# THE IMPACT OF CLIMATE CHANGE AND THE EUROPEAN UNION GSP-SCHEME ON EAST AFRICA'S HORTICULTURAL TRADE

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## Declaration

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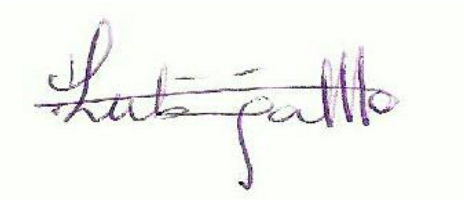

M. H. LUBINGA

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## Dedication

This work is first and foremost dedicated to my wife (Stellah) and the beloved daughter Sonia. Furthermore, I dedicate it to Engineer C.J. Mutyaba (dad), Ms. H. Nansubuga (Mum-R.I.P) and my siblings (Dianah, Ibra, Angela and Benjamin).

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## List of acronyms

| | | |
|---|---|---|
| ACCI | : | Australian Chamber of Commerce and Industry |
| ACODE | : | Advocates Coalition for Development Environment |
| ACP | : | African, Caribbean and Pacific |
| AD | : | Absolute Difference |
| AGOA | : | African Growth and Opportunity Act |
| AGRODEP | ; | African Growth and Development Policy Modelling Consortium |
| ASARECA | : | Association for Strengthening Agricultural Research in Eastern and Central Africa |
| AVE | ; | Ad valorem Equivalent |
| BCPR | : | Bureau for Crisis Prevention and Recovery |
| BRC | : | British Retail Consortium |
| CEECs | : | Central and Eastern European countries |
| CEEPA | : | Centre for Environmental Economics and Policy in Africa |
| CODED | : | Eurostat's Concepts and Definitions Database CODED |
| COLEACP | : | Europe-Africa-Caribbean-Pacific Liaison Committee |
| COMESA | : | Common Market for East and Southern African |
| COMTRADE | : | Common Format for Transient Data Exchange |
| CPI | : | Consumer Price Index |
| CPIA | : | Country Policy and Institutional Assessment |
| DFID | : | Department for International Development |
| DICA | : | Domestic and Import Competition Adjusted |
| DGVM | : | Dynamical Global Vegetation Model |
| DNCA | : | Dunning index of Net Competitive Advantage |
| DSSAT | : | Decision Support System for Agrotechnology Transfer |
| EEC | : | European Economic Community |
| EA | : | East Africa |
| EAC | : | East African Community |
| EBA | : | Everything but Arms |
| EC | : | European Commission |
| EM-DAT | : | Emergency Disasters Database |

| | | |
|---|---|---|
| EPA | : | Economic Partnership Agreement |
| EPOPA | : | Export Promotion of Organic Products from Africa |
| EU | : | European Union |
| EU-GSP | : | European Union Generalised System of Preferences |
| FAO | : | Food and Agricultural Organisation |
| FiBL | : | Research Institute of Organic Agriculture |
| FPEAK | : | Fresh Produce Exporters Association of Kenya |
| FV | : | Fruits and Vegetables |
| GDP | : | Gross Domestic Product |
| GHG | : | Green House Gas |
| GLI | : | Grubel-Lloyd Index |
| GLOBALG.A.P | : | Global Good Agricultural Practices |
| GNI | : | Gross National Income |
| H-O | : | Heckscher-Ohlin |
| HS | : | Harmonised System |
| HT-test | : | Harris-Tzavalis test |
| ICA-PM | : | Import Competition-Adjusted Preference Margin |
| ICTSD | : | International Centre for Trade and Sustainable Development |
| IFOAM | : | International Federation of Organic Agriculture Movement |
| IFPRI | : | International Food Policy Research Institute |
| IPPC | : | Intergovernmental Panel on Climate Change |
| IRS | : | Increasing Returns to Scale |
| ITC | : | International Trade Centre |
| LDCs | : | Less Developed Countries |
| LLC-test | : | Levin–Lin–Chu test |
| MFN | : | Most Favoured Nation |
| MRLs | : | Maximum Residue Levels |
| NAADS | : | National Agricultural Advisory Services |
| NBR | : | Negative Binomial Regression |
| NCCRS | : | National Climate Change Response Strategy |
| NECOFA | : | Network for Ecofarming in Africa |
| NEI | : | Net Export Index |
| NOGAMU | : | National Organic Agriculture Movement of Uganda |
| NOP | : | National Organic Program |

