traditional theory are completed by the next step. At the end of this process, freedom of movement of goods and services, freedom of establishment and provision of services, free competition are established by the common will. Political will is however more feasible because the last two steps go beyond commercial flows.

2.2.5 The Benefits of Regional Integration

Regional integration has several advantages, many of which relate to the exchange and well-being of citizens. These benefits include free trade, trade creation, economies of scale, increased competition, reduction of internal inefficiencies, increased market size, and increased bargaining power.

2.2.5.1 The supremacy of free trade over autonomy

Based on the theories of Ricardo and A. Smith stipulating the superiority of the system of free trade. For Adam Smith, foreign trade is a positive sum game because it benefits both countries. As for Ricardo (1772-1823), the nation obtains, because of the international exchange, a larger quantity than that which they had before the exchange. Thus, the citizens of both countries benefit from a gain of well-being. From these theories, the removal of barriers related to integration is in the interest of countries that trade because of the gains associated with it.

2.2.5.2 The effect of "trade creation

In 1950, a classic analysis, Jacob Viner's model, demonstrated that agreements between neighboring nations are "creators" of commerce within zones. Indeed, exchanges are intensifying within the Union thanks to the RIAs (Regional Integration Agreements) because the consumers coming from each Member State buy in large quantities from the producers of the other Member States from which an additional creation is created Trade. An efficiency of this created trade is a necessity in order to create a "diversion effect"

Viner's model is based on the conventional theory of comparative advantages that justify free trade through consumer gain: imports push economies to specialize and thus, specialization spawning competitiveness, starting to export. As the balance between imports and exports has been balanced, there remains free trade only a general price decline benefiting all consumers irrespective of their country of origin. And the more sources of supply, the more the country will specialize and therefore these gains will be important.

2.2.5.3 Economies of scale and increased competition

Economics of scale is an expression referring to the decrease in the cost of a product per unit thanks to the increase in productivity. In other words, achieving economy of scale means that the company will have to create its products in large quantities to reduce the cost of each individually. Faced with the problem of the narrowness of the market in some countries, companies cannot fully exploit their production capacity because they cannot sell it. Regional integration then provides a way to overcome this barrier with its "effects of increasing market size". In addition, the widening of the market makes it possible to obtain at the same time a growth of size of the companies and markets more and more competitive.

The potential to accelerate economic growth, which is one of the aims of economic integration experiments, depends on the susceptibility of economies of scale to be favored by the unification of national markets and the intensification of trade relations between countries.

2.2.5.4 Avoid internal inefficiencies.

For fear of being squeezed out of the market by regional competition, firms seek to eliminate internal inefficiencies and increase productivity. On the side of the workers, the same effect occurs in order to avoid the dismissals that may result from the probable bankruptcy if the firms fail to adapt to regional competition. This improvement in productivity by workers leads to an optimal allocation of labor in the different sectors of economic activity.

2.2.5.5 Increasing the size of the market

With the gathering of people from different countries in the same market, there is a tendency for firms to make profits because of the increase in perceived demand. This perceived increase in demand attracts other firms that are moving into the region, and industrial and commercial activity is exploding. Production increases and this situation gives freedom to the consumer who is in a large rather than small market. The price as for him decreases with the competition.

2.2.5.6 Increased bargaining power

Together, countries become stronger in international negotiations than when they were individually. For example, they can take advantage of tariff reductions for products exported from the Union

2.2.6 Structure of the East African Community

The two main bodies of the EAC are the Summit of Heads of State and Government and the Council of Ministers:

- The Summit of Heads of State and Government define the main lines of Community policy. It meets at least once a year.

- The Council of Ministers is the principal decision-making body of the Community. It meets at least twice a year and its decisions are binding on the Member States.

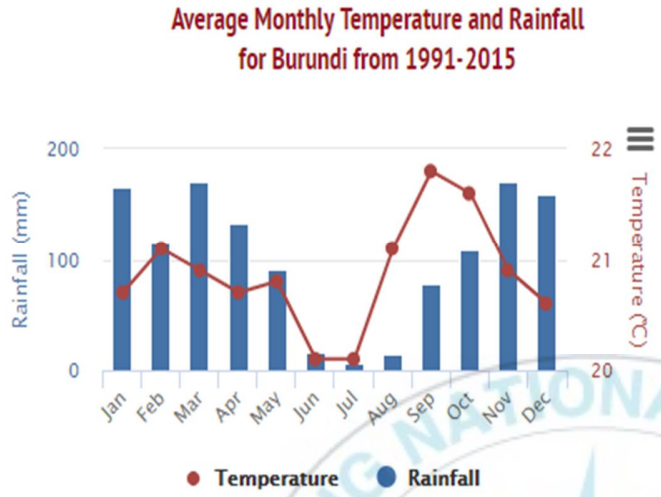
-The EAC also includes a Coordination Committee, Sectorial Committees, a Court of Justice and a legislative Assembly. EAC is based in Arusha, Tanzania.

2.2.7 Climate of the East African Community

The agricultural sector is generally the main driver of East Africa's economy. It plays a key role in economic growth, poverty reduction, food security and employment. In East Africa's countries the majority of the labor force is engaged in agricultural activities.

2.2.7.1 Climate Change overview: Burundi

Figure 2. 8 Burundi climate

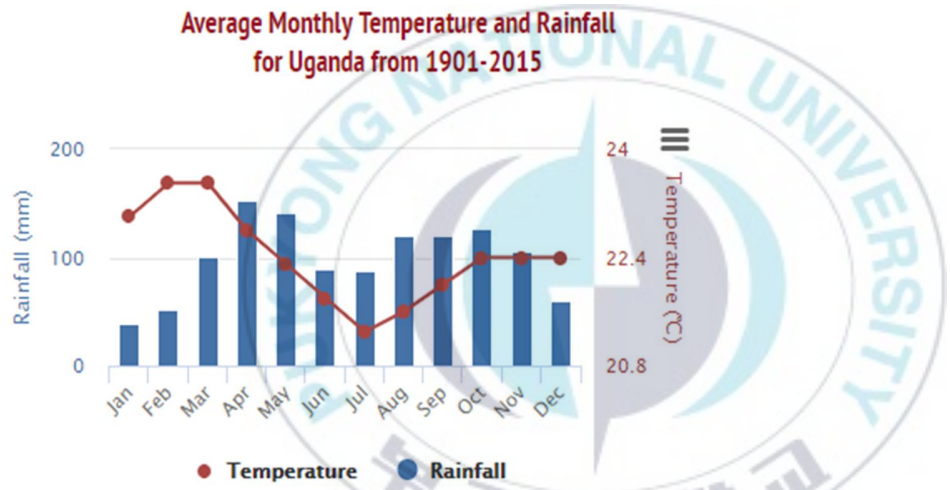


Burundi is a country characterized by a hilly highland plateau that drops to lowlands on the western and eastern borders. Burundi's climate is mild or warm, and varies according to altitude, while there is little seasonal variation in temperature. From June to August, the austral winter, dominated by cool breezes from the south-east, is a dry season, during which there is little rain and the sun often shines. From mid-August, the temperature begins to rise, and in September and October the highest values of the year are recorded; at the same time, however, the rains begin, which occur in the form of downpours or thunderstorms, and gradually lower the temperature, which returns to the values of the rest of the year, around 22/25 °C (72/77 °F) during the day on the plateau, and around 27/28 °C (81/82 °F) in the western lowlands.

If we exclude the three dry months, moderate rains fall in the rest of the year. The rains tend to increase with altitude, ranging typically from 1,200/1,400 millimeters (47/55 inches) per year in the plateau, while they drop below 1,000 mm (40 in) in the western area, which is the warmest and least rainy of the country

2.2.7.2 Climate Change overview: Uganda

Figure 2. 9 Uganda climate

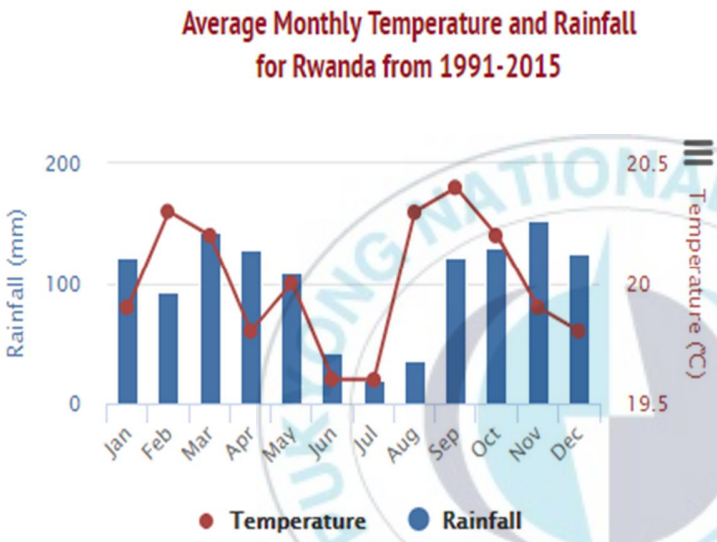


Uganda is among the countries that are crossed by Equator. The weather of Uganda is influenced by altitude. In fact, most of country's area is occupied by a plateau, at an altitude of 1,000/1,400 meters (3,300/4,600 feet). The weather of the plateau is moderately warm, with ordinary temperatures ranging between 20 °C and 25 °C (68 and 77 °F), and the average annual rainfall of each year is between 900 and 1,500 millimeters (35 and 60 inches). Changes of temperature throughout the year are little, however, the warmest period start from December to March, more apparent in the north, and the coldest period start from June to September. In

general, the weather is moderate; even if sometimes the temperature is high during the day, principally from December to April, while the nights are cold, depending on altitude, throughout the year, but this happen from June to August.

2.2.7.3 Climate Change overview: Rwanda

Figure 2. 10 Rwanda climate

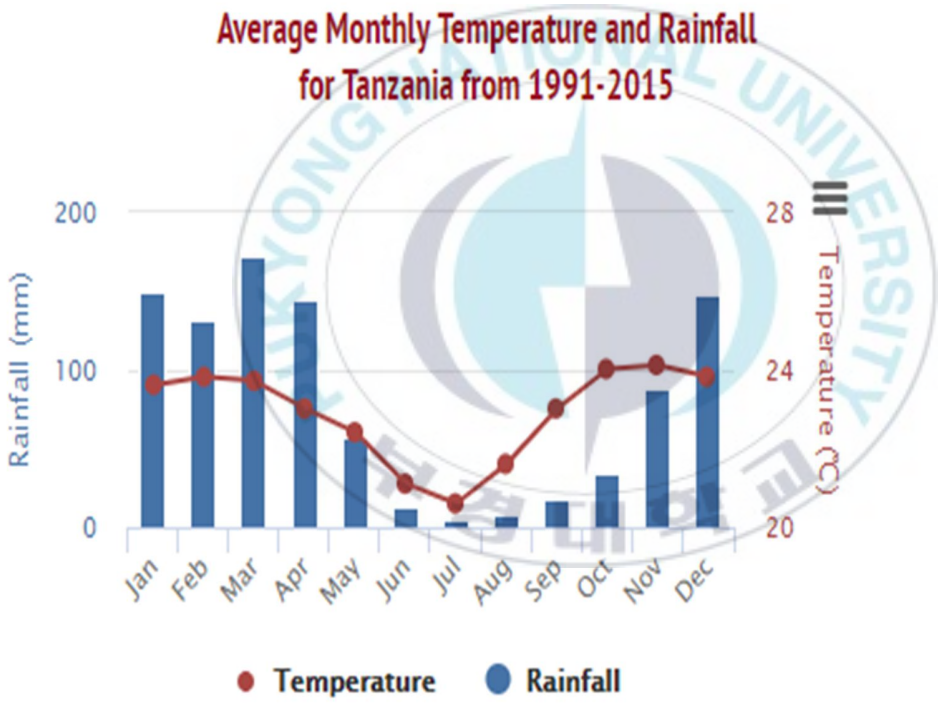


Rwanda, a highland country, whose climate is strongly affected by altitude. It is warm, with cool nights year-round. Most of the country is a highland plateau, about on a plateau, about 1,500 meters (5,000 feet) above sea level. The altitude declines to less than thousand meters (3,300 feet) only in the westernmost part, along the Rusizi River, which shows the Rwanda's border and Democratic Republic of the Congo and is therefore the hottest part of the country where the temperature can sometimes to reach 35 °C (95 °F).

Precipitation ranges is between 1,000 and 1,400 millimeters (40 to 55 inches) per year depending on locations; there's a dry season between June and August (and July is the driest month) and the rainy season is between September and May.

2.2.7.4 Climate Change overview: Tanzania

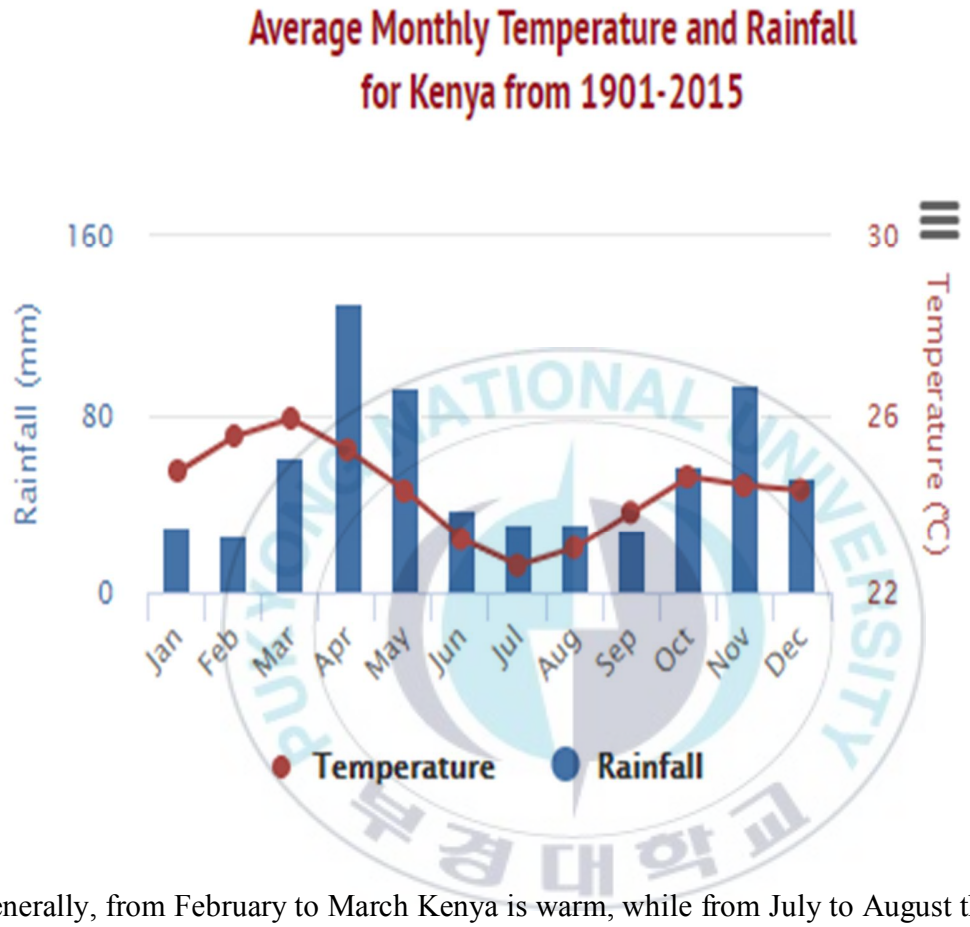
Figure 2. 11 Tanzania climate



Tanzania is large country which lies along the Indian Ocean the south of the Equator. Much of the country is covered by a plateau characterized by a tropical climate and moderate, weather because of its attitude. The period of June to August is the coolest of the year and everywhere is almost dry.

2.2.7.5 Climate Change overview: Kenya

Figure 2. 12 Kenya climate



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Generally, from February to March Kenya is warm, while from July to August the coolest period, even if the seasonal fluctuations in temperature are small. Both temperature and rainfall fluctuation is according to the prevailing winds, which produce two seasons: between October and March, in this period is characterized by the hottest and dry winds coming from Arabia (called kaskazi) triumph, while between April and September, the triumph winds (called Kuzi) is characterized by the coolest and the wettest from the Indian Ocean. In the starting of the two periods, and in correspondence with the two zenith passages of the sun, exist two rainy seasons

which are between Marches and May "the long rains", and the less intense between October and December "short rains".

CHAPTER III. LITERATURE REVIEW

3.1 Empirical Literature

The issue of global warming has been highly studied and discussed in recent years. Many studies, particularly academic studies, have examined the impact of climate change on the agricultural sector. These studies do not usually take account economy as a whole. This study however looks at the macroeconomic impact of climate changes.

The impacts of climate change on the economy have been issu of several studies. (Wei X et al.2018) for example, provides evidence of the impacts of climate change on China's agriculture, with particular attention to market, and trade responses. Their results show that under climate change the wheat yield in China is projected to decline by 9.4% by 2050. This, is the biggest lost among the crops and the market respond due to climate change, as farmers can change inputs in response to decreased yields and rising prices impacts and the reduced in crop production will be further reduced the trade. Agriculture grew 5 percent in 2017, while industry grew 10.5 percent;

Wang H et al. (2009) used a general equilibrium model to assess climate change impacts on agriculture in China and found that the percentage decrease in the production of rice, wheat, and maize in 2030 would be lower than the yield changes predicted by biophysical crop modelers.

Georgopoulou(2017) studied climate change impacts and adaptation options for the Greece's agriculture in 2021–2050. He found that a climate change may create winners and losers

depending on the agricultural activity and location, while adaptation can mitigate adverse effects of climate change under cost-effective terms.

Using sub-national data for the United States and the European Union. Ding et al examined the relationship between temperature and growth. They found that the optimal degree of the temperature is much lower. Because production is highest in areas where temperature is above the optimal, projected that when the temperature is increased, it would have a negative impact on the economic growth of both the United States and the European Union. Their results suggest the need for more proactive climate policy.

Kang H et al., (2017) in studied climate change impacts on green water droughts based on the hydrologic simulations. They used a variation infiltration capacity model to compare the possible impacts of climate change on future agricultural drought and economic conditions in the US region of Virginia. To do this, they estimated a soil moisture index (SSI), which they then employed with historic and future climate data to generate SSI predictions.

Asbjorn et al.(2009) applied macroeconomic general equilibrium to assess the impacts of climate change on Europeans economies under an increase in mean of temperature by $+2^0$C and $+4^0$C. In their study they checked the effect of the climate on different economic activities due to market change. To capture climate variation in vulnerabilities they divide Europe in 87 sub- regions. In their results they found that when mean temperature increased by + 2^0C, the impacts were moderate with a positive impact on GDP in some sub-regions and a negative effect in other sub-region due to annual decrease of 0.1 per cent. At a mean temperature raised by $+4^0$C, they found that the GDP would decrease throughout Europe, but most substantially in southern parts,

where in some sub-regions it will be increase0.7 per cent per year, they found also that change of climate caused differentiation of wage in Europe.