| | | |
|---|---|---|
| OECD | : | Organisation for Economic Co-operation and Development |
| OLS | : | Ordinary Least Squares |
| PIP | : | Pesticides Initiative Programme |
| PM | : | Preference Margin |
| PPM | : | Potential Preference Margin |
| PRCA | : | Porter-adapted index of RCA |
| PRISM | : | Parameter-Elevation Regressions on Independent Slopes Model |
| PTA | : | Preferential Trade Agreement |
| RC | : | Revealed Competitiveness |
| RCA | : | Revealed Comparative Advantage |
| RD | : | Relative difference |
| RER | : | Real Exchange Rate |
| RMA | : | Relative Import Advantage |
| RPM | : | Relative Preference Margin |
| RSCA | : | Revealed Symmetric Comparative Advantage |
| RTA | : | Relative Trade Advantage |
| RXA | : | Relative Export Advantage |
| SIDA | : | Swedish International Development Co-operation Agency |
| SITC | : | Standard International Trade Classification |
| SPSS | : | Statistical Package for Social Scientists |
| SRES | : | Special Report on Emissions Scenarios |
| SSA | : | Sub-Saharan Africa |
| SSMI | : | Special Sensor Microwave Imager |
| TOL | : | Tolerance |
| TRAINS | : | Trade Analysis and Information System |
| TRQ | : | Tariff Rate Quotas |
| UAE | : | United Arab Emirates |
| UIA | : | Uganda Investment Authority |
| UK | : | United Kingdom |
| UN | : | United Nations |
| UNBS | : | Uganda National Bureau of Standards |
| UNCTAD | : | United Nations Conference on Trade and Development |
| UNDP | : | United Nations Development Programme |
| UNFCC | : | United Nations Framework Convention on Climate Change |

| | | |
|---|---|---|
| USA | : | United States of America |
| USAID | : | United States Agency for International Development |
| VIF | : | Variance Inflation Factor |
| WBDI | : | World Bank Development Indicators |
| WUOGNET | : | Women of Uganda Network |
| ZIP | : | Zero Inflated Poisson |

# Abstract

With the aim of generating reliable information upon which appropriate decisions can be based to benefit the various stakeholders, this research at one hand aims at developing a set of meteorological indices, which are used as proxies to evaluate the impact of climate change on horticultural trade flows to the European Union (EU) market. On the other hand, the study examines the role of European Union's Generalised System of Preferences (EU-GSP scheme) in boosting agricultural imports into the EU. Furthermore, the study assesses the export competitiveness of various horticultural commodities of East African states within the EU market, as well as exploring East Africa's trade potential and performance of the selected commodities within the EU.

Various techniques were used to attain the above objectives. Such techniques include; Balassa's Revealed Comparative Advantage (RCA) approach, the out-of sample technique, the relative difference and absolute difference methods. To estimate the various gravity models specified, a set of the extended Poisson models, *viz*: Zero Inflated Poisson (ZIP) and Negative Binomial Regression (NBR) techniques for panel data estimations were employed so as to deal with the excess zeros and over dispersion problems associated with highly disaggregated data. Time series data for a period of 23 years (1988-2011) for 15 EU member states and 3 East African states (Kenya, Tanzania and Uganda) were used for the analysis. Data was obtained from various sources such as the TRAINS database, World Bank Development Indicators, African Growth and Development Policy Modeling Consortium (AGRODEP) database, Food and Agriculture Organisation (FAO) database, and TYN CY 1.11 database provided by the Tyndall Centre for Climate Change Research.

Some of the key empirical findings decomposed at country level reveal that:

- Kenya has export competitiveness in Asparagus, Mushrooms and truffles. Uganda exhibits competitiveness in exporting pepper, bananas and eggplants while for Tanzania, vegetables were the most competitive. Therefore, each of these countries should put much emphasis on producing and exporting commodities over which she has comparative advantage.

- Climate change generally has both positive and negative effects on horticultural trade flows into the EU-Market, depending on the kind of proxy being put into consideration. Within the EU market, anomalies in precipitation enhance horticultural imports from East Africa while temperature anomalies tend to hinder trade. Anomalies in temperature in exporting countries boost horticultural trade flows from Tanzania and Uganda while the contrary is true for Kenya. Precipitation anomalies in exporting countries favor horticultural trade flows from Kenya while they curtail trade flows from Tanzania and Uganda. Thus, results imply that the use of anomalies as proxies for climate change in agrarian based economies provides a more reliable measure of the effects of climate change in trade than using the generalized Kyoto Protocol policies.

- The EU-GSP scheme selectively favors importation of certain horticultural commodities into the EU-market, depending on the country of origin. It promotes importation of bananas, beans and peppers from Uganda and beans from Tanzania. On the contrary, it deters asparagus and bean imports from Kenya. Given that the findings concur with findings of other scholars, it is imperative to argue that the use of preference margin, based on all policy instruments (tariff rates, MFN, specific duties and Tariff Rate Quotas) embedded within the EU-GSP scheme provides apt commodity specific inferences regarding the effect of the EU-GSP scheme on horticultural imports into the EU-market.

- Kenya and Uganda exhibit existence of un realised trade potential within the EU market. For Kenya, asparagus has room for further market expansion across all EU-member states while Uganda's beans and pepper can further be imported many EU member states like France, Germany, Luxembourg, Portugal and Greece, among others. A similar scenario applies to beans from Tanzania. This implies there is still have room to expand East Africa's horticultural trade within the EU-market.

- The three East African states evidently exhibit poor trade performance within the EU-market in the various commodities. This suggests that there exists some barriers to trade which limit the proliferation of East Africa's horticultural imports into the EU. Thus, it is incumbent upon East African states to foster cooperation in horticultural trade with the EU member states..

Conclusively, it is commendable that anomalies in temperature and precipitation may be used as climate change proxies, particularly when evaluating the impact of climate change on international trade skewed towards agricultural commodities rather than using other based on Kyoto Protocol policies. It is also recommended that assessment of the influence of non-reciprocal preferential trade agreement(s) granted to developing countries, based on preference margins should always take into account all the policy instruments embedded within the agreement.

# CHAPTER ONE

## 1.1 Background

Export-driven growth of horticulture has been impressive in a number of countries in Sub-Saharan Africa (SSA) and the involvement of small-scale growers in the production of fruits and vegetables, which are exported mainly to the European Union (EU), has contributed to poverty alleviation and rural development (UNCTAD, 2008). According to Minot and Ngigi (2004), horticulture has at times been referred to as an "African success story". In particular, exports of fresh fruits and vegetables have seen high growth rates and better prices, as compared with Africa's traditional agricultural exports (FAO, 2004). In countries such as Kenya, the subsector has attracted considerable participation of smallholder growers in production for export. The EU is the key destination market for fruits and vegetables from East African countries. For instance, the value of Uganda's horticulture exports to the EU increased by more than fivefold, from $1.5 million in 1996 to over $8 million in 2006 (UNCTAD, 2008).

The fruit and vegetable exports to the EU mainly go to wholesale markets in the United Kingdom and to small supermarkets in the Netherlands. In Uganda, the main fruit exports include off-season fruits (like citrus fruit and pears), major tropical fruits (like bananas, pineapples, avocados, mangoes and papayas) and other fruits, such as passion fruit. Furthermore, the major vegetable exports are beans, peas, green chillies (cayenne) and hot peppers (Scotch Bonnet), among others. The leading Kenyan vegetable exports are French beans, mixed vegetables, runner beans, okra snow peas and "Asian vegetables", while the key fresh fruit exports include avocados, mangoes, passion fruit and pine apples (UNCTAD, 2008).

According to Petriccione *et al.* (2011), imports into the EU market for fruits and vegetables are subject to two types of duties, *viz,* the ad-valorem duties and specific duties. In addition, the EU largely categorizes a majority of the products as being sensitive which are thus subjected to a special entry price system. This is aimed at ensuring price stability and to prevent very cheap products entering the European market. With this approach, each product is accorded a trigger price such that when the import price surpasses this threshold, a specific duty is applied. However, when the import price is less than this trigger price, the commodity is then levied both the specific and the ad-valorem duty. More often than not, the commensurate value of the specific duty is equivalent to the difference between the import price and the trigger price.

However, in a scenario where the import price is lower than 92 % of the trigger price, the specific duty is then fixed and equals to the maximum specific duty as specified by the EU. The EU market also employs a mechanism of altering tariff levels of fruits and vegetables within a calendar year. This is probably aimed at favouring EU's production calendar, thereby protecting the domestic producers within the EU market. In most cases, altering of tariffs arises during harvesting periods which coincide with the northern hemisphere winter season. For instance, Uganda Investment Authority (UIA) (2001) notes that the November to February harvesting period in Uganda coincides with the winter season in Europe and during this period, the demand for fresh fruits and vegetables is relatively low.

As with many other parts of the world where climate change has become a critical predicament, Sub-Saharan Africa is not exceptional. Globally, climate change has been distinguished as one of the major challenges man is facing. Despite the fact that Less Developed Countries (LDCs) have negligibly contributed to causing climate change, coupled with their limited capacity to adapt, they have succumbed to its harshest impacts (Dinda, 2011). This phenomenon has led to melting glaciers, more precipitation, more and more extreme weather events, and drastic changes in seasons.

According to Nelson *et al.* (2009), the hastening pace of climate change, coupled with global population and income growth, is a threat to the agricultural sector, hence to food security globally. Notably, increasing temperatures cause yield loss of desirable crops, while boosting weed and pest proliferation. The variation in precipitation patterns enhances the likelihood of short-run crop failures and long-run production declines (Nelson *et al.,* 2009). On the other hand, climate change can truly provide opportunities to re-design economic activities, for instance through the formation of non-traditional production technologies and use of enhanced technological developments.

### 1.2 Problem statement

International trade is a crucial mechanism for industrialization and sustainable economic development. The gravity flow model has been used in various studies to evaluate how various trade policy issues, such as the effects of openness of an economy or protectionist policies and the merits of proposed regional trade arrangements (such as the Common Market for East and Southern African (COMESA), European Economic Community (EEC), and East African Community (EAC)), affect trade flows. Notably, the gravity flow model is at the forefront in enhancing a better understanding of the determinants of a country's / region's trade flows from an empirical point of view. The model broadens the horizons of a country's / region's trade policies (Deardorff, 1998; Eichengrean and Irwin, 1997; Luca and Vicarelli, 2004).