Ding D et al. (April 2017) they used sub-national data to assess the relationship between temperature and economic growth within in United States and Europe. In the result they found that the optimal temperature is much lower, they argue that because the most production areas is where the temperature is above the optimal. They suggest that because of projected high temperature have a negative impact on economic growth of both US and European Union, they should be proactive climate policy

Vahid K et all (2018) conducted the study "Climate Change and Agriculture: Impacts and Adaptive Responses in Iran. The purpose of this study was to document the expected impacts of climate change on the agricultural sector of Iran's economy and the current adaptation achievement made by government and farmers. In designing study they combined and assessed different literatures and they found that change in rainfall and water endowment have a significant on crop output, crop's water requirement, warfare of farm families and income. In adaptation side, the government's efforts distinguished between developing agricultural productivity and irrigation based on recent technology. Their conclusion suggests that to reduce negative impacts of climate change, it is better to increase the adaptive capacity of farmers.

In the study done by Dan W et al (2017) Climate Change and the Economy in Baja California, they assess macroeconomic impacts of California Climate Action Plan. The purpose of this study was to assess macroeconomic impacts of the Climate Action Plan (CAP) process undertaken in the Mexican border state of Baja California (BC) which was to decrease atmospheric concentrations, and hence the coming potential damages of these pollutants, the motivation to the

BC economy from the application of its CAP. They find that the combined impacts include an means annual of increased in new jobs is around 1680 (or about 0.11% of the mean annual employment in the baseline economic forecast) and the increase of Gross State Product (GSP) is $9.85 billion pesos in NPV for the 2015–2030 planning horizon. Moreover, this in contrast to the long-term will take place in the near-term and more uncertain benefits associated with decreasing climate change damages.

Bocchiola D. al., with the agronomic model Poly-Crop they studied the impact of climate change on agricultural productivity and food security in the Himalayas: A case study in Nepal. The purpose was to assess whether cropping at higher altitudes may help adaptation. They asses the present and the future until 2100. To explore food security, they use nutritional index given by given by the ratio of the caloric content from our goal cereals, to daily caloric demand by estimation of crop yield and food security at half a century (2040-2050) and at the end of the century (2090-2100), compared to a decade of control, CR (2003-2013), with one use constant land and projected land occupation. On average, the specific yield of wheat would decrease relative to the RC from -25% (rice -42%, maize -46%) to 2100, with a largely annual variability for an unchanged land use scenario. In the modified land use scenario, the wheat yield would decrease by -38%, while the yield of rice and maize would improve very slightly (-22% and -45% against CR) in response to the occupation, altitude higher than today. Our food security index would decrease in all scenarios (111% in 2010, 49% on average in 2050, with a population peak, and 51% in 2100) and would become more variable, with, however, a potential for adaptation by colonization higher land (75%, 62%, at 20:50, 21h). A very large expansion of a cereal (ie maize) can make food security more unstable as it depends mainly on the irregular yield of that cereal only. Many studies economic analysis have been done but most of them didn’t take look

externals effects on economic variables. In our study we will take look on how change in climate will impact economy.

CHAPTER IV. MATERIALS AND METHOD

4.1 The Computable General Equilibrium Model

The Computable General Equilibrium model is formally defined as "a set of non-linear simultaneous equations relating composed by endogenous (determined within the model) and exogenous (Independent variable that affects a model without being affected by it) describing the constrained optimization of behaviors of economic agents. The advantage of this model is its capacity to measure policies ultimate effect on aggregate welfare in theoretically consistency way by quantifying any change of income and consumption in the representative agent in their interactions in the economy as a whole. According to Borges (1986), the strength of the CGE model is its solid macroeconomic foundation. The demand and production functions for all economic agents are explained and specified in the CGE model.

The difference between the CGE model and the partial equilibrium model is that the basic of CGE is the general equilibrium theory. All factor markets and commodities of an economy are treated at the same time in the model, while a partial equilibrium model considers only specific sectors. The CGE model's difference from a macro-econometric model is that the CGE model encompasses numerous specific sectors, while a macro-econometric model considers an aggregated economy. There are four differences between the CGE and input-output model (Ko, 1993). First in the CGE model quantity and price are simultaneously determined by the interactions of demand and supply, while in the input-output model there is a dichotomy between price and quantity. Second, in a CGE model, all final demand components such as private consumption, government expenditure, investment, exports, and imports are functionalized;

while in an input-output model they are exogenous. Third, in a CGE model, price-dependent input coefficients can be used, whereas in an input-output model fixed input coefficients are used. Fourth, supply curves of primary factors of production such as labor and capital in the CGE model are positively sloped, while they are assumed in an input-output model to be perfectly elastic.

A global general equilibrium in economics has its origin in the work of the classical interrelated markets in which the equilibrium of all variables must be determined , in structure of an interregional bottom-up CGE model, in theoretical perspective and social accounting matrices (SAM) is the basis for CGE modeling.

Lemelin (2015) explains that the core of CGE is based on equations representing consumer behavior and market equilibrium, and is a Walrasian model solution competitive general model. All economic agents optimization meet their (first order) optimality conditions subject to budget's constraint and all markets are in equilibrium.

4.1.1 Model Specification

We used the global CGE model to assess the impact of climate change on macroeconomic level of East Africa community in 2050. To carry out the simulation, we used economic inputs which are from biophysical projection. The biophysical projection that use statistical or mechanical and output projected within the Global Climate Model (GCM) to simulate the impacts of projected climate change on biological and physical processes and systems such as water supply, crop yields, and human health and productivity. The widely recognized Intergovernmental Panel climate change data, (IPCC, 2013) includes projected socioeconomic data such as income growth,

energy, population use policies, and other variables that influence levels of greenhouse gas emissions. Increasingly collaboration of experts from both the physical and social sciences research, and the integration of their data have led to better understanding of the potentially enormous implications of climate change on human processes. In the IPCC study, economists are asked to assess the macroeconomic variables and develop a basic scenario of the EAC in 2050 both with and without climate change. Based on the previous studies we shocked the projected population growth, GDP growth, cultivated area and endowments labor and capital. The counterfactual experience of climate change included the same growth projections as in the baseline scenario, with the addition of crop yield shocks from biophysical models of climate change

Figure 4. 1 The CGE model data of East Africa community

	Commodities						Final Demand					
	Import variety	Domestic variety	Production activities	Factors	Taxes	Regional household	Private households	Government	Savings-investment	Trade margins	Rest-of-world	Total
Imports			Demand for imported inter-mediates				Demand for imports	Demand for imports	Demand for imports			
Commodities												Aggregate demand
Domestic			Demand for domestic inter-mediates				Demand for domestic	Demand for domestic	Demand for domestic	Export of trade margins	Exports	
Production activities		Domestic production										Domestic sales
Factors of production			Factor payments									Factor income
Taxes	Import tariff	Export tax	Taxes on output, factor use, inputs	Income tax			Sales tax	Sales tax	Sales tax			Tax revenue
Regional household				Net factor income	Tax revenues							Aggregate income
Private household						Household income						Private household income
Government						Government income						Government income
Savings-investment				Depreciation		Domestic savings				Foreign savings	Foreign savings	Savings
Trade margins	Trade margins on imports										Foreign exchange outflow	
Rest-of-world	Imports											
Total	Aggregate supply		Gross domestic production	Factor expenditure	Tax expen-diture	Aggregate expenditure	Private consumption expenditure	Gov't. consumption expenditure	Gross investment expenditure	Foreign exchange inflow		

The EAC data in the GTAP model is displayed as Social Accounting Matrix (S.A.M). The SAM shows the interrelationship of sectors within the economy and transactions among between all agents. In this economy, it is assumed that each sector produces one commodity. This data is represented by a row and a column. Each cell indicates a payment from the column account to the row account; revenue appears along the rows expenditure along the columns. Double-entry accounting requires that, for each account, total revenue (the total row) equals total expenditures (the total columns). The components of EAC's SAM compatible with GTAP are following:

1. Sectors and commodities

Sectors in SAM are entities that carry out production and commodities are representing markets for goods and non-factor services. The SAM flows are valued at producer prices in sector accounts and at market prices in commodity accounts, i.e., inclusive of indirect taxes and transactions cost margins. Commodities consist of activity outputs, either exported or sold domestically, and imports. In the sector columns, payments are made to commodities (intermediate input demand) and factors of production (value-added, equal to operating surplus and compensation of employees). In the commodity columns, payments are made to domestic sectors, the rest of the world, and to different tax accounts (for domestic and import taxes). The number of sectors and commodities in the EAC is 6.

2. Factors of production

Factors of production are the resource endowments of land, labor, and capital. Some modelers further subdivide these factors by types. For example, labor may be divided into skilled and unskilled workers, or land divided into cropland and forest, or irrigated and non irrigated. The row account for each factor reports the income it receives from the production activities in which it is employed

3. Private Households

The private household column and row accounts represent the expenditures and revenues of all of the individual's agents in an economy, aggregated into a single, "representative" household. The private household row account gets shares from the national income that is from the regional

household's column account. Households utilize this income in its entirety on goods and services and related sales taxes, as portrayeds in the household's column account. Private household consumption is usually a large component of an economy's final demand for goods and services.

4 Government

Government is disaggregated into a core government account and different tax collection accounts. Tax accounts are indispensable since otherwise the economic interpretation of certain payments becomes ambiguous. Government's direct payments to domestic institutions are reserved for transfers. Payments of factors by government are captured in the government services activity. Government expenditure is a purchase of the output from the government services activity, which in turn, pays labor.

5 Saving investment

The savings and investment row and column accounts represent an economy's loanable funds market, showing the supply of savings that is ready for investment and how these investable funds are spent. The savings row account shows the accumulation of saving from domestic sources and from foreign sources. Foreign savings equals the trade balance in goods and services and in trade margin services. The row account also reports the depreciation of the existing capital stock which is the investment spending by firms to replace the capital stock that is used up or worn out in the production process.

The investment column account records gross national investment, which is the combined spending on replacement of depreciated capital plus investment in new equipment and machinery that will be used in future production activities. The SAM reports the goods and services that investor's purchase, but not the destination of those investment goods.

6 Taxes

The tax row accounts in a SAM describe the economic activities on which taxes are levied and the amount of tax revenue that is generated. Some taxes are reported as negative values, which denote a subsidy. Tax row sums report the value of total revenue from each tax, which is paid in its entirety by the column account for each tax to the regional household account.

7 Regional Household

The regional household is a macroeconomic account describes CGE models. It is very similar to the concept of GDP from the income and expenditure side. Its row account represents the sources of aggregate national income from factor incomes and taxes, and its column account represent the total domestic spending by private households and government, and national savings.

8 Trade investment

The trade margin accounts describe the insurance and freight charges which are when the goods are shipped by air, sea or land from an exporting country to an importing country. These costs push up the price of imports relative to the price received by the exporters. The exporter's margin-exclusive price is called the free on board, or fob price. The importer's margin-inclusive price is called CIF (Cost, Insurance, and Freight) price. The difference between the CIF and FOB (Free on Board) values of imports is the trade margin

9 Rest-of-World

This account describes trade and investment flows between a country and the rest of the world (ROW). The ROW's row account in the SAM shows the home country's foreign exchange outflow, which is its spending on each import valued in ROW's fob world export prices.

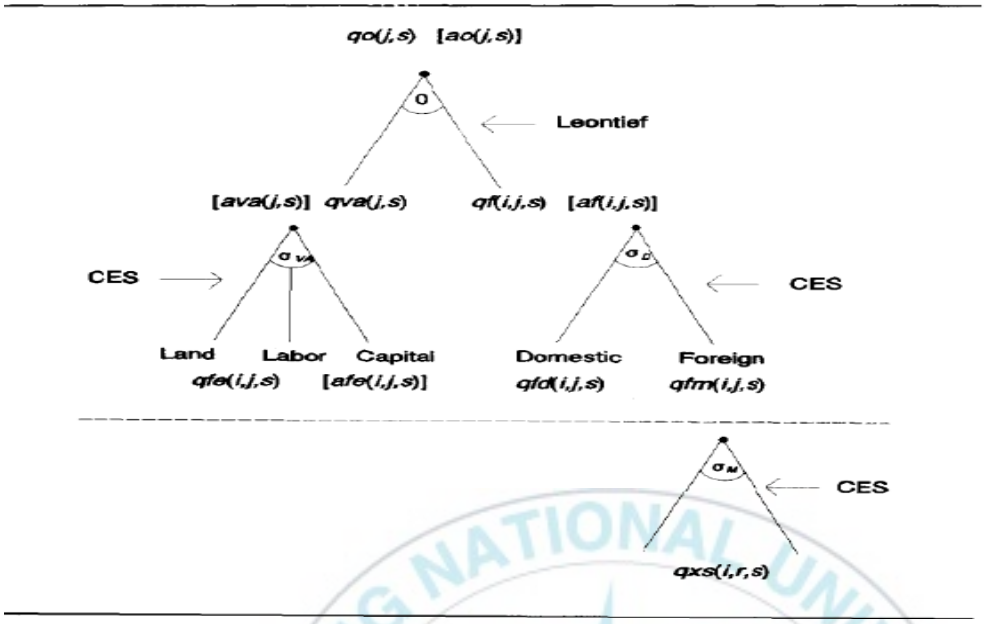
The ROW column account reports domestic foreign exchange inflow, or export sales of each commodity, valued in domestic fob world export prices. The column account also records the balance of trade as a payment by, or inflow from, the rest-of-world to the savings-investment account. The balance of trade is the difference between the fob values of domestic's total export and total imports. When the country runs a trade deficit (its imports exceed its exports), its foreign savings inflow is positive. In this case, the country is borrowing from abroad and the foreign savings inflow increases its supply of savings. When a country runs a trade surplus (the value of its exports exceed the value of its imports), its foreign savings inflow is negative. In effect, it is lending its capital to foreigners

4.1.2 The Behavior Equation

4.1.2.1 Firm behavior

Firm behavior provides a visual display of the assumed technology for for each the industries within model. This kind of production tree is a convenient way of representing separable, constant return-to-scale technologies. At the bottom of the production tree are the individual input demanded by the firm: labor, land and capital. The quantities of factor are denoted QFE(i,j,s), or, in percent a change form, qfe (i,j,s).

Figure 4. 2 Production three



Global trade analysis: modeling and application by Thomas Hertel

Firm purchase also intermediate input, some of which is produced domestically, qfd(i,j,s), and some which is imported qfm I,j,s) . The imported goods must be sourced from the particular exports qxs (i,r,s). The dashed line between the firms' production and the constant elasticity of substitution (CES) nest combining bilateral imports.

The manner in which the firm combines individual inputs to produce its output, QO(i,s) depends largely on assumptions that we make about separability in production. Firms choose their optimal mix of primary factors independently of the prices of intermediate inputs. Since the level of output is irrelevant owning the assumption of constant return to scale, this levels only the relative prices of factors of production (land, labor, capital) as arguments in the firms conditional demand equations for components for value added. By assuming this type of separability, we

impose the restriction that the elasticity of substitution between any individual primary factor on one hand and intermediate inputs on the other hand: this is what permit us to draw the production tree at which the intermediate and primary factors of production are joined.

Composite imports equations

$$pim(i,s) = \sum_{REG} MSHRS(i,k,s) * pms(i,k,s)$$

$$pim(i,s) = \sum\_REG \; [MSHRS(i,k,s) * pms(i,k,s)]$$

$$pxs(i,r,s) = qim(i,s) - \tau_M(i) * [pms(i,j,r) - pm(i,s)]$$

Behavior equation for producers

pf(i,j,r) # firms' price for commodity i for use by j in r

$$pf(i,j,r) = FMSHR(i,j,r) * pfm(i,j,r) + [1 - FMSHR(i,j,r)] * pfd(i,j,r);$$

qfm(i,j,r) industry j demands for composite import

$$qfm(i,j,s) = qf(i,j,s) - ESUBD(i) * [pfm(i,j,s) - pf(i,j,s)];'$$

qfd(i,j,s): industry j demands for domestic good i

$$qfd(i,j,s) = qf(i,j,s) - ESUBD(i) * [pfd(i,j,s) - pf(i,j,s)]$$

Value added nest

pva(j,r) # firms' price of value added in industry j of region r

*pva(j,r) = sum(k,ENDW_COMM, SVA(k,j,r) * [pfe(k,j,r) - afe(k,j,r)]);*

qfe(i,j,r) # demand for endowment i for use in ind. j in region r

*qfe(i,j,r)= - afe(i,j,r) + qva(j,r)- ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)];*

Equation ZEROPROFIT

#sector zero pure profits condition

(all,j,PROD_COMM)(all,r,REG)

ps(j,r) + ao(j,r)

*= sum(i,ENDW_COMM, STC(i,j,r) * [pfe(i,j,r) - afe(i,j,r) ava(j,r)])*

*+ sum(i,TRAD_COMM, STC(i,j,r) * [pf(i,j,r) - af(i,j,r)])*

Linearization

To obtain the derived CES demand equations. The exposition begins with the definition of elasticity of substitution. Thus the functional form of CES was invented (Arrow and all 1961). Consider the two cases of inputs, where the elasticity of substitution is defined as the percentage

change in the ratio between the two requests for cost-minimizing inputs, with a percentage equal to 1 in inverse of their price ratio:$\sigma = (Q1\uparrow Q2)/(P1\uparrow P2)$

↑= percent change

σ =1

If σ =1 Cost shares are invariant to price changes. For larger values of σ, the rate of change of the quantity ratio is greater than the rate of change of the price ratio and the share of costs of the inputs that become more expensive actually falls. In the percent form (lowercase laters), we obtain $(q1-q2) = (p2-p1)$. To obtain the form of demand equation, several substitutions are necessary. Let us first note that the differentiation of the production function and the fact that the firms' compensation factors constitute their marginal value product give the following relationship between inputs and output (ie the composite good). q=□1q1+(1- □)q2;

Where □1 is the cost share if input 1 and (1- □) is the cost share of input solving for q2 gives:

q2=(q- □1q1)((1- □)

Substitute this into (2.6)

q1= σ(p2-p1)+[q- □q1] (1- □)

This simplifies the following derived demand equation for the first input:

q1= (1- □) σ (p2-p1) +q

Note that the above conditional demand equation is homogenous of degree zero in prices and the composite price.