Despite the fact that a large volume of literature evaluates the role of trade agreements (for instance, the European Union Generalised System of Preferences (EU-GSP Scheme)) in enhancing trade, a majority of these studies (Nakakeeto *et al.,* 2011; Teweldemedhin and Van Schalkwyk, 2010; Korinek and Melatos, 2009; Martìnez-Zarzoso *et al.*, 2009; Caporale *et al*. 2009; Naude and Saayman, 2005; Péridy, 2005) use a dummy variable to proxy for such trade policies. On the contrary, scholars (Aielo and Damalia, 2009; Cardamone, 2009; 2007; 2011) argue that this approach does not adequately describe the trade preferences granted, hence it can be misleading. In detail, the use of dummy variables is inadequate because; (*i*) it also captures all other factors that are specific to the country-pair and concomitant to the preferential trade agreements; (*ii*) it does not discriminate among different instruments adopted for non-reciprocal preferential treatment; (*iii*) it does not recognize the level of trade preferences and it does not capture the strength of preferential access. Thus, this traditional approach does not allow for appropriate estimation of the effect of non-reciprocal preferential treatment on trade flows.

In light of the above setbacks, the literature has drifted towards the use of a continuous variable, generally referred to as the preference margin. However, the current literature (Cipollina *et al*., 2013; Raimondi *et al.*, 2011; Cirera *et al.*, 2011; Cipollina and Salvatici, 2010; 2009; 2008; Philippidis *et al*., 2011; Emlinger *et al.*, 2008) reveals that this continuous variable is calculated basing on at least one of the policy instruments, *viz*, the tariff rate, the Most Favoured Nation (MFN) rate, specific duties and tariff rate quota embedded within the non-reciprocal preferential treatment (the EU-GSP scheme). None of the studies uses a combination of all the policy instruments, yet ignoring any of them jeopardizes the true value of the preferential margin. Thus, the existing approach (preferential margin) used to proxy the role of the trade policies, particularly in the EU-GSP scheme, under the gravity model framework does not allow for appropriate estimation of the effect of the non-reciprocal preferential treatment granted by the EU.

Additionally, significant progress has recently been made in terms of quantifying the effects of climate change on international trade flows, thus leading to a better understanding of the associated barriers it imposes on doing business. However, this advancement in academic research has led to various measures, such as greenhouse gas emissions, environmental permits, regulations, directives, emissions trading certificates, and tradable renewable energy certificates, being used to proxy climate change. For instance, the World Bank (2008) used carbon/energy tax and energy efficiency standards to study the impact of climate change on the exports of OECD countries. Climate change proxies, such as the carbon tax and greenhouse gas emissions used in capturing climate change effects among developed (industrial) countries, are less reliable, especially in the context of developing regions like East Africa (EA), given that the composition of their exports are skewed towards agriculture (Hoekman and Nicita, 2011; Bineau and Montalbano, 2011), which is directly influenced by consequences of weather-related natural factors, such as temperature, rainfall, cloud cover and humidity, among other climatic factors.

Specifically, Melo and Mathys (2010) mention that measuring greenhouse gas in the agriculture sector is very difficult, thus complicating the actual quantification of the effects of climate changes on agricultural trade. According to Bineau and Montalbano (2011), this is compelling developing countries to substitute machinery of poor energy efficiency with modern machinery that is energy efficient, so as to catch-up with industrialization. Notably, given that this transition is unprecedented and requires heavy initial investment costs, the United Nations (UN) (2009) asserts that this is the major obstacle in curbing climate change effects. The World Bank (2008) reveals that most of these climate change measures do not directly target any particular product, but rather focus on the method by which greenhouse gases may implicitly be related to production.

Therefore, climate-related policies based on those measures may have implications for trade (Bineau and Montalbano, 2011), especially in agricultural commodities. Better measures should be based on temperature, precipitation, humidity and other weather-related factors since these directly affect the agricultural sector. The most plausible way to assess climate change effects on the architecture of international agricultural trade is to redefine the proxy measures of climate change, which can be easily and directly linked to agriculture. Therefore, the current approach employed to model climate change effects on trade does not appropriately reflect how this phenomenon influences trade in agricultural commodities. So, evaluation of the influence of climate change on trade in agricultural commodities should be based on variables that directly relate to the agriculture sector, which are temperature and precipitation.

## 1.3 Objectives of the study

The overall objective is to develop and illustrate an improved methodology for evaluating the impact of climate change on international trade in agricultural commodities by using climate change proxies based on meteorological data; and to provide empirical evidence on the relationship between the European Union non-reciprocal preferential trade agreement and agricultural trade flows. Successfully achieving this objective will enhance the making of informed trade related and climate change adaptation policy decisions. This will enable the realization of the full trade potential of the East African States.

The overall objective will be met through the following sub-objectives:

***Sub-objective 1***

To determine the export competitiveness of East Africa's fruit and vegetable exports within the European Union market. The identified horticultural commodities for each country will then be used to demonstrate how climate change and preferential treatment affect international trade in agricultural commodities.

This objective will be attained by using the index of Revealed Comparative Advantage (RCA). This index measures the export competitiveness in a given horticultural product by beneficiaries of the trade agreement relative to other countries of the world. The RCA uses actual trade flows to ascertain the competitiveness of exporters in fruit and vegetable products. Attainment of this objective will enable EA states to identify the fruit and vegetable commodities over which they have export competitiveness. This implies that if such economies allocate adequate resources to these commodities, more benefits could be realized instead of thinly spreading limited resources over a wide spectrum of products.

***Sub-objective 2***

To investigate the effects of a developed set of climate change proxies, based on meteorological data, on international trade by using panel estimation techniques. As an alternative to climate change proxies based on Kyoto Protocol policies, such as the carbon tax and energy efficiency standards, anomalies in temperature and precipitation will be developed and used as proxies for climate change. This set of climate change variables will then be incorporated into the gravity model and run using the family of Poisson model estimators.

***Sub-objective 3***

To determine the effect of the EU-GSP preferential trade agreement on East Africa's fruit and vegetable imports into the European Union market.

Unlike other scholars who use dummy variables, preferential treatment will be measured at HS 6-Digit level as a continuous variable (absolute preference margin), while following Cardamone (2011). The absolute difference will be measured as the difference between the trade-weighted applied MFN rate and the Ad Valorem Equivalents (AVEs). The computation of the preference margin that is employed in this study differs from Cardamone's in two aspects: (*i*) the reference tariff, *viz,* the trade-weighted applied MFN rate, takes into consideration competition within the EU market, and (*ii*) the preferential tariff (AVEs) accounts for all the policy instruments (tariff rates, MFN, specific duties and Tariff Rate Quotas) embedded within the EU-GSP scheme. The obtained preference margin per selected horticultural commodity, at a given time, will then be used as the variable within the augmented gravity model framework to run the family of Poisson model estimators to predict the effect of the non-reciprocal preferential treatment.

***Sub-objective 4***

To predict East Africa's unilateral trade potential and performance.

This study will employ the *out of sample* approach to predict East Africa's potential unilateral trade flows. With this approach, the exact parameters estimated by the gravity flow model will be used to project the "natural" trade relations between the trading partners, such that the difference between the actual and predicted trade flows represent the un-exhausted export potential (Wang and Winters, 1992; Hamilton and Winters, 1992; and Brulhart and Kelly, 1999).

Realization of this objective will enable each East African state to comprehend the level of its trade with the EU at commodity level. Succinctly, this will enhance the ascertainment of how much more of the selected fruits and vegetables need to be exported to the EU market so as to fully benefit from the non-reciprocal preferential trade. Furthermore, accomplishment of this objective will enable the identification in detail of the specific EU member states with which East African states have room for trade expansion with respect to particular commodities.

Following Lie *et al.,* (2002) and Amita (2004), trade performance will be analysed using two indices, that is, the Relative Difference (Rd) and Absolute Difference (Ad). Although Rd can be a convenient index to describe the relative relation of actual and simulated trade volume, it does not explain the deviation volumes between them. However, use of Ad enables computation of the gain or owned trade potential value, hence identifying the future trade partner of the exporting country (Chen *et al.,* 2007). All in all, the study uses the Absolute difference index to cross check findings obtained while employing the Relative Difference index.

## 1.4 Lay out of the study

The subsequent chapters are organized as follows. In Chapter Two, relevant literature relating to export competitiveness and preferential treatment (EU-GSP Scheme), as well as the agriculture-climate change nexus and how it affects trade, are discussed in detail. Furthermore, a literature review of trade potential and trade performance is also presented in this chapter. Chapter Three presents an overview of the horticulture sector in Kenya, Tanzania and Uganda. In Chapter Four, a brief overview about the gravity model, the study area, data and data management procedures, and the data sources, as well as the estimation techniques used to achieve the set objectives, are discussed. Detailed results and discussions of the results of each objective are presented in Chapter Five. Lastly, Chapter Six provides the conclusions with regard to the objectives and recommendations generated from the results of the study.

## CHAPTER TWO:
## LITERATURE REVIEW

### 2.1 Introduction

This chapter presents relevant literature relating to the concept of, and measures for evaluating, export competitiveness, the impact of the non-reciprocal EU-GSP preferential trade agreement on international trade, and the predicting of trade potential and trade performance. The purpose of this review is to ascertain what other scholars have done with regard to the above-mentioned aspects so as to establish the existing knowledge gap(s). The identified knowledge gap(s) will then be addressed through this research. At the end of each main sub-section, limitations and probable means of improving the existing pool of knowledge are highlighted.

### 2.2 The concept of competiveness and its measures

Despite the fact that the concept of competitiveness is well known in economics, no definition based on economic theory exists (Latruffe, 2010; Sharples, 1990; Ahearn *et al*., 1990), and previous studies have adopted definitions depending on the context of analysis, as well as the measurement approach to be used. According to the Eurostat's Concepts and Definitions Database (CODED), competitiveness refers to "The ability of companies, industries, regions or supranational regions to generate while being and remaining exposed to international competition, relatively high factor income and factor employment levels on a sustainable basis." On the other hand, the International Institute for Management Development (IMD) (2009) defines export competitiveness as the country's ability to create and maintain a suitable environment that can sustain more value creation for its enterprises and increased prosperity for its populace. According to the European Commission (EC) (2009), competitiveness refers to "a sustained rise in the standards of living of a nation or region and as low a level of involuntary unemployment as possible".