P=□1p1+ (1+□1) p2

The final substitution required to obtain the CES demand equation introduces the percentage change in composite price

P= □1p1+ (1-□1) p2

When the zero profit equation condition is defined above in (), we have deducted both sides of the output value at the agent prices. Since revenues are exhausted on costs, the resulting coefficients, weighting input prices, are respective cost shares. From there, we proceed analogously to the one explored above, first solving p2 as a function of p1 and p, then substituting this forq1= (1-□1) σ {[p-□1p1]/ (1-□1)-p1} +q

This simplifies to the following final form of the derived demand equation for the first input in this CES composite

q= σ (p-p1) +q

This equation decomposes the evolution of the derived demand q1 of a company into two parts: the first substitution effect. It is the product of the (constant) substitution elasticity and the percentage change in the composite price ratio on the price of input 1. The second component is the expansion effect. Possessing constant returns to scale, it is simply the equitable relationship between production and inputs

4.2 Data

For Projections for real GDP of Eastern Africa community from 2011 to 2050 we used the Quantitative Technical for Macroeconomic Analysis in this way:

Xt+1 = X* (1 + growth rate/100)

The real GDP of the East Africa Community members countries from 2010 to 2050

In this real GDP, the data from 2002 to 2018 are available in World Bank Data and from 2019 to 2050 are computed by authors by using the Quantitative Technical for Macroeconomic Analys

Table 4. 1 GDP of five member of EAC

Year	Burundi	Kenya	Tanzania	Uganda	Rwanda
2002	1492133657	17502583535	17502583535	10422546785	2847406189
2003	1558481670	18756390477	18756390477	11332715044	3223037870
2004	1539410094	20047998014	20047998014	12066311003	3294021296
2005	1613819909	21617415118	21617415118	12887692950	3539350101
2006	1628344288	23384279055	23384279055	13703814498	3871265953
2007	1716499708	24474119982	24474119982	15181735862	4228471205
2008	1775752462	26545702803	26545702803	16458888152	4553283968
2009	1862084450	28023394740	28023394740	17892251887	5061760727
2010	1933081018	29531710853	29531710853	19109196503	5379885027
2011	2032135247	31409598704	31409598704	20186496527	5773084568
2012	2114083183	33892372812	33892372812	22082345211	6222456868
2013	2208090294	35634784314	35634784314	22929745405	6771297545
2014	2316820972	38222960435	38222960435	23752213779	7090466089
2015	2415069278	40885241206	40885241206	24965074811	7631084047
2016	2320881502	43730597180	43730597180	26260227907	8307806854
2017	2306955749	46777776620	46777776620	27515729480	8804722944
2018	2318490758	50100945307	50100945307	28578668646	9338098208
2019	2515286750	48993865622	48993865622	29273331584	9107520357
2020	2578082440	50970060683	50970060683	30399612515	9492424584
2021	2640878130	52946255745	52946255745	31525893446	9877328810

2022	2703673819	54922450807	54922450807	32652174377	10262233036
2023	2766469509	56898645868	56898645868	33778455308	10647137262
2024	2829265199	58874840930	58874840930	34904736240	11032041489
2025	2892060888	60851035991	60851035991	36031017171	11416945715
2026	2954856578	62827231053	62827231053	37157298102	11801849941
2027	3017652268	64803426114	64803426114	38283579033	12186754167
2028	3080447957	66779621176	66779621176	39409859964	12571658394
2029	3143243647	68755816237	68755816237	40536140896	12956562620
2030	3206039337	70732011299	70732011299	41662421827	13341466846
2031	3268835026	72708206361	72708206361	42788702758	13726371072
2032	3331630716	74684401422	74684401422	43914983689	14111275299
2033	3394426406	76660596484	76660596484	45041264620	14496179525
2034	3457222095	78636791545	78636791545	46167545551	14881083751
2035	3520017785	80612986607	80612986607	47293826483	15265987977
2036	3582813475	82589181668	82589181668	48420107414	15650892204
2037	3645609164	84565376730	84565376730	49546388345	16035796430
2038	3708404854	86541571791	86541571791	50672669276	16420700656
2039	3771200544	88517766853	88517766853	51798950207	16805604882
2040	3833996233	90493961915	90493961915	52925231139	17190509109
2041	3896791923	92470156976	92470156976	54051512070	17575413335
2042	3959587613	94446352038	94446352038	55177793001	17960317561
2043	4022383302	96422547099	96422547099	56304073932	18345221787
2044	4085178992	98398742161	98398742161	57430354863	18730126014
2045	4147974682	1.00375E+11	1.00375E+11	58556635795	19115030240
2046	4210770371	1.02351E+11	1.02351E+11	59682916726	19499934466
2047	4273566061	1.04327E+11	1.04327E+11	60809197657	19884838692
2048	4336361751	1.06304E+11	1.06304E+11	61935478588	20269742919
2049	4399157440	1.0828E+11	1.0828E+11	63061759519	20654647145
2050	4461953130	1.10256E+11	1.10256E+11	64188040451	21039551371

GDP data that we used in our different scenarios are from our forecasted data and others are from different sources like arable land projections are from Bruinsma (2011). Growth, which is estimated. Projected real population from Population Pyramids of the World from 1950 to 2100, projected labor force and physical capital growth for 2010–2050 are from Foure et al. (2012).

Table 4. 2 Projected data for EAC in 2050

	Real GDP (qgdp)	Population (pop)	Labor force (qo)	Physical capital (qo)	Arable land (qo)
Kenya	210.68	127.24	60	60	0.44
Malawi	284.5	37.3	38.4	213.1	4.4
Tanzania	251.03	197.47	60	60	0.44
Rwanda	264.44	99.50	60	60	0.44
Uganda	217.98	200.33	60	60	0.44
Rest of EAC	119.57	241.98	60	60	0.44
USA	284.5	37.3	38.4	213.1	4.4
China	284.5	37.3	38.4	213.1	4.4
Korea	284.5	37.3	38.4	213.1	4.4
Rest of the world	284.5	37.3	38.4	213.1	4.4

Source: Authors calculation

CHAPTER V. EMPIRICAL RESULTS

5.1. Scenarios

The purpose of this study is to use the GTAP model to run simulations in order to carry out quantitative results analysis. This will help show the effect of climate change on the economies of five East African Community member countries in 2050. The results are demonstrated in two parts which are the EAC economies in 2050, with and without climate change. Their differences show the projected effect of climate change on the East African Community in 2050.

In this study from biophysical crop models to an economic model we constructed a baseline scenario and a second scenario. The baseline presents the East African Community economy without climate change. To develop this model, we supplied our CGE model with projected socio-macroeconomic data (Table4. 1) of EAC for 2050. The projection of agricultural land area is from Bruinsma (2011). The second scenario shows the impact of climate change on land supply and agricultural productivity. For projections of real GDP of East African community (Table4. 1) we used the Quantitative Technical for Macroeconomic.

5.1.1 Experiment Design

In this experiment we carried out economic analysis on climate change which is part of an integrated modeling framework GTAP that links the effects from global climate models to an economic model, by way of biophysical crop models. To expand the baseline, we supplied our model with projected changes in values between 2011 and 2050 for five macroeconomic variables: real GDP, population,labor, land supply , and capital (Table 4.2).

First scenario without climate

In our projections of real GDP of the East African Community from 2011 to 2050 we used the Quantitative Technical for Macroeconomic Analysis and projected population data for 2010–2050 using data from PopulationPyramid.net. Based on this projected population data we calculated labor forces in 2050. Projected capital supply growth for 2011–2050 is from Four et al. (2012). Projected growth in agricultural land area is drawn from Bruinsma (2011).

In our experiment, because GDP is not exogenous we changed our closure by swapping real GDP for total output productivity, which is an exogenous variable. This closure swap was done for the purpose of creating our baseline scenario experiment that resolves for the change in economy as a whole productivity. This is necessary to attain the projected growth in real GDP, based on the projected growth in factor supplies and population. To run a simulation we increased all exogenous variables simultanously, following their projected value for 2050. To finalize the first experiment we then restored the original closure, and made real GDP and endogenous and productivity exogenous. We then restored the original closure. We added the solution values for productivity growth to our baseline shocks, turned off the exogenous GDP growth targets, and re-solved the baseline experiment. The results for this experiment are the baseline scenario of the East Africa economy in 2050.

Table 5. 1 shock without climate change

Variable to shock	Country	%
qgdp	Kenya	210.68;
Qgdp	Malawi	284.5
Qgdp	Rwanda	264.44
Qgdp	Tanzania	251.03
qgdp	Uganda	217.98
Qgdp	Rafrica	119.57
qgdp	USA	284.5
Qgdp	China	284.5
qgdp	Korea	284.5;
Qgdp	ROW	284.5
Pop	Kenya	127.24
pop	Malawi	37.3
pop	Rwanda	99.50
pop	Tanzania	197.47
pop	Uganda	200.33
pop	REAfrica	241.98
pop	USA	37.3;
pop	China	37.3;
pop	Korea	37.3;
pop	ROW	37.3;
qo("Labor")	Kenya	60;
qo("Labor")	Malawi	38.4;
qo("Labor")	Rwanda")	60
qo("Labor")	Tanzania")	60
qo("Labor")	Uganda	60
qo("Labor")	Rafrica	60
qo("Labor")	USA	38.4
qo("Labor")	Chine	38.4
qo("Labor")	Korea	38.4;
qo("Labor")	ROW	38.4
qo("Capital")	Kenya	60
qo("Capital")	Malawi	213.1
qo("Capital")	Rwanda	60
qo("Capital")	Tanzania	60
qo("Capital")	Uganda	60
qo("Capital")	Rafrica	60
qo("Capital")	USA	213.1
qo("Capital")	China	213.1
qo("Capital")	Korea	213.1

qo("Capital")	ROW	213.1
qo("Land")	Kenya	0.44
qo("Land")	Malawi	4.4

qo("Land")	Rwanda	0.44
qo("Land")	Tanzania	0.44
qo("Land")	Uganda	0.44
qo("Land")	RAfrica")	0.44
qo("Land")	USA	4.4
qo("Land")	China	4.4
qo("Land")	Korea	4.4
qo("Land")	ROW	4.4
aoreg	Kenya	43.78
Aoreg	Malawi	46.67
aoreg	Rwanda	75.4
Aoreg	Tanzania	60.72
aoreg	Uganda	57.69
Aoreg	Rafrica	23.99
aoreg	USA	55.84
Aoreg	China	28.39
Aoreg	Korea	28.46
Aoreg	ROW	40.41

Second scenario with climate change

For the experiment with climate change we used the same factor endowment and productivity projections from the first experiment, and we included the effects of climate change, particularly land supply and agricultural productivity. The differences between the results of the first scenario without climate change and the second experiment with climate change represent the effects of climate change in 2050 on the EAC. Different steps for the first experiment are as follows:

Table 5. 2 shock with climate change

Shocks	Country	%
Pop	Kenya	127.24
Pop	Malawi	37.3
pop	Rwanda	99.50
Pop	Tanzania	197.47
Pop	Uganda	200.33
Pop	RAfrica	241.98
Pop	USA	37.3
Shock pop	China	37.3
Shock pop	Korea	37.3
Shock pop	ROW	37.3
qo("Labor")	Kenya	60
qo("Labor	Malawi	38.4
qo("Labor")	Rwanda	60
qo("Labor")	Tanzania	60
qo("Labor")	Uganda	60
qo("Labor")	RAfrica	60
qo("Labor")	USA	38.4
qo("Labor")	China	38.4
qo("Labor")	Korea	38.4

qo("Labor")	ROW	38.4
qo("Capital")	Kenya	60
qo("Capital")	Malawi	213.4;
qo("Capital")	Rwanda	60
qo("Capital")	Tanzania	60
qo("Capital")	Uganda	60
qo("Capital")	RAfrica	60
qo("Capital")	USA	213.1
qo("Capital")	China	213.1
qo("Capital")	Korea	213.1
qo("Capital")	ROW	213.1
aoreg	Kenya	43.78
Aoreg	Malawi	46.67
aoreg	Rwanda	75.4
Aoreg	Tanzania	60.72
aoreg	Uganda	57.69
Aoreg	RAfrica	23.99
aoreg	USA	55.84
aoreg	China	28.39
aoreg	Korea	28.46
Aoreg	ROW	40.41
qo("Land")	Kenya	11.44
qo("Land")	Malawi	11.44
qo("Land")	Tanzania	11.44
qo("Land")	Uganda	11.44
qo("Land")	Rwanda	11.44
qo("Land")	RAfrica	11.44
qo("Land")	USA	15.4
qo("Land")	China	15.4
qo("Land")	Korea	15.4
qo("Land")	ROW	15.4;
aoall("Agr")	allREG	uniform -11

5.2 Simulation Results

The simulation results of two scenarios with and without climate change on the East African Community's real GDP(qgdp),agricultural output(qo),agricultural producer price(ps),agricultural private consumption(qpd), agricultural consumer price(pp),agricultural exports(qxw), agricultural imports(qiw), agricultural aggregate world price index(pxw), agricultural import price(piw)are shown in following tables;

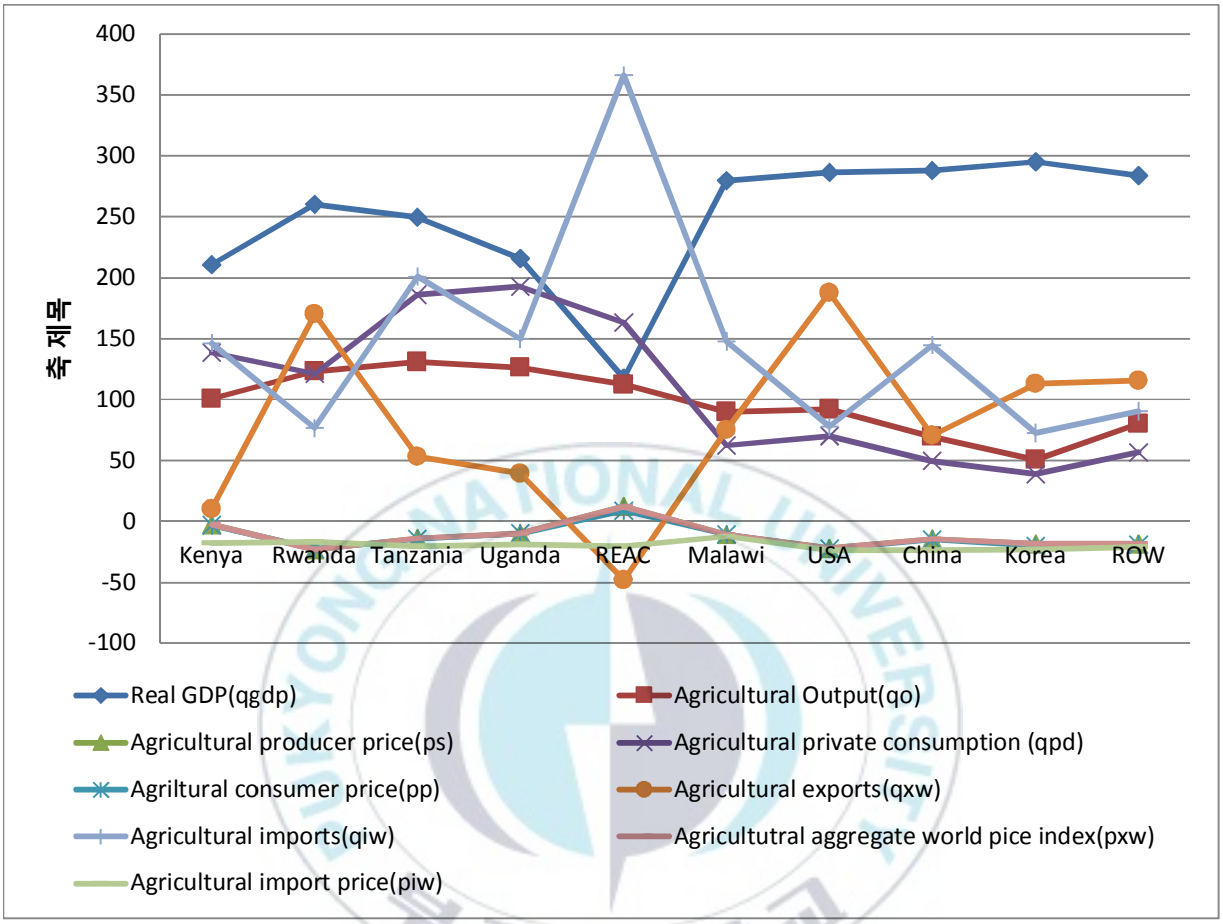
5.2.1 The economy of The EAC in 2050 without Climate Change

Table 5. 3 The economy of the EAC in 2050 without climate change

Countries / variables	Kenya	Rwanda	Tanzania	Uganda	REAC	Malawi	USA	China	Korea	ROW
Real GDP(qgdp)	210.44	260.45	249.5	215.64	117.61	279.47	286.23	287.7	294.79	283.71
Agricultural Output(qo)	100.91	123.09	130.9	126.46	112.46	90.06	91.8	69.53	50.61	80.37
Agricultural producer price(ps)	-2.7	-22.91	-13.98	-9.75	12.08	-11.02	-22.26	-14.38	-18.51	-18.47
Agricultural private consumption (qpd)	138.44	120.91	185.88	192.73	162.9	62.09	70.03	49.65	38.81	56.62
Agricultural consumer price(pp)	-3.28	-22.82	-14.42	-9.81	8.79	-11.02	-22.53	-14.74	-20.19	-18.9
Agricultural exports(qxw)	9.96	170.38	53.32	39.54	-47.93	75.04	187.75	70.73	112.79	115.36
Agricultural imports(qiw)	146.04	76.7	200.79	149.67	365.88	147.85	77.6	144.74	72.6	90.69
Agricultural aggregate world price index(pxw)	-2.7	-22.91	-13.98	-9.75	12.08	-11.02	-22.26	-14.38	-18.51	-18.47
Agricultural import price(piw)	-17.92	-17.04	-20.31	-18.89	-20.53	-12.4	-23.37	-23.62	-23.02	-21.17

Source: Authors calculation

Figure 5. 1 The economy of EAC in 2050 without climate change



Source: Authors calculation

In our experiment on the EAC economy in 2050 without climate change, we shocked by increasing the real GDP, population, and factors production simultaneously as is forecasted. We found that real GDP, agricultural output, agricultural private consumption increased. Our results show that the quantity of output will be increased. According to microeconomic theory as the quantities of output (qo) in the agricultural sectors of all EAC member countries increase, the quantities of output in this sector supply will exceed the quantities demanded. In this case, there will be excess supply. This will cause the producer price (ps) to decline in all EAC member

countries (table 5.3). As the price declines, consumer purchasing power increases. Consumers can buy more goods with the same amount of money that they used before. This means that without climate change agricultural private consumption (qpd) will increase

The quantities and price of EAC member country exports and imports without climate change will depend on world price. As the table results shows agricultural exports (qxw) will increase in four countries and will decrease in one country. The increase in exported goods will be observed in Kenya by 9.96%, in Rwanda by 170.38%, in Tanzania by 53.32%, in Uganda by 39.54%. In these four countries agricultural export (qxw) will increase because the price of exported agricultural commodities in domestic market will be less than the agricultural aggregate world price index (pxw). This result contrasts with, the results of the Rest of the East African Community (REAC) where the agricultural exports (qxw) will decrease because of agricultural producer price (ps) on the domestic market will be higher than the agricultural aggregate world price index (pxw)

Without climate change agricultural imports (qiw) in EAC member countries will increase because the agricultural import price (piw) on the world market will be less than the agricultural import price (piw) on the domestic markets of each of the EAC member countries.