In the scientific literature, more often than not, the concept of competitiveness is used to assess a region's or a country's macroeconomic performance by comparing a number of key economic features that may influence international trade flows. Theoretically, scholars

(Meiliene and Snieska, 2010; Saboniene, 2009; Anisimovaite and Marcisauskiene, 2008) argue that a country's export competitiveness for a given product depends on the concept of comparative advantage. That is, a country has increasing competiveness if it exhibits an increase in exports, a rise in particular exports in the external markets, or an increase in revenues and variety within the exports. Therefore, for the purpose of this study, export competitiveness is defined as the proportionate share of a country's products in the world markets (Michael *et al.*, 2008).

It is worthwhile to mention that the literature presented in this sub-section does not claim to be exhaustive in reviewing all possible measures of competitiveness. However, it showcases a general insight into the most often used measures of analysing competitiveness. According to Latruffe (2010), competitiveness measures can broadly be categorized into two, *viz,* trade-related measures of competitiveness and strategic management measures of competitiveness.

Trade related measures of competitiveness are grounded in neoclassical economics and they employ real exchange rates, comparative advantage indices, and import or export indices. On the other hand, strategic management measures are defined as those measures that dwell much on the firm's structure and strategy. Their relevance was first brought to light by Porter (1990), when he proposed "the diamond model". According to Kleynhans (2003), the model provides an insight into the determinants of export competitiveness of firms and it is founded on demand conditions, factor conditions, and related firms, as well as firm strategy, structure and rivalry (Porter, 1998).

Within this framework, commonly used measures under this category are further subdivided into cost measures (*Domestic Resource Costs ratio, Social cost-benefit ratio, cost of production*); profitability measures (*gross margins, cost to revenue ratio, value added to sales*); and productivity and efficiency measures (*total factor productivity, growth of labour productivity, technical efficiency, allocative efficiency*) among others. However, given that this study focuses more on trade, strategic management measures are not discussed in detail. Particular emphasis is accorded to trade related measures. Because most of the trade related measures are based on the concept of comparative advantage, it is prudent that this concept be introduced first and then followed by the trade related measures.

### 2.2.1 The concept and theoretical framework of Comparative Advantage

One of the most firmly established ideas in economics is that a country's or a region's competitiveness depends on its comparative advantage. The concept of Comparative Advantage was first described by David Ricardo in the 1800s (Esterhuizen, 2006) in his book entitled "On the principles of political economy and taxation" but the concept was later refined and popularized by Balassa (1965). According to Balassa's (1965) index, comparative advantage is revealed through the assessment of actual commodity trade patterns on the assumption that the real exchange of goods and services depicts the relative costs and the divergences in factors that may not easily be quantified in monetary terms. This index has been widely used to identify international trade related patterns across borders in an effort to determine a country’s export competitiveness position.

There are two popular trade related theories that can be used to explain the concept of comparative advantage, *viz,* the Ricardian theory and the Heckscher-Ohlin (H-O) theory. According to the Ricardian theory, it is assumed that comparative advantage is the result of technological differences across countries, while on the other hand, the H-O theory opines that comparative advantage is attributable to differences in production costs across countries. The H-O theory further argues that all countries are technologically indifferent. Therefore, a country is expected to export goods produced by its reasonably abundant factors of production and to import goods that are intensive in the rather scarce factors.

As an example in support of the H-O theory, Utkulu and Dilek (2004) assert that many non-industrialized nations are skewed towards producing primary products rather than manufacturing products because they have land and labour in abundance but are constrained by capital, education and technology. However, according to Balance (1988), the major limitation of this theory is that the concept of comparative advantage is expressed in non-concrete terms, based on relative prices which hypothetically prevail in a completely closed economy.

The H-O theory is associated with two problems: (*i*) it is practically difficult to quantify comparative advantage, given that all nations to some extent take part in international trade; (*ii*) hardly any facts on autarkic prices can be accessed (Balassa, 1989; Utkulu and Dilek, 2004). That is, the prices for specific commodities cannot be observed in ex-post trade equilibrium, thus consequently rendering use of this theory in estimating comparative advantage challenging.

Acknowledging the above-mentioned drawbacks of the H-O theory, Balassa (1965) developed and popularized the “Revealed” Comparative Advantage (RCA) index, which is based on Ricardian theory. Balassa (1965; 1977) noted that the index differs from that based on Heckscher-Ohlin theory in that it is assumed that a nation’s comparative advantage is “revealed” in its observed trade patterns, rather than in focusing on factors that determine comparative advantage.

## 2.3 Trade related measures of competitiveness

### 2.3.1 The Revealed Comparative Advantage (RCA) and its adjusted indicators

The index is computed as:

$$RCA_k = \left(\frac{x_{ik}}{X_{ip}}\right) \Big/ \left(\frac{x^*_{wk}}{X^*}\right) \quad \text{.................................................} \quad (1)$$

Where the variables $x_{ik}$ and $X_{ip}$ denote the value of exports of product *k* from country *i* and total exports (*p*) from country *i*, respectively. The variables $x^*_{wk}$ and $X^*$ represent the value of world exports of product *k* and total world exports, respectively. Thus, a country is said to have a revealed comparative advantage in commodity *i*, if $(x_{ik} / X_{ip}) > (x^*_{wk} / X^*)$ (Kulapa *et al.*, 2013; Török and Jámbor, 2013; Athanasoglou *et al.*, 2010; Latruffe, 2010).

At this point, commodity *i*’s export market share is greater than the country’s total export market share, hence implying that the country is competitive in exporting commodity *i*. The major limitation of this index centres on the fact that its value is asymmetric, *viz,* for commodities that register comparative advantage, the RCA value ranges from one to infinity, while for those commodities regarded as comparatively disadvantage, the index starts from zero and stops at one (Mirzaei *et al.*, 2006).

The definition of RCA has been revised and modified (Kunimoto, 1977; Bowen, 1983; and Vollrath, 1987, 1989 and 1991). For instance, Vollrath (1987; 1989; and 1991) introduced three alternative RCA indices, *that is,* Relative Trade Advantage (RTA), the logarithm of relative Export Advantage (lnRXA) and Revealed Competitiveness (RC). These different modifications of Balassa's index were set to measure RCA at different levels, *that is,* at global level, at regional or sub-regional level and others to limit the analysis to trade flows between only two trading partners (Fertő and Hubbard, 2001; 2002). By definition, the RTA index refers to the difference between Relative Export Advantage (RXA) and the Relative Import Advantage (RMA). This index (RTA) accounts for both imports and exports. Conspicuously, it is postulated that RXA is the same as the commonly used Balassa's index.

Following the work of Fertő and Hubbard (2002), Utkulu and Dilek (2004), and Vollrath (1991), RTA is computed as:

$$RTA_a^i = RXA_a^i - RMA_a^i \quad \text{.........} (2)$$

where RXA and RMA denote relative export advantage and relative import advantage, respectively. The disaggregated indices are obtained as:

$$RXA^i = \left( X_a^i / X_n^i \right) \Big/ \left( X_a^r / X_n^r \right) \quad \text{.........}(3)$$

$$RMA^i = \left( M_a^i / M_n^i \right) \Big/ \left( M_a^r / M_n^r \right) \quad \text{.........}(4)$$

where superscript r refers to the world without country i, while subscripts a and n refer to the commodity of concern and all traded commodities minus commodity a, respectively. In the case of the RMA index, a value of less than one implies revealed comparative advantage, hence a country is said to be competitive in that particular product. It is worthwhile to note that the lnRXA index and Revealed Competitiveness Index can ably overcome the asymmetric problem associated with Balassa's index (Fertő and Hubbard, 2002; and Utkulu and Dilek, 2004). Positive index values imply that the country has comparative advantage, thus being competitive in exporting that particular commodity, while negative values denote competitive disadvantage.

The logarithm of relative Export Advantage (lnRXA) is defined as the natural logarithm of the commonly used Balassa index. That is:

$$\ln RXA^{i} = \ln \frac{\left( X_{a}^{i} / X_{n}^{i} \right)}{\left( X_{a}^{r} / X_{n}^{r} \right)} \text{................................(5)}$$

The third index, Revealed Competitiveness (RC), refers to the difference between the natural logarithms of Balassa's index and the relative import advantage index. Mathematically, RC is expressed as:

$$RC_{a}^{i} = \ln RXA_{a}^{i} - \ln RMA_{a}^{i} \text{.............................................................. (6)}$$

### 2.3.2 The Revealed Symmetric Comparative Advantage (RSCA)

The RSCA index, developed by Dalum *et al*. (1998) and Laursen (1998), is a simple decreasing monotonic transformation of Balassa's index. According to Nwachuku *et al*. (2010), the introduction of this index was aimed at controlling the asymmetry problem associated with the original Balassa index. Mathematically, it is expressed as:

$$RSCA = \left(RCA - 1\right) / \left(RCA + 1\right) \text{....................................................(7)}$$

where RCA is Balassa's index. The index ranges between −1 and +1, and a country is said to exhibit higher competitiveness in exporting a particular commodity if the values tends towards +1.

### 2.3.3 The Porter-adapted index of RCA (PRCA) and Dunning index of net competitive advantage index (DNCA)

In order to account for production by a firm in foreign countries, Pitts and Lagnevik (1998) argued that the RCA index should be adjusted and two indices were developed by Porter and Dunning, *henceforth*, referred to as Porter-adapted index of RCA (PRCA) and Dunning index of net competitive advantage index (DNCA). In practice, the PRCA index is founded on the assumption that national firms that produce abroad retain their country of origin as their home base. Thus, all production generated abroad by these firms is treated as exports of the country from which they originate, and hence added to exports. On the contrary, the DNCA index deducts all production by foreign firms from total exports (Latruffe, 2010). Symmetrically, these indices are expressed as:

$$PRCA = \frac{\left(\left(X_{ic} + Y_{ic}\right) / \left(X_{ik} + Y_{ik}\right)\right)}{\left(\left(X_{nc} + Y_{nc}\right) / \left(X_{nk} + Y_{nk}\right)\right)} \quad \text{......................................................(8)}$$

where $Y_{ic}$ denotes outbound production. This is the value of output c produced by firms of country *i* in foreign countries. *n* denotes all countries other than *i*.

$$DNCA = \frac{\left(\left(X_{ic} + Y_{ic}\right) - \left(M_{ic} + P_{ic}\right)\right)}{\left(X_{ic} + Y_{ic} - P_{ic}\right)} \quad \text{......................................................(9)}$$

where $P_{ic}$ denotes inbound production, *viz*, the value of output *c* produced by foreign firms operating within country *i*. X and M denote exports and imports, respectively.