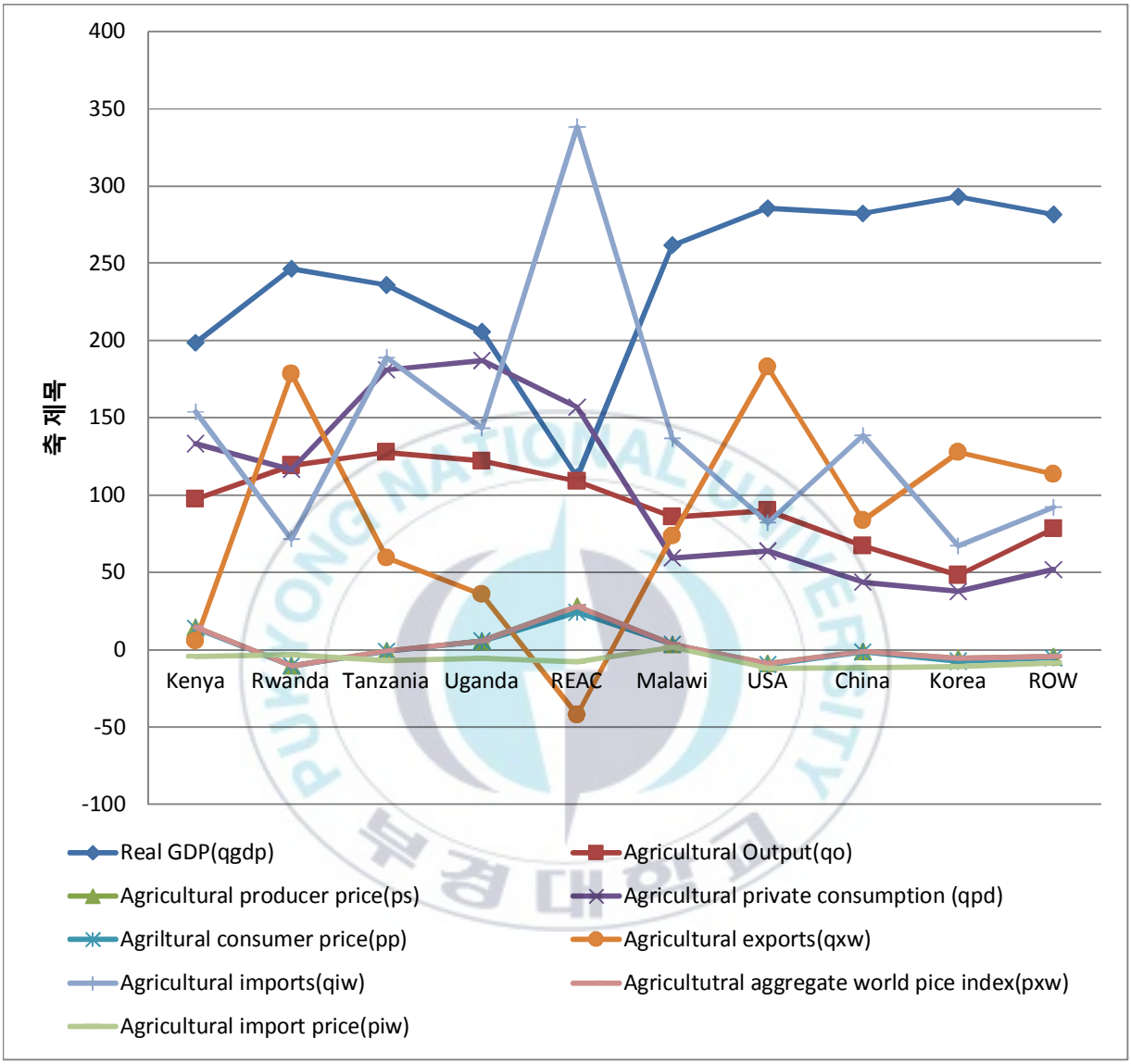
5.2.2 The Economy of the EAC in 2050 with Climate Change

Table 5. 4 The economy of EAC in 2050 with climate change

Countries / variables	Kenya	Rwanda	Tanzania	Uganda	REAC	Malawi	USA	China	Korea	ROW
Real GDP(qgdp)	198.56	246.35	236.06	205.86	111.82	261.82	285.47	282.29	293.06	281.5
Agricultural Output(qo)	97.47	118.94	127.53	122.05	109.22	85.78	90.16	67.21	48.23	78.31
Agricultural producer price(ps)	14.63	-10.59	-0.58	5.69	27.86	3.44	-8.8	-1.15	-5.76	-4.58
Agricultural private consumption (qpd)	133.3	116.53	181.01	187.22	156.67	59.19	63.7	43.81	37.65	51.81
Agricultural consumer price(pp)	13.88	-10.48	-1.04	5.62	24.34	3.43	-9.53	-1.56	-7.63	-5.22
Agricultural exports(qxw)	5.44	178.62	59.53	35.79	-42.17	73.39	183.05	83.63	127.77	113.46
Agricultural imports(qiw)	153.98	71.82	189.02	143.5	338.34	136.62	82.33	138.57	67.19	92.32
Agricultural aggregate world price index(pxw)	14.63	-10.59	-0.58	5.69	27.86	3.44	-8.8	-1.15	-5.76	-4.58
Agricultural import price(piw)	-4.61	-3.52	-7.25	-5.42	-7.69	1.48	-11.78	-11.74	-10.8	-8.59

Source: Authors calculation

Figure 5. 2 The Economy of EAC in 2050 with Climate Change



Source: Authors calculation

This second experiment which represent the EAC economy in 2050 show that under a warming climate yields in the EAC member countries will be different than in the previous experiment. The results of this second experiment shows that with climate change real GDP, agricultural

output (qo), and agricultural private consumption will decrease compared to those in the first experiment. Since agricultural output will probably be less, if the expected quantities are less than the current quantities, it means that the quantities supplied will be less than the quantities demanded. Microeconomic theory asserts that when the quantity supplied is less than the quantity demanded, the price will increase. When the price increases, real income will drop and agricultural private consumption will decrease. Because consumers will need to maximize their utility under budget constraint, it means that in 2050 the climate changed-affected EAC econmy of 2050, higher prices will effectively reduce real income and consumer will not be satisfied.

With the climate change scenario, trade within EAC will be determined by world market. As is shown in the results above, export from some countries like Kenya, and Uganda will decline. In contrast to this exports from Rwanda, Tanzania, and REAC will increase. This volatility of exports will be dependent on prices of agricultural export commodities in Rest of the world. Our results also indicate that in the case of agricultural import (qiw) in 2050 within EAC member's economies differ from each other. In some member countries, like Rwanda, Tanzania, Uganda, and the REAC, they will decrease. Only Kenya in 2050 under changed climate the agricultural imports will increase.

These two experiments help us to quantify the economic effects of climate by comparing the difference between the first experiment and the second experiment

5.2.3 The Effect of Climate Change on Economy of the EAC in 2050

Table 5. 5 The effect of climate change on economy in EAC in 2050

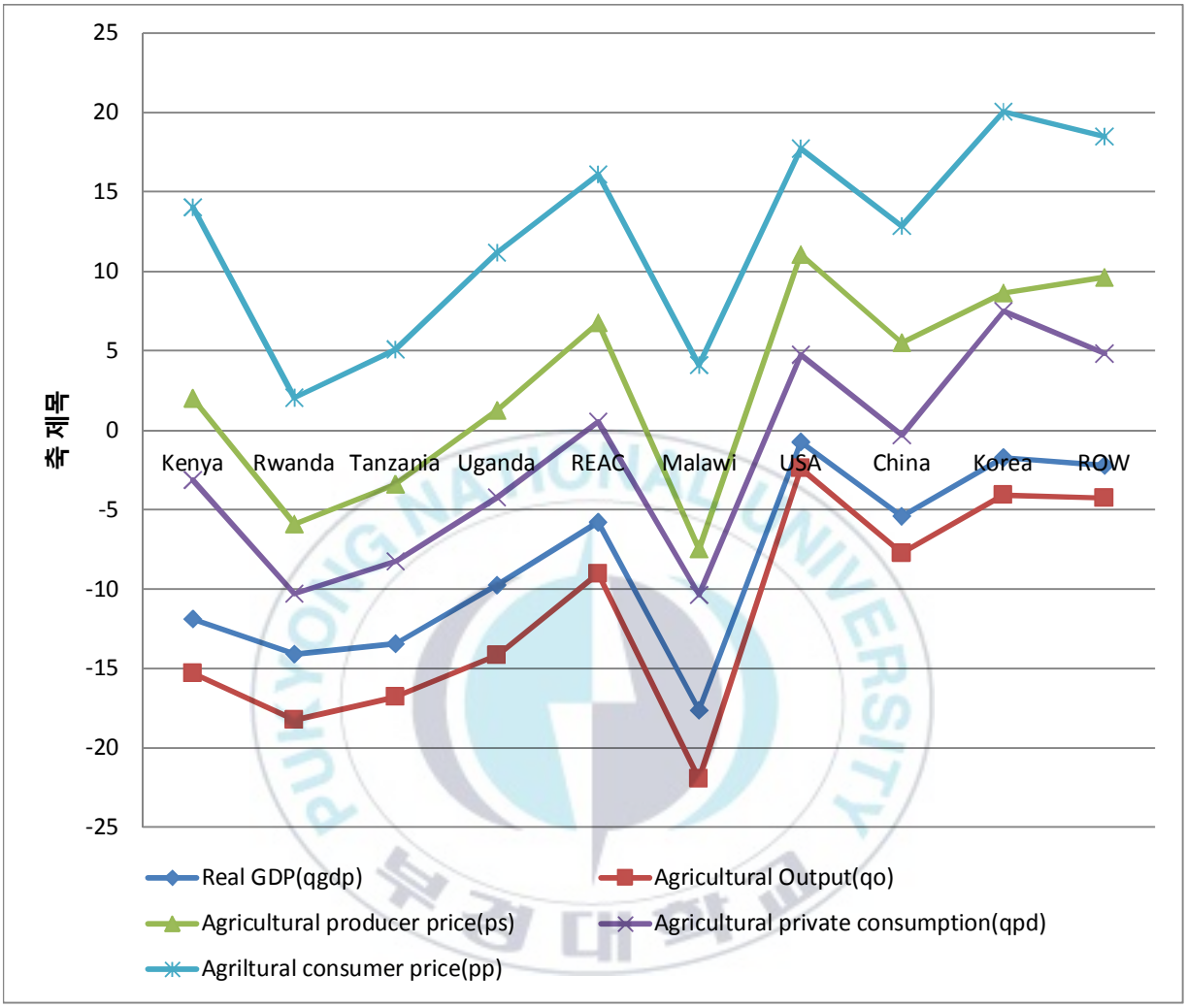
Countries / variables	Kenya	Rwanda	Tanzania	Uganda	REAC	Malawi	USA	China	Korea	ROW
Real GDP(qgdp)	-11.88	-14.1	-13.44	-9.78	-5.79	-17.65	-0.76	-5.41	-1.73	-2.21
Agricultural Output(qo)	-3.44	-4.15	-3.37	-4.41	-3.24	-4.28	-1.64	-2.32	-2.38	-2.06
Agricultural producer price(ps)	17.33	12.32	13.4	15.44	15.78	14.46	13.46	13.23	12.75	13.89
Agricultural private consumption (qpd)	-5.14	-4.38	-4.87	-5.51	-6.23	-2.9	-6.33	-5.84	-1.16	-4.81
Agricultural consumer price(pp)	17.16	12.34	13.38	15.43	15.55	14.45	13	13.18	12.56	13.68
Agricultural exports(qxw)	-4.52	8.24	6.21	-3.75	5.76	-1.65	-4.7	12.9	14.98	-1.9
Agricultural imports(qiw)	7.94	-4.88	-11.77	-6.17	-27.54	-11.23	4.73	-6.17	-5.41	1.63
Agricultural aggregate world price index(pxw)	17.33	12.32	13.4	15.44	15.78	14.46	13.46	13.23	12.75	13.89
Agricultural import price(piw)	13.31	13.52	13.06	13.47	12.84	13.88	11.59	11.88	12.22	12.58

Source: Authors calculation

The table above shows how much climate change will affect the EAC economy in 2050. Among 10 countries in our experiment, 5 are East African Community countries, which are our case study, and others are considered the rest of the world.

Our results show that in all of the East African Community countries, climate change will have negative impact on real GDP, and on agricultural output (qo). The effect of climate change will cause price increases in agricultural production (ps) and agricultural consumption (pp) . This will cause the agricultural private consumption to decline. With a worsened climate in 2050, EAC community member countries will have a trend similar to that of the domestic market: the output will decline, agricultural commodities' prices will increase, and real GDP will decline

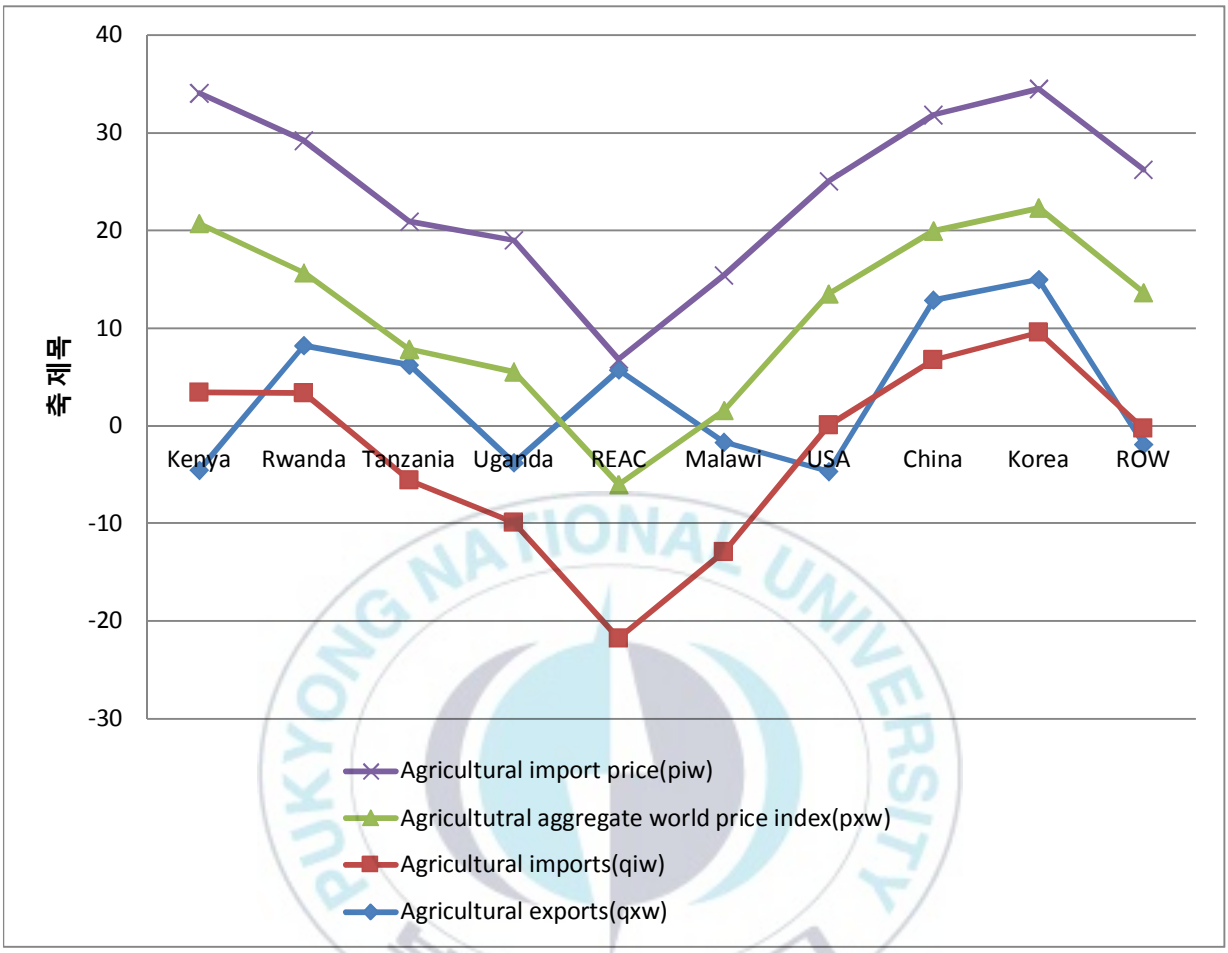
Figure 5. 3 The effect of climate change on domestic market of EAC in 2050



Source: Authors calculation

The response of the domestic market to climate change will probably be producer behavior raising the price because the quantities demanded will be higher than the quantities supplied. The consumer behavior that would probably result from these price increases would be to reduce the quantities they demand because their income has reduced.

Figure 5. 4 The effect of climate change on trade in EAC in 2050



Source: Authors calculation

In 2050 with climate change trade of agricultural commodities for each EAC member country will depend on world market prices.

In Kenya, climate change will probably lead to a decrease in agricultural exports (qxw) because world prices for agricultural commodities will be lower than the price of exported goods produced by Kenya. The table shows that Kenya's exported agricultural commodities' prices in 2050 will increase by 17.33%. This will be more expensive than in the world market prices where will increase in the USA by 13.46%,in Rwanda by 12.34,in Tanzania 13.38, in Uganda by

15.43%,in REAC by 15.55%, in China 13.23%, in Korea 12.75%, and the ROW by 13.89%. The quantity of agricultural imports (qiw) in Kenya will increase by 7.94%. This is because prices of imported agricultural commodities on the world market will be lower than on Kenya's domestic market where the price will increase by 13.31%. In the world market it will increase in the REAC by 12.84%, in the USA by 11.59%, in China by 11.88%, in Korea by 12.22%, and the ROW by 12.58%.

In Rwanda in 2050 under changed of climate conditions, exports and imports will depend will depend on the world price. Rwanda's export quantities of agricultural (qxw) will increase by 8.24% response to world prices which will be higher than the prices in Rwanda. In Kenya, Tanzania, Uganda, REAC, USA, China, Korea and Malawi, the agricultural aggregate world price index (pxw) will increase more than in Rwanda. Because of this increase of price in the world market Rwanda's demand for agricultural imports will decrease.

Tanzania's trade in agricultural commodities in 2050 will be similar to the Rwanda case because agricultural exports (qxw) will increase due to high prices on the world market. In countries like Kenya, Uganda, the USA, China and the ROW prices will be higher than the those onTanzania's domestic market price. Tanzania's agricultural imports (qiw) will decrease by 11.77% because the world prices will exceed price on the domestic market in neighboring countries like Kenya, Rwanda, Malawi negatively influencing the quantity Tanzania will be able to import.

For Uganda our results show that climate negatively affect agricultural exports (qxw) decreasing them by 3.75% domestic market will exceed aggregate output world price.

In the REAC , our results show that in 2050, climate change will negatively affect imports and positively affect exports. Agricultural exports (qxw) will increase because world market prices will increase more than the domestic market prices. The results show that in 2050 the percent change on exports into REAC will be 15.78% which is low compared with the world market. Agricultural imports (qiw) will be negatively affected decreasing by 27.54% .

The trade results are explained in import side by the consumer's behavior to substitute the domestic and import and their relative price. For exported goods is explained by the behavior of the producers to shift their supply in the world market because of the increased relative price in the world market.

5.3 Conclusion

The purpose of this study was to introduce a common set of climate change in East African Community in 2050 and its agricultural sector in economic models in 2050 with GTAP so that any divergences in economic effect could be understood in terms of differences in the structure and parameters of the economic models. In our study we structured our experiment in three parts which are: the economy of EAC in 2050 without climate change, the economy of EAC in 2050 with climate change and the effect of climate change on economy in EAC in 2050 and among these, the main purpose was to assess quantitative effect of climate change on EAC economy in 2050 and to get this we made difference between the economy with and without climate change

To make the experimentation we use update socioeconomic variable for 2050: real GDP, population growth, labor, capital and Arable land. After two experiments of EAC with and

without climate change and our main objective was to find the effect of climate change on EAC in 2050. With climate change we found that the real GDP, the agricultural output (qo), Agricultural private consumption (qpd) will decrease in all EAC country members and agricultural producer price(ps), agricultural consumer price(pp) will increase. We found also that the export and import for EAC in 2050 under climate change will dependent on the world market: the interaction between supply and demand in world market. Brief with worse of climate the welfare in East Community will be destroyed

All results described the responses of producers and consumers to lower yields. Due to the decrease in crop production means that prices ascend. Depending on the kind of experiment, producers respond to higher prices by intensifying their farming practices (and increasing yields) and expanding their cultivated area. These moderate economic responses expected output and production impacts of climate change that are estimated in GTAP model. Consumers react to rising food prices by reducing the amount of food required. Trade plays a bridge role supply and demand in all regions.

5.4 Limitations of the Model

There are limitations in every economic methodology. The main problem with the CGE model is the complicated nature of its equations. Again, according to Mukhppadhyay and Chkraborty (2012), in the end, the policy model is just an organizing framework permitting careful analysis of complex issues; if individual doing the analysis is not trained in economic theory, does not understand the model, or simply seeks to get a particular result, the outcome will not be useful

• In much of the 'critical' work done to date on the land use issue, individuals have played around with the model enough to figure out which parameters drive the results and then they have focused exclusively on that parameter – e.g., raising the crop yield response to commodity prices from 0.25 to 25! The model will not complain; it will just proceed and compute the new results.

5. 5 **Recommendations for Future Studies**

This study focuses on Impact of Climate Change on the Global Economy in 2050: The Case of East African Community. Firstly, climate change in 2050 to avoid a low yield due to the negative impact of climate change on the agricultural sector, policymakers should mainstream to the agricultural technic plans. Secondly for the GTAP modelers should improve the structure and include specific variables of production sectors like agricultural sector which needs more factors to improve their productivity.

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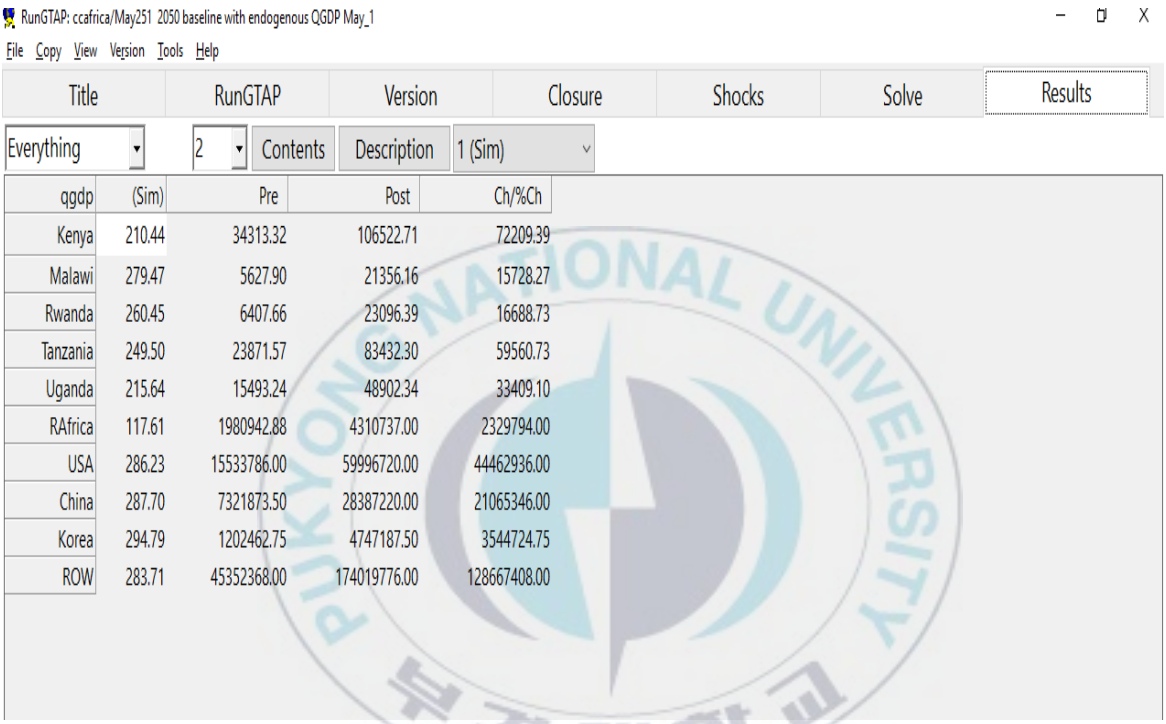
Appendices

A.The Estimation Results from GTAP without Climate Change

Table A. 1 Percent Change in real GDP (qgdp) of the EAC in 2050 without Climate Change


RunGTAP: ccafrica/May251 2050 baseline with endogenous QGDP May_1

File Copy View Version Tools Help

Title | RunGTAP | Version | Closure | Shocks | Solve | Results

Everything | 2 | Contents | Description | 1 (Sim)

qgdp	(Sim)	Pre	Post	Ch/%Ch
Kenya	210.44	34313.32	106522.71	72209.39
Malawi	279.47	5627.90	21356.16	15728.27
Rwanda	260.45	6407.66	23096.39	16688.73
Tanzania	249.50	23871.57	83432.30	59560.73
Uganda	215.64	15493.24	48902.34	33409.10
RAfrica	117.61	1980942.88	4310737.00	2329794.00
USA	286.23	15533786.00	59996720.00	44462936.00
China	287.70	7321873.50	28387220.00	21065346.00
Korea	294.79	1202462.75	4747187.50	3544724.75
ROW	283.71	45352368.00	174019776.00	128667408.00

Table A. 2 Percent Change in Output (qo) of the EAC in 2050 without Climate Change

RunGTAP: ccafrica/May251 2050 baseline with endogenous QGDP May_1

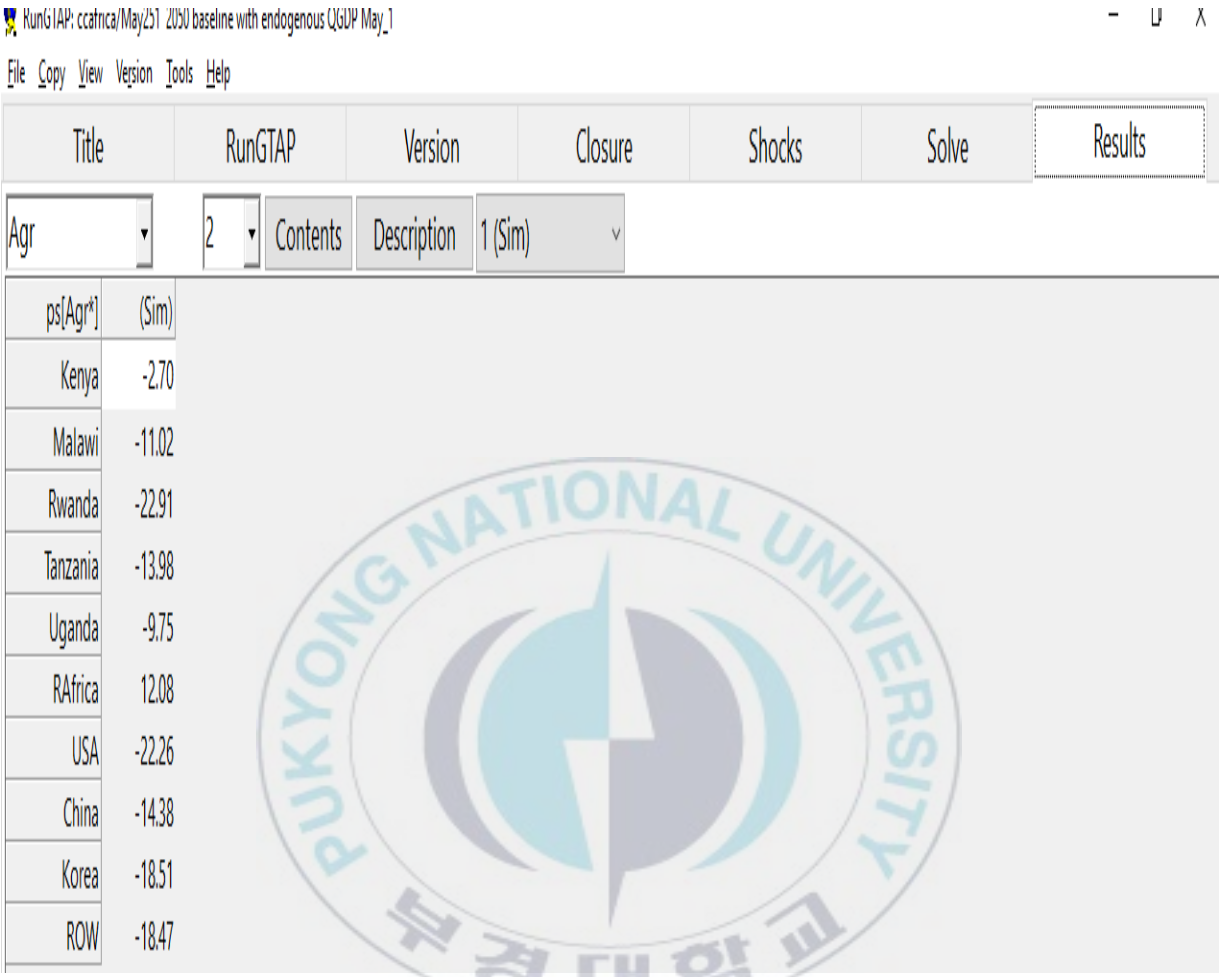
File Copy View Version Tools Help

Title | RunGTAP | Version | Closure | Shocks | Solve | Results

Agr | 2 | Contents | Description | 1 (Sim)

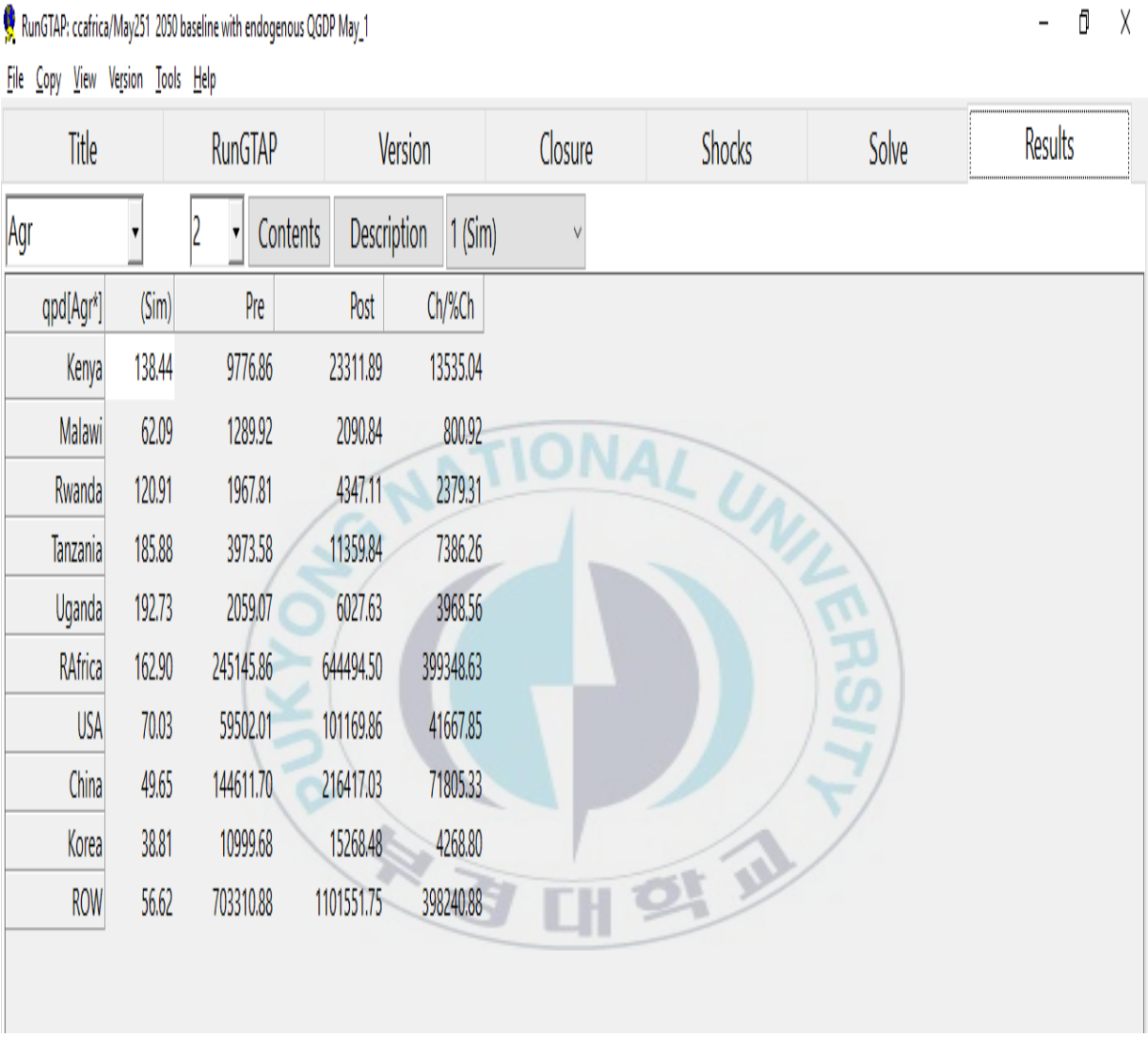
qo[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	100.91	14117.18	28362.69	14245.51
Malawi	90.06	2899.38	5510.52	2611.13
Rwanda	123.09	2530.64	5645.55	3114.90
Tanzania	130.90	7514.88	17351.77	9836.89
Uganda	126.46	4092.72	9268.52	5175.79
RAfrica	112.46	382426.13	812489.81	430063.69
USA	91.80	404688.19	776204.38	371516.19
China	69.53	958514.25	1624933.63	666419.38
Korea	50.61	40134.52	60448.43	20313.91
ROW	80.37	2600649.75	4690892.00	2090242.25

Table A. 3 Percent Change in Supplied price (ps) of the EAC in 2050 without Climate Change



ps[Agr*]	(Sim)
Kenya	-2.70
Malawi	-11.02
Rwanda	-22.91
Tanzania	-13.98
Uganda	-9.75
RAfrica	12.08
USA	-22.26
China	-14.38
Korea	-18.51
ROW	-18.47

Table A. 4 Percent Change in Private Consumption (qpd) of the EAC in 2050 without Climate Change


RunGTAP: ccafrica/May251 2050 baseline with endogenous QGDP May_1

File Copy View Version Tools Help

Title | RunGTAP | Version | Closure | Shocks | Solve | Results

Agr | 2 | Contents | Description | 1 (Sim)

qpd[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	138.44	9776.86	23311.89	13535.04
Malawi	62.09	1289.92	2090.84	800.92
Rwanda	120.91	1967.81	4347.11	2379.31
Tanzania	185.88	3973.58	11359.84	7386.26
Uganda	192.73	2059.07	6027.63	3968.56
RAfrica	162.90	245145.86	644494.50	399348.63
USA	70.03	59502.01	101169.86	41667.85
China	49.65	144611.70	216417.03	71805.33
Korea	38.81	10999.68	15268.48	4268.80
ROW	56.62	703310.88	1101551.75	398240.88

Table A. 5 Percent Change in Consumer Price (pp)of the EAC in 2050 without Climate Change