### 2.3.4 The Net Export Index (NEI)

Banterle and Carraresi (2007) and Latruffe (2010) define the NEI as the ratio of the difference between a country's or sector's exports and imports to the total value of trade by that country or sector. Mathematically, it can be expressed as:

$$NEI = \frac{\left(X_{ij} - M_{ij}\right)}{\left(X_{ij} + M_{ij}\right)} \quad \text{..............................................................................(10)}$$

where X represents exports; M symbolizes imports; while subscripts *j* and *i* denote a sector or commodity and the country under consideration, respectively. The index assumes a negative value of (-1) if the country/sector is a net importer; this implies negative competitiveness, while a positive value implies increasing competitiveness in exporting that particular good.

### 2.3.5 The Grubel-Lloyd index (GLI)

The GLI was proposed by Grubel and Lloyd (GL) [1971]. It takes into consideration the fact that products are often exported and imported during the same period. It is computed as follows:

$$GLI_{ij} = 1 - \left(\frac{\left(X_{ij} - M_{ij}\right)}{\left(X_{ij} + M_{ij}\right)}\right) \quad \text{........................................................................(11)}$$

where X represents exports; M symbolizes imports; while subscripts *j* and *i* denote a sector or commodity and the country under consideration, respectively. Index values range from 0 to

1. A value of 0 implies the country is undertaking inter-industry trade, while a value of 1 depicts intra-industry trade flows. That is, exports are equal to imports (Latruffe, 2010).

### 2.3.6 The export to import price ratio

According to Bojnec (2003), this is the ratio of the unit value per ton of exported product to the unit value per ton of imported product. Values greater than one (1) imply that the exports represent goods of higher quality, as they command a higher price than the imports and vice versa. Going without saying, the reverse is true.

### 2.3.7 The Real exchange rate (RER)

The RER index is defined as the ratio of the price index of tradable goods to the price index of non-tradable goods (Latruffe, 2010). It is expressed as:

$$RER = \frac{P^{T}}{P^{T*}} \qquad (12)$$

where $P^T$ and $P^{T*}$ denote the price index of tradable goods and the price index of non-tradable goods, respectively.

As put by Fertő and Hubbard (2002), the major drawback of all indices based on comparative advantage is that they can be misleading if the underlying comparative advantage is misrepresented, especially in the presence of government policies and interventions which tend to distort actual trade flow patterns. Government interventions and policies, such as export subsidies and import restrictions, may distort trade.

There are a number of RCA indices that can be employed to assess a country's export competitiveness (Yilmaz, 2002; Akgüngör *et al*., 2002; and Lohrmann, 2000). However, scholars (Bruneckiene and Paltanaviciene, 2012; and Fertő and Hubbard, 2002) assert that, "There is no common scientific approach regarding the most efficient measure of export competitiveness, or reliable indicators, able to reflect the country's export competitiveness position at the international level." Secondly, despite the fact that Krugman (1994) disputes the use of this concept of comparative advantage, especially while measuring competitiveness at national level, it remains the most common basis for measuring export competitiveness (Palit and Nawani, 2012; Gilbert, 2010).

Thirdly, researchers such as Vollrath (1991) and Fertő and Hubbard (2002) note that in instances of government intervention, Balassa's index is less susceptible to policy-induced distortions in trade flow patterns, given that the computation of the index relies only on export data. Furthermore, it is argued that trade flow distortions are more evident at the import side than at the exporters' side. Therefore, taking the above considerations into account and given that this study is based on highly disaggregated data, which Capalbo *et al.* (1990) argue should be the basis for measuring competitiveness, it can be posited that Balassa’s index be accepted as an appropriate measure of export competitiveness.

## 2.4 Empirical evidence of competitiveness studies based on RCA methodology in the agriculture sector

The literature on the competitiveness of individual commodities, as well as the agricultural sector as a whole, is addressed here, first for non-African economies and then for Africa. Literature focussing on specific agricultural sectors, specifically the fruits and vegetable sector, is very scanty, especially for the African economies. Most studies either deal with entire sectors within an economy or focus on sectors, such as manufacturing.

### 2.4.1 Empirical studies of non-African economies (Rest of the world)

Akgüngör *et al*. (2002) measured the competitiveness of Turkey's tomato, grape, and citrus fruit processing industry exports to the EU market. Empirical results showed that Turkey's competitive power was higher than that of Spain and Portugal in processed grape exports, and was higher than Greece and Portugal in citrus fruit exports. The results further revealed that Turkey had a competitive