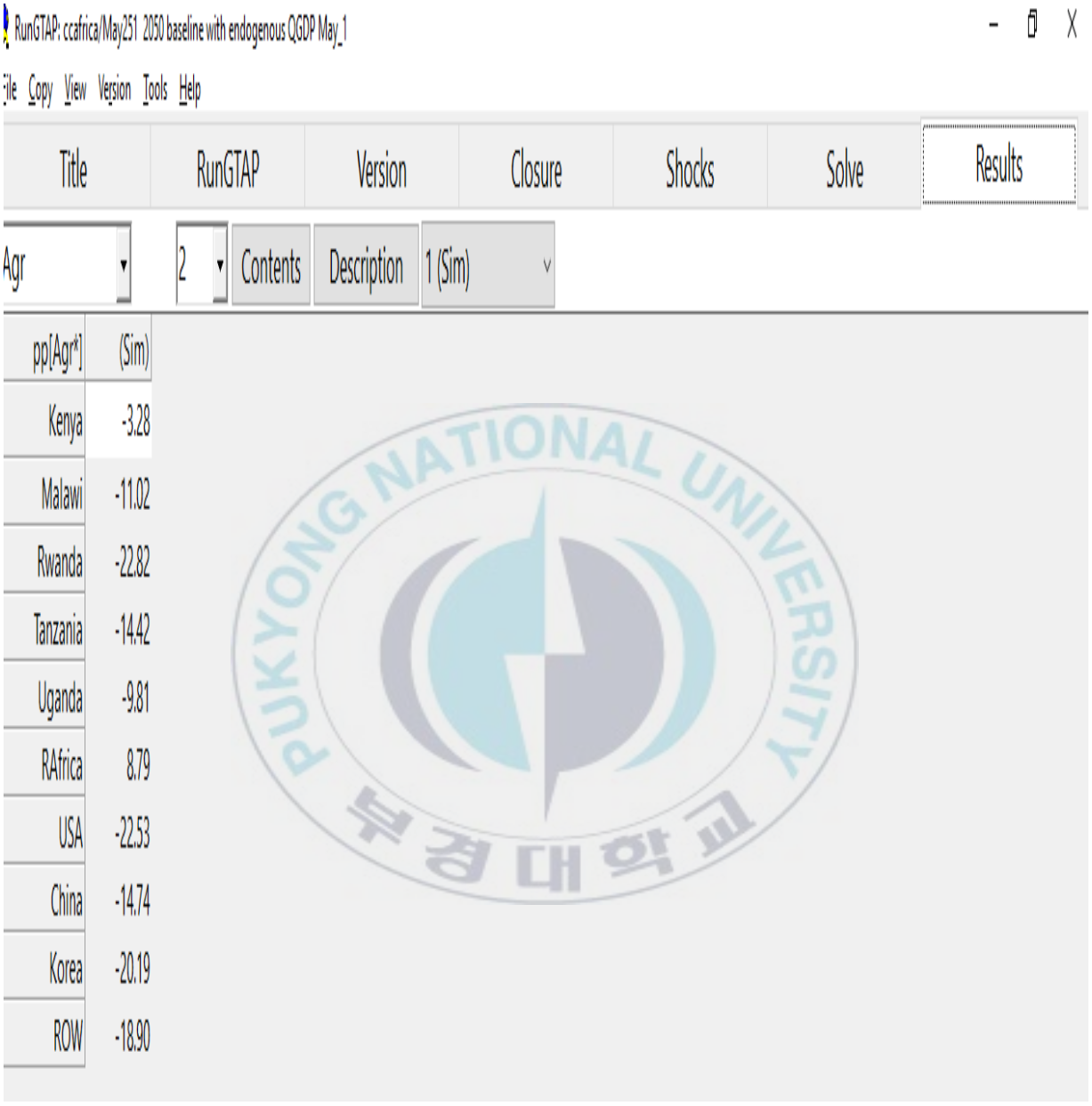
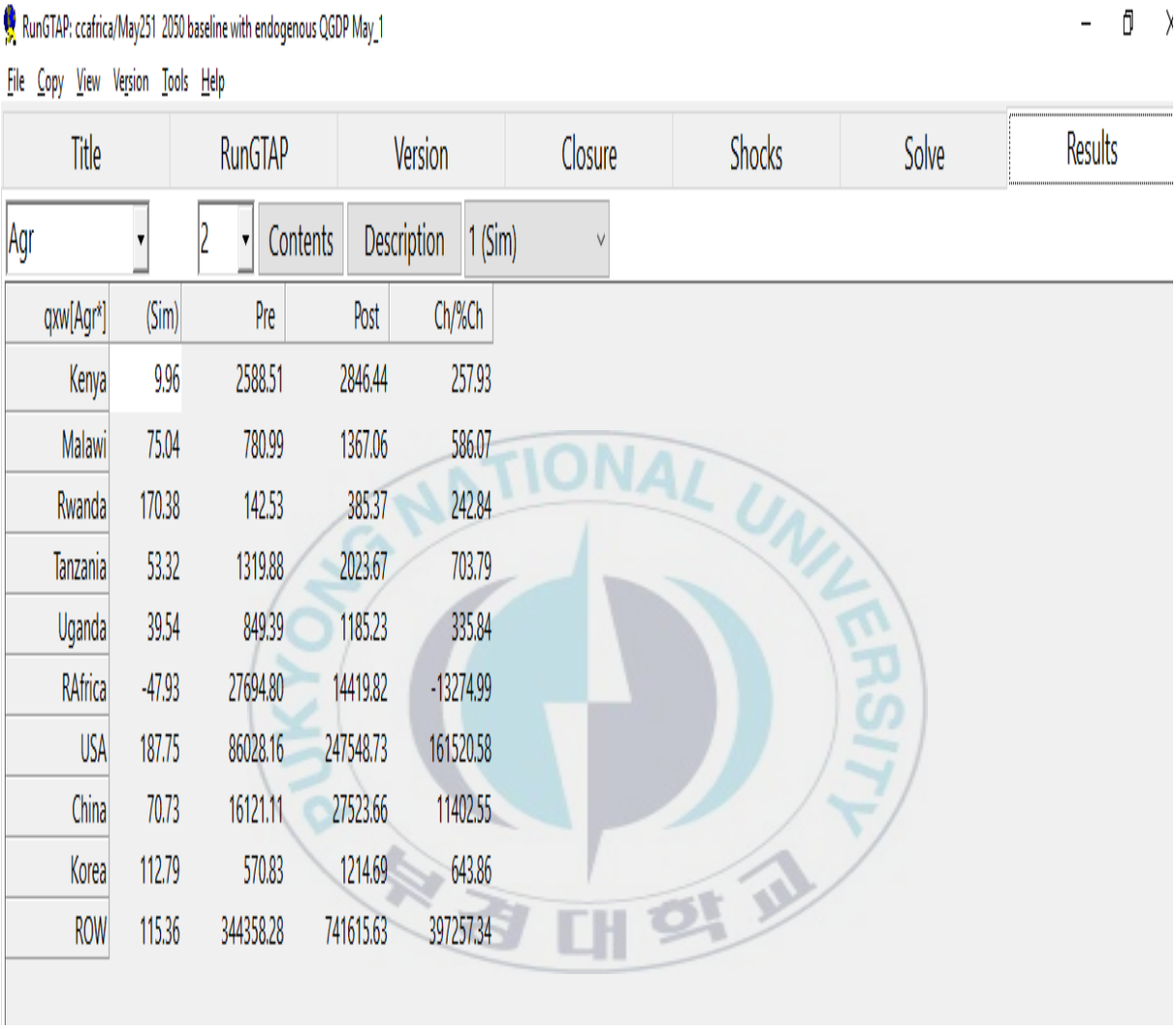


Table A. 6 Percent Change in Exported Quantity (qxw) of EAC in 2050 without Climate Change


RunGTAP: ccafrica/May251 2050 baseline with endogenous QGDP May_1

File Copy View Version Tools Help

Title | RunGTAP | Version | Closure | Shocks | Solve | Results

Agr | 2 | Contents | Description | 1 (Sim)

qxw[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	9.96	2588.51	2846.44	257.93
Malawi	75.04	780.99	1367.06	586.07
Rwanda	170.38	142.53	385.37	242.84
Tanzania	53.32	1319.88	2023.67	703.79
Uganda	39.54	849.39	1185.23	335.84
RAfrica	-47.93	27694.80	14419.82	-13274.99
USA	187.75	86028.16	247548.73	161520.58
China	70.73	16121.11	27523.66	11402.55
Korea	112.79	570.83	1214.69	643.86
ROW	115.36	344358.28	741615.63	397257.34

Table A. 7 Percent Change in imported Quantity (qiw) of EAC in 2050 Without Climate Change

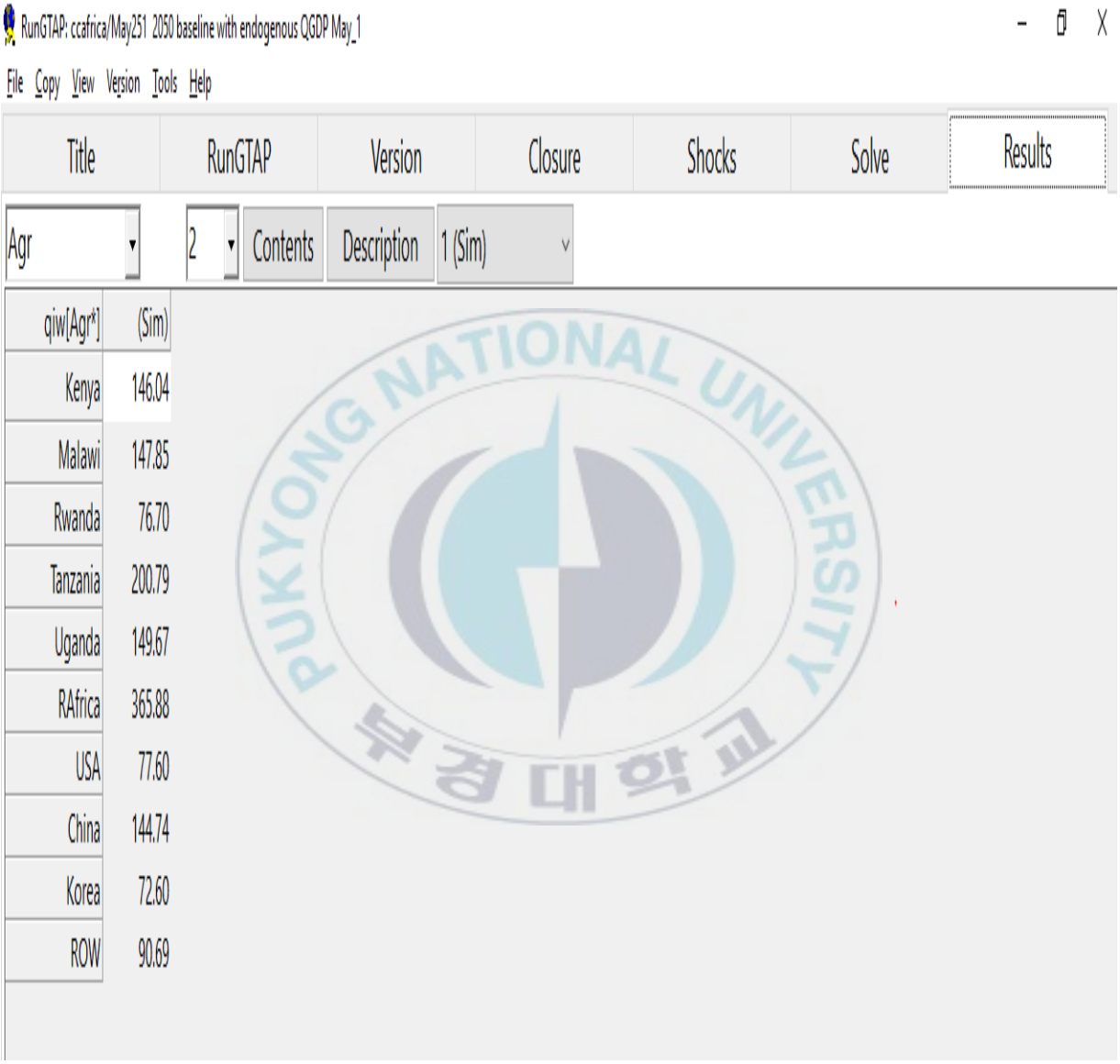
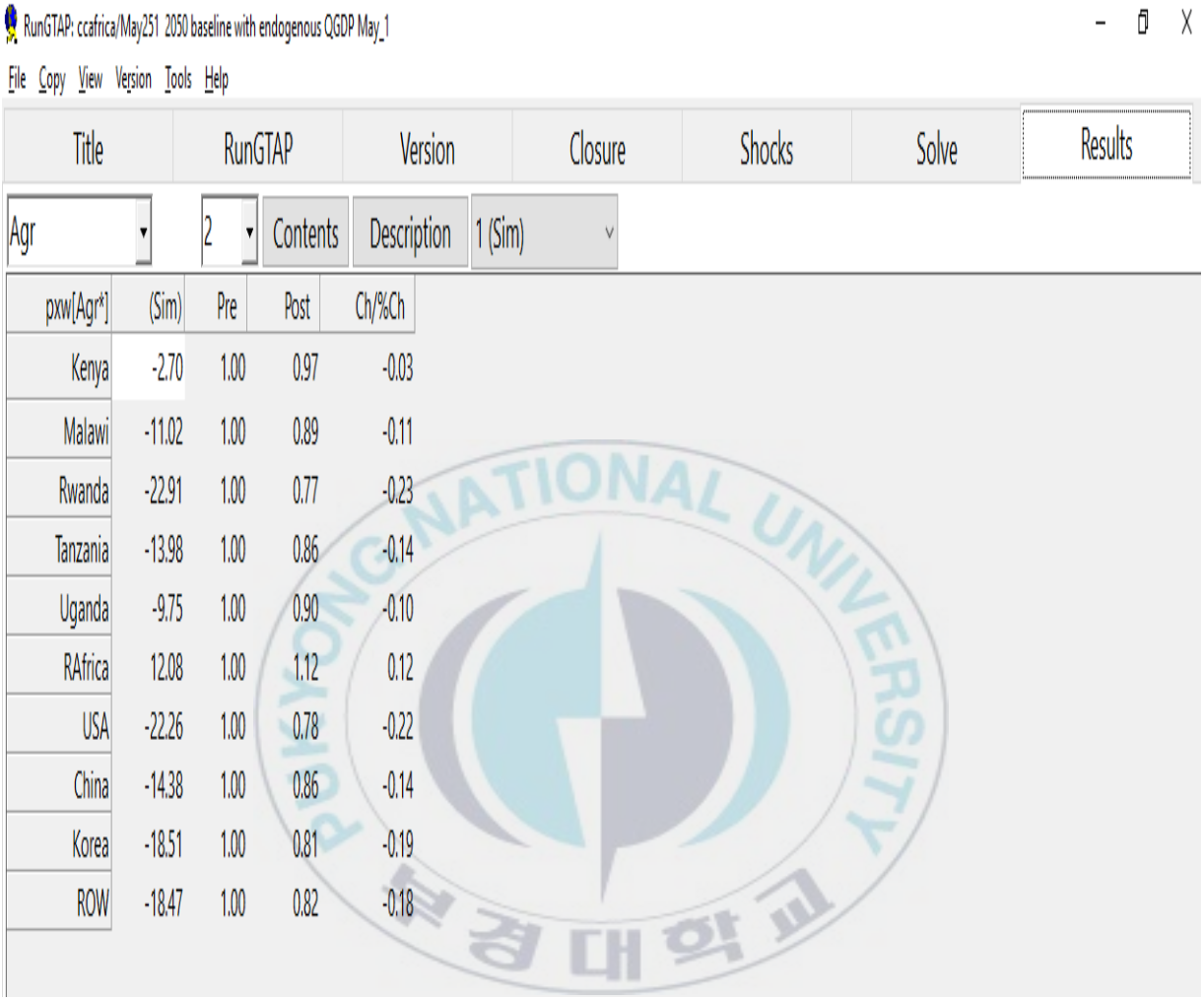
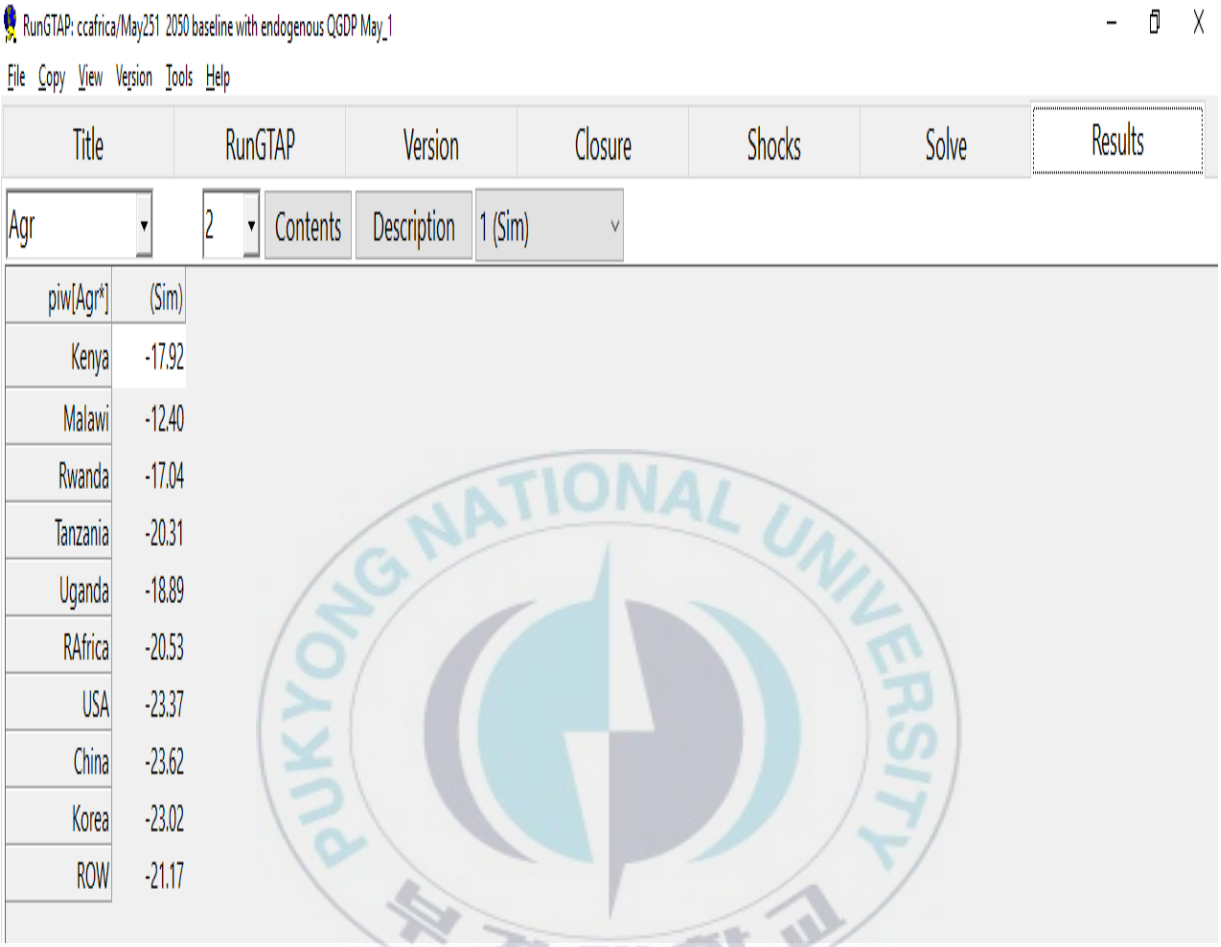


Table A. 8 Percent Change in World Price of Exported Quantity (pxw) of the EAC in 2050 without Climate Change



pxw[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	-2.70	1.00	0.97	-0.03
Malawi	-11.02	1.00	0.89	-0.11
Rwanda	-22.91	1.00	0.77	-0.23
Tanzania	-13.98	1.00	0.86	-0.14
Uganda	-9.75	1.00	0.90	-0.10
RAfrica	12.08	1.00	1.12	0.12
USA	-22.26	1.00	0.78	-0.22
China	-14.38	1.00	0.86	-0.14
Korea	-18.51	1.00	0.81	-0.19
ROW	-18.47	1.00	0.82	-0.18

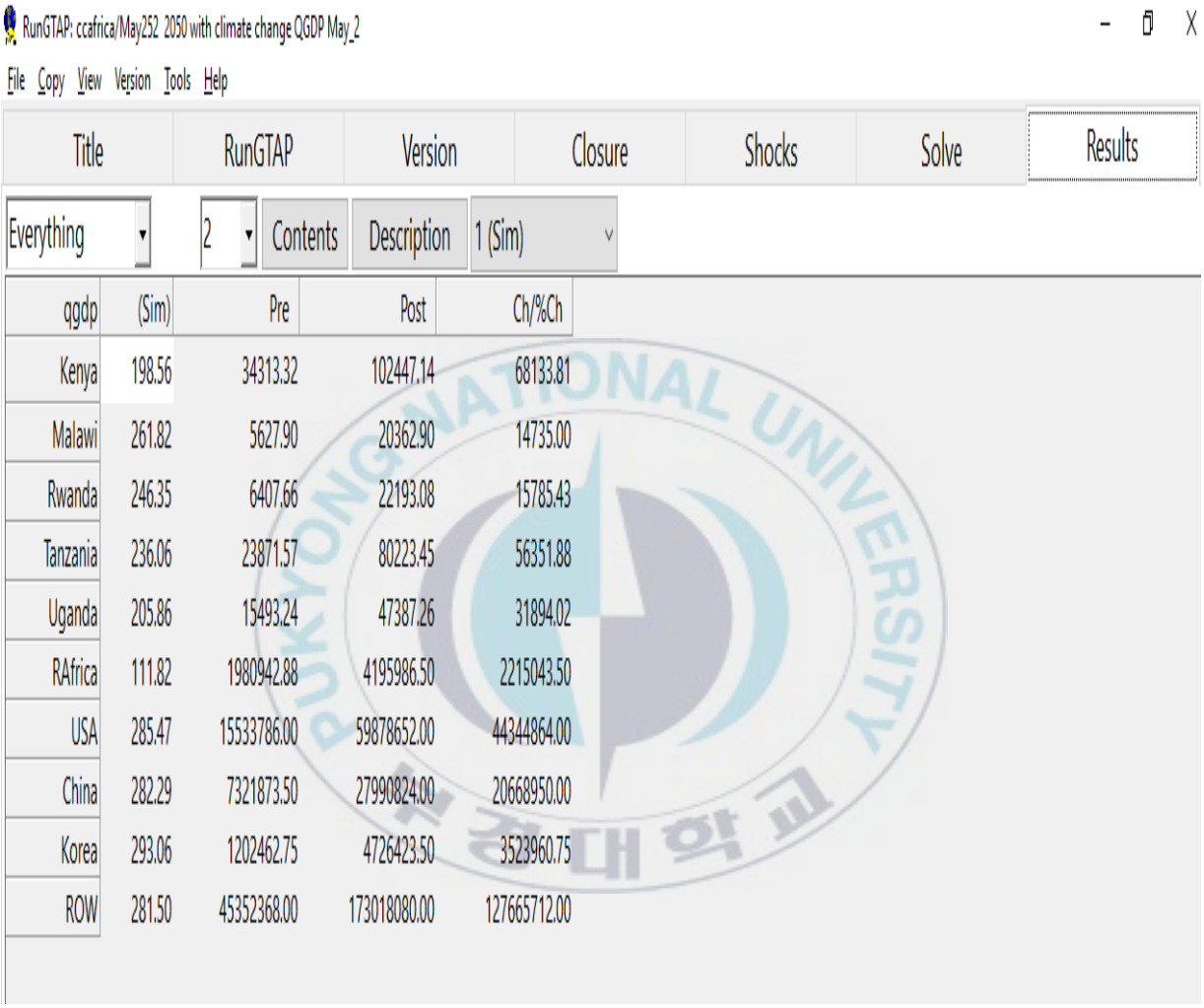
Table A. 9 Percent Change in World Price of Imported Quantity of the EAC 2050 without Climate Change



piw[Agr*]	(Sim)
Kenya	-17.92
Malawi	-12.40
Rwanda	-17.04
Tanzania	-20.31
Uganda	-18.89
RAfrica	-20.53
USA	-23.37
China	-23.62
Korea	-23.02
ROW	-21.17

B. Estimations Results from GTAP with Climate Change

Table B. 1 Percent Change in Gross Domestic Product (qgdp) of the EAC in 2050 with Climate Change


RunGTAP: ccafrica/May252 2050 with climate change QGDP May_2

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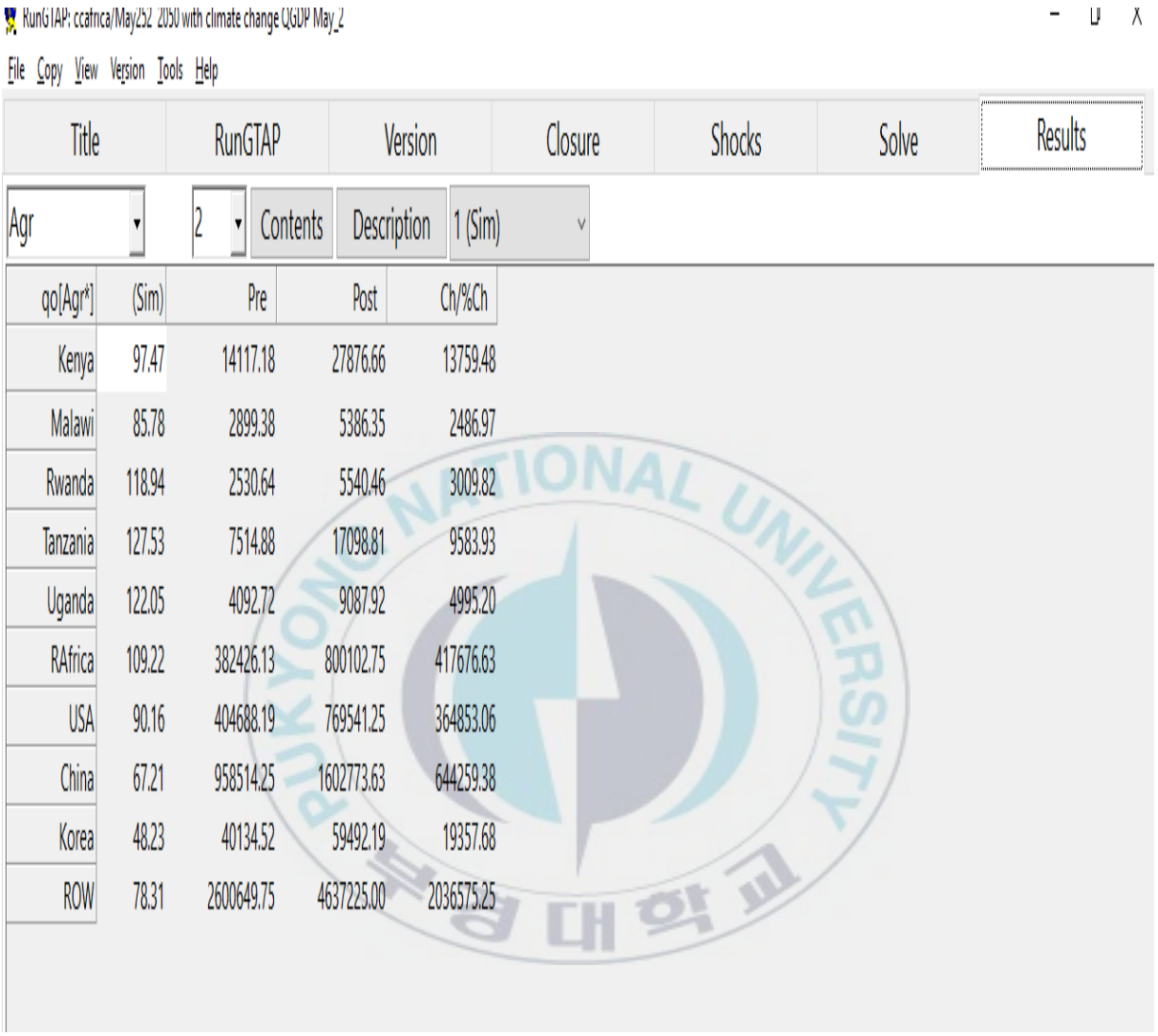
Title | RunGTAP | Version | Closure | Shocks | Solve | Results

Everything | 2 | Contents | Description | 1 (Sim)

qgdp	(Sim)	Pre	Post	Ch/%Ch
Kenya	198.56	34313.32	102447.14	68133.81
Malawi	261.82	5627.90	20362.90	14735.00
Rwanda	246.35	6407.66	22193.08	15785.43
Tanzania	236.06	23871.57	80223.45	56351.88
Uganda	205.86	15493.24	47387.26	31894.02
RAfrica	111.82	1980942.88	4195986.50	2215043.50
USA	285.47	15533786.00	59878652.00	44344864.00
China	282.29	7321873.50	27990824.00	20668950.00
Korea	293.06	1202462.75	4726423.50	3523960.75
ROW	281.50	45352368.00	173018080.00	127665712.00

Table B. 2 Percent Change in Output (qo) of the EAC in 2050 with Climate Change



qo[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	97.47	14117.18	27876.66	13759.48
Malawi	85.78	2899.38	5386.35	2486.97
Rwanda	118.94	2530.64	5540.46	3009.82
Tanzania	127.53	7514.88	17098.81	9583.93
Uganda	122.05	4092.72	9087.92	4995.20
RAfrica	109.22	382426.13	800102.75	417676.63
USA	90.16	404688.19	769541.25	364853.06
China	67.21	95851425	1602773.63	644259.38
Korea	48.23	40134.52	59492.19	19357.68
ROW	78.31	2600649.75	4637225.00	2036575.25

Table B. 3 Percent Change in Supply Price (ps) of the EAC in 2050 with Climate Change

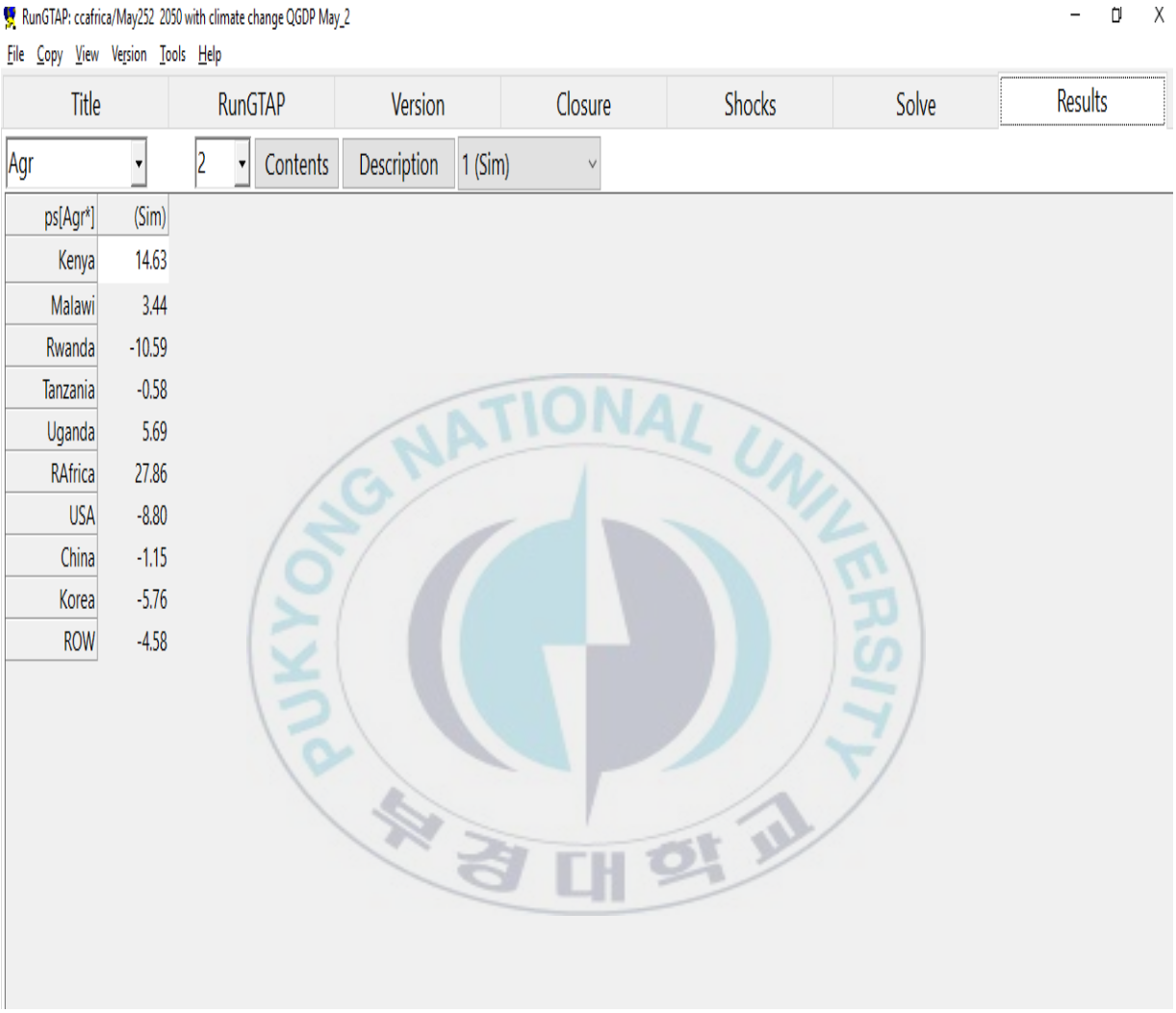
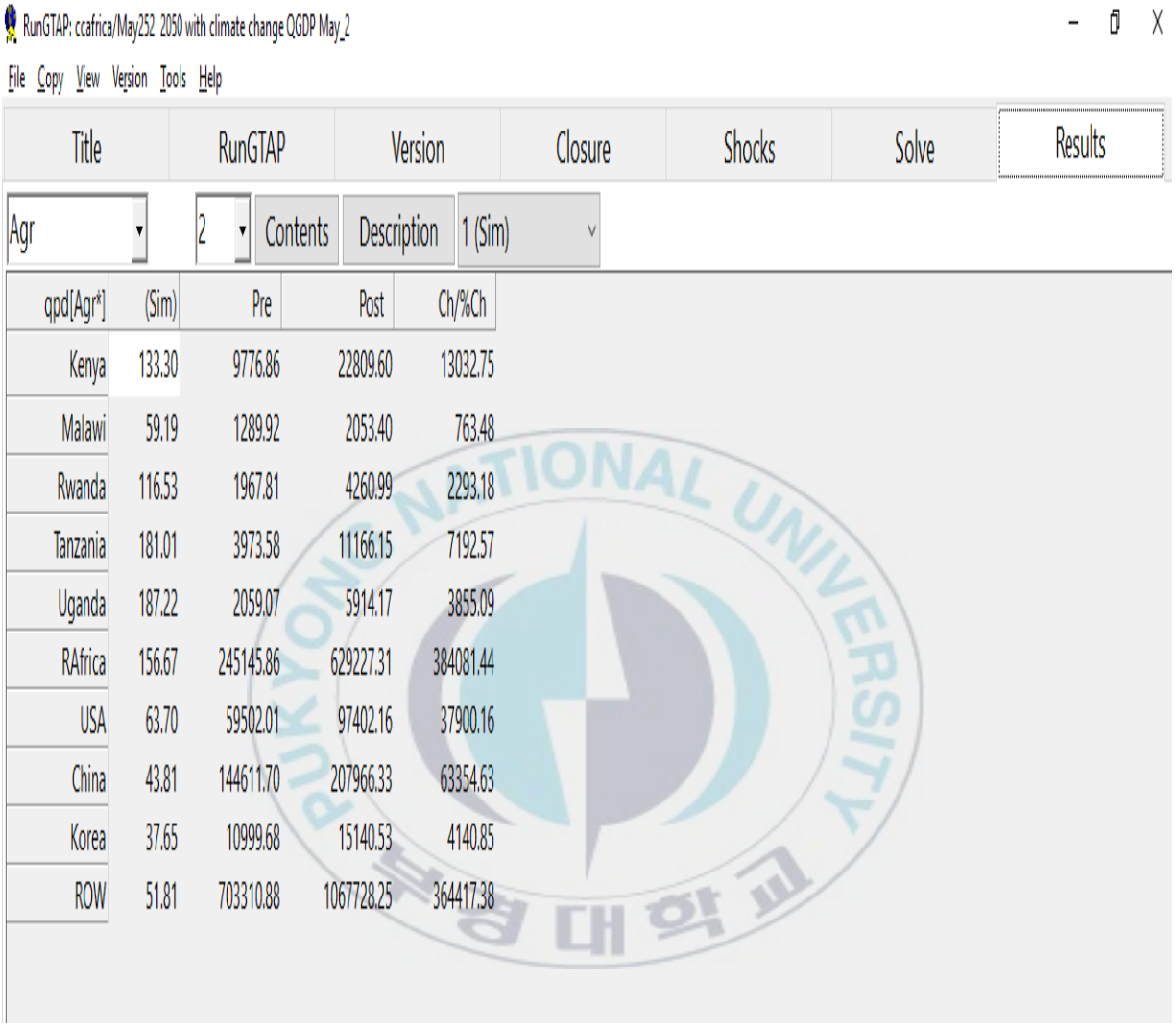


Table B. 4 Percent Change in Quantity of Private Consumption (qpd) of The EAC in 2050 with Climate Change.



qpd[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	133.30	9776.86	22809.60	13032.75
Malawi	59.19	1289.92	2053.40	763.48
Rwanda	116.53	1967.81	4260.99	2293.18
Tanzania	181.01	3973.58	11166.15	7192.57
Uganda	187.22	2059.07	5914.17	3855.09
RAfrica	156.67	245145.86	629227.31	384081.44
USA	63.70	59502.01	97402.16	37900.16
China	43.81	144611.70	207966.33	63354.63
Korea	37.65	10999.68	15140.53	4140.85
ROW	51.81	703310.88	1067728.25	364417.38

Table B. 5 Percent Change in Consumer Price (pp) of the EAC in 2050 with Climate Change

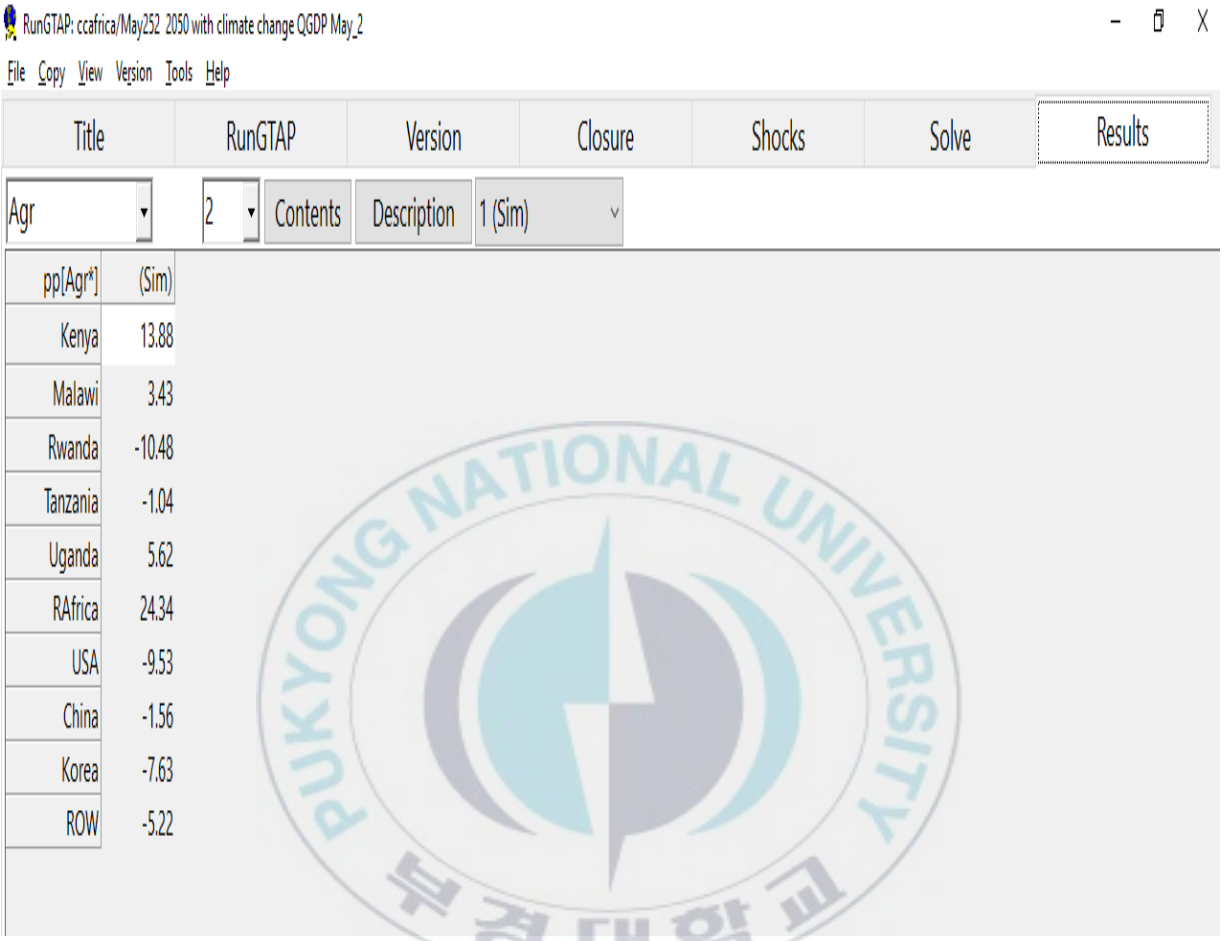
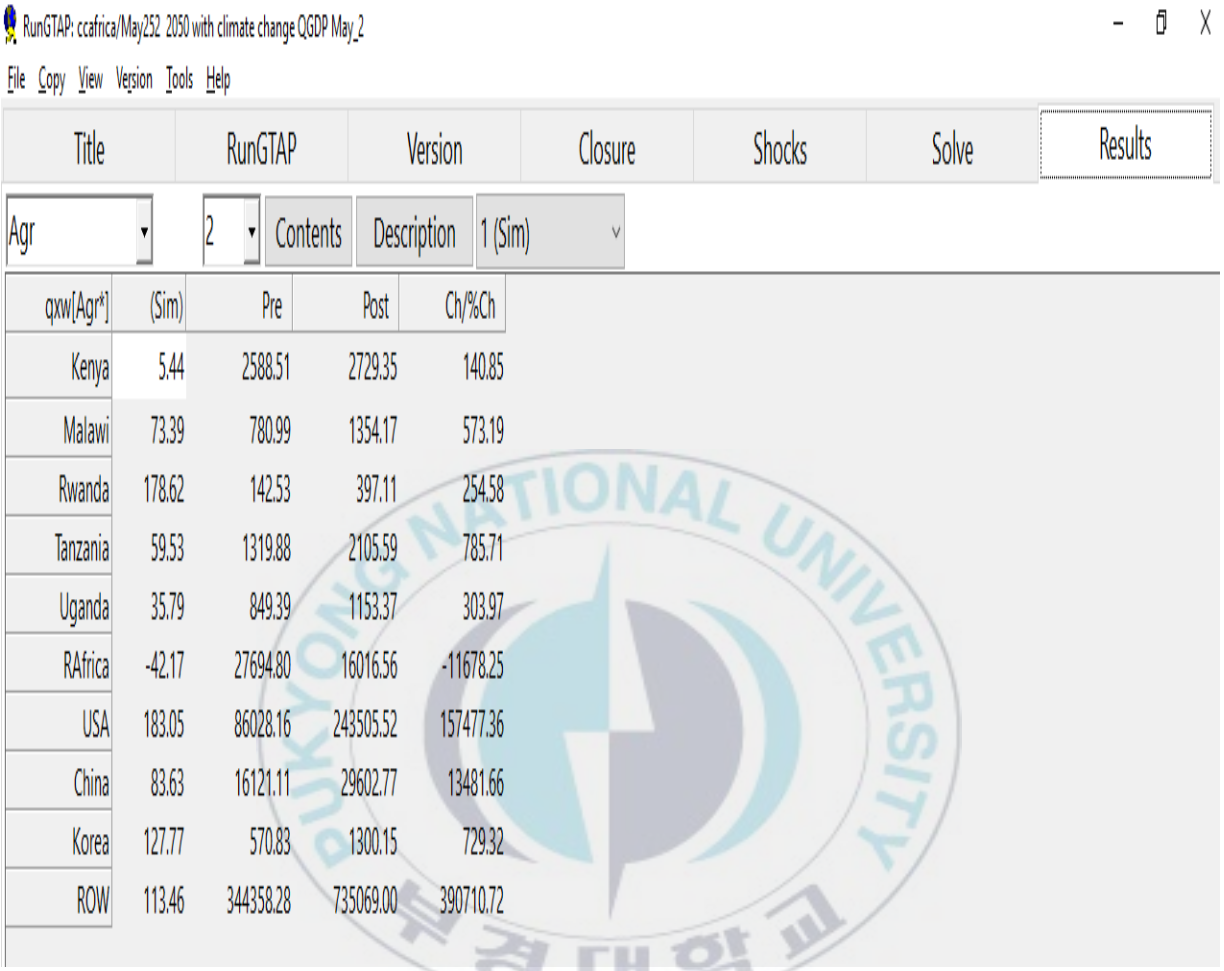


Table B. 6 Percent Change in Exported Quantity (qxw) of the EAC in 2050 with Climate Change



qxw[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	5.44	2588.51	2729.35	140.85
Malawi	73.39	780.99	1354.17	573.19
Rwanda	178.62	142.53	397.11	254.58
Tanzania	59.53	1319.88	2105.59	785.71
Uganda	35.79	849.39	1153.37	303.97
RAfrica	-42.17	27694.80	16016.56	-11678.25
USA	183.05	86028.16	243505.52	157477.36
China	83.63	16121.11	29602.77	13481.66
Korea	127.77	570.83	1300.15	729.32
ROW	113.46	344358.28	735069.00	390710.72

Table B. 7 Percent Change in Imported Quantity (qiw) of the EAC in 2050 with Climate Change

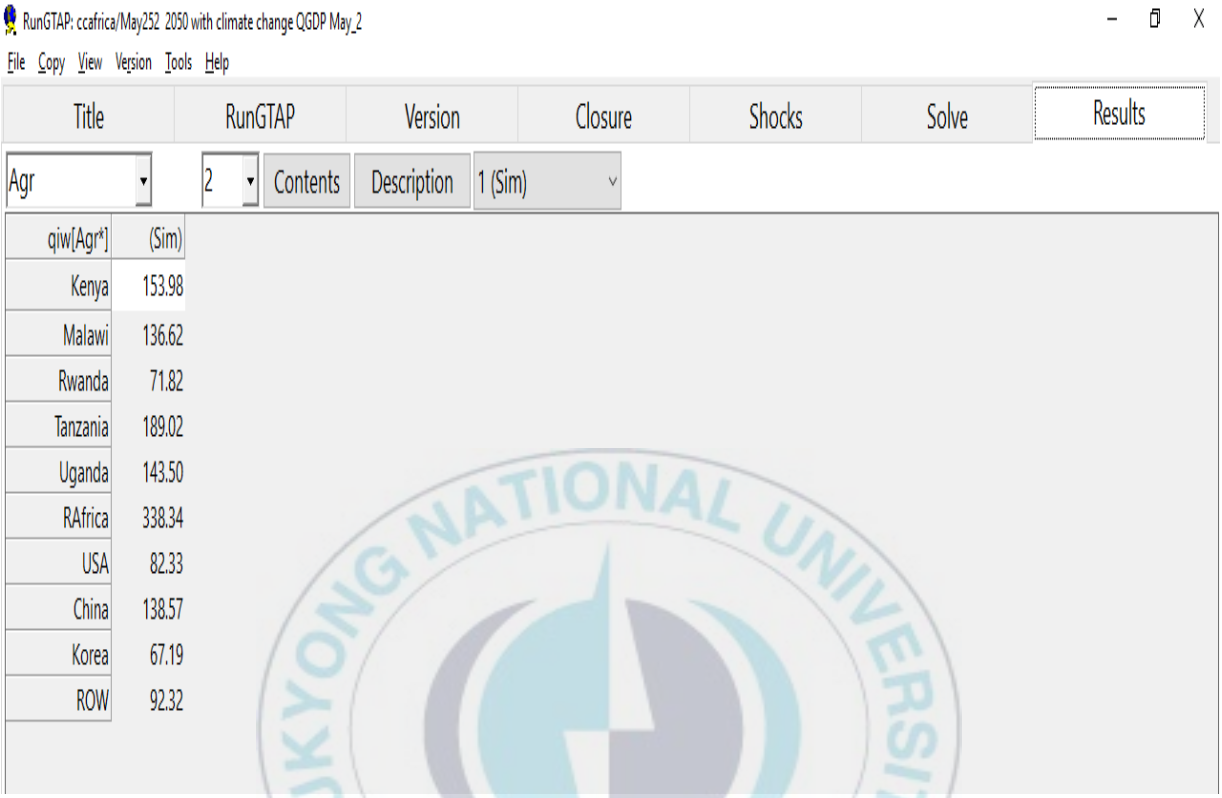
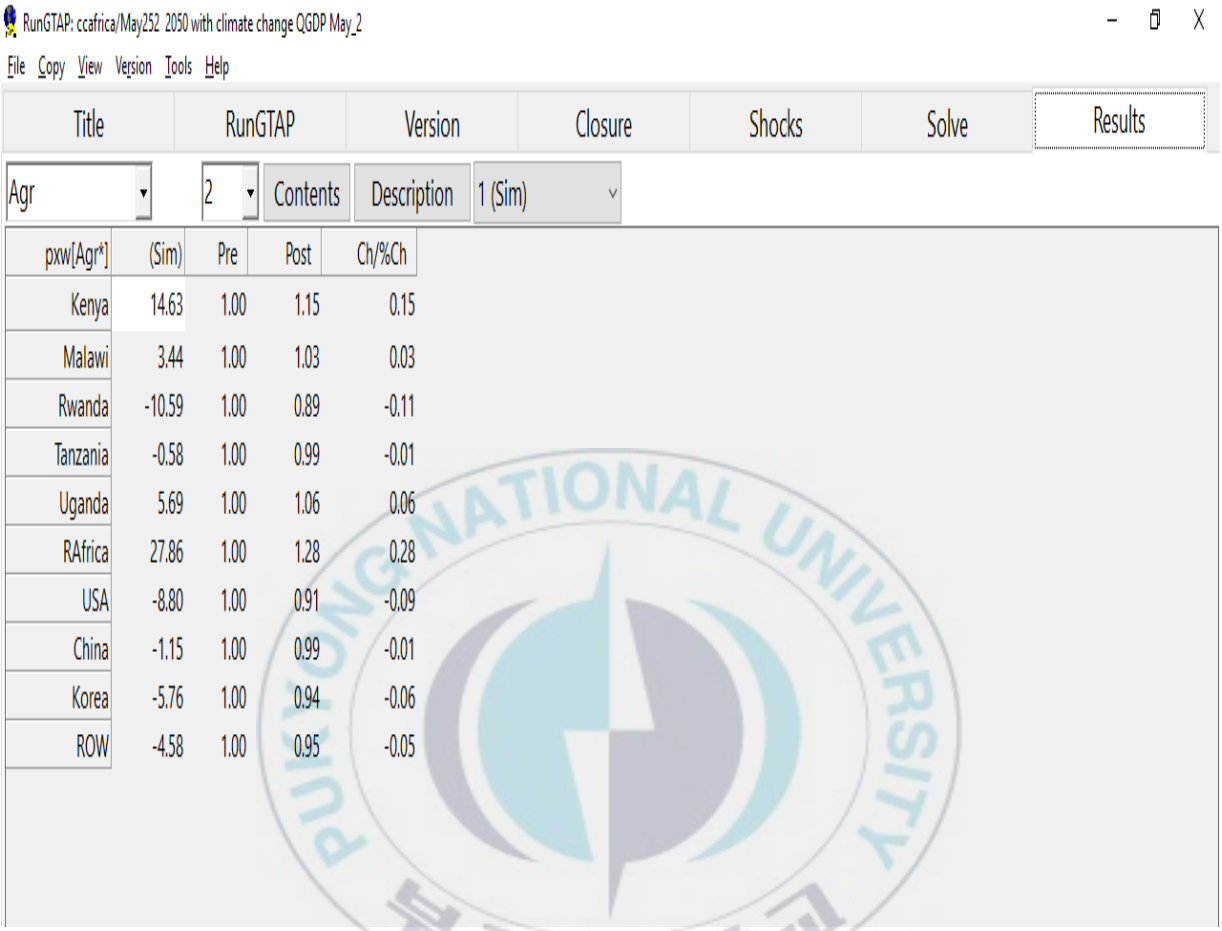
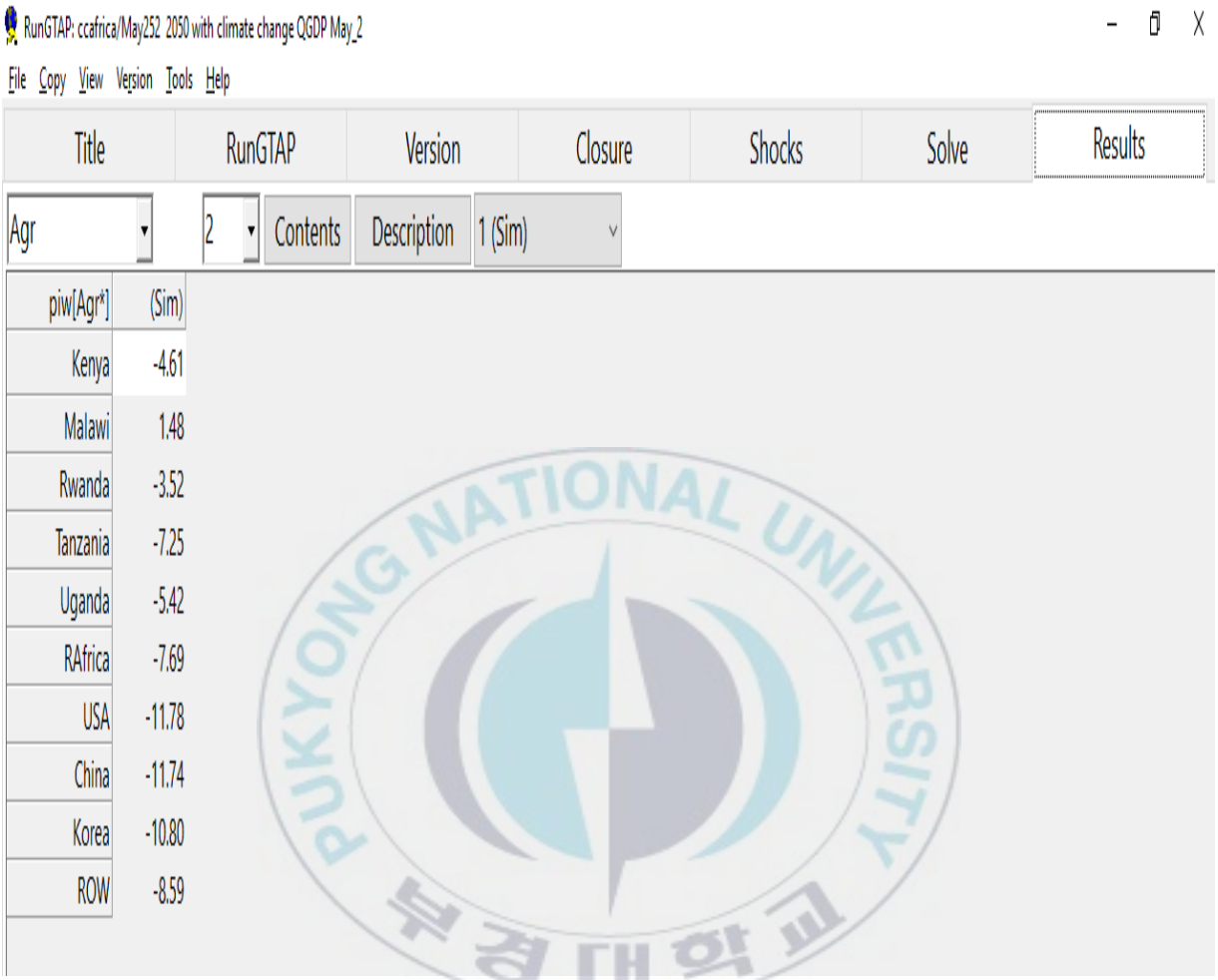


Table B. 8 Percent Change in World Price of Exported quantity (pxw) of the EAC in 2050 with Climate Change



pxw[Agr*]	(Sim)	Pre	Post	Ch/%Ch
Kenya	14.63	1.00	1.15	0.15
Malawi	3.44	1.00	1.03	0.03
Rwanda	-10.59	1.00	0.89	-0.11
Tanzania	-0.58	1.00	0.99	-0.01
Uganda	5.69	1.00	1.06	0.06
RAfrica	27.86	1.00	1.28	0.28
USA	-8.80	1.00	0.91	-0.09
China	-1.15	1.00	0.99	-0.01
Korea	-5.76	1.00	0.94	-0.06
ROW	-4.58	1.00	0.95	-0.05

Table B. 9 Percent Change in Imported Price (piw) of the EAC in 2050 with Climate Change



piw[Agr*]	(Sim)
Kenya	-4.61
Malawi	1.48
Rwanda	-3.52
Tanzania	-7.25
Uganda	-5.42
RAfrica	-7.69
USA	-11.78
China	-11.74
Korea	-10.80
ROW	-8.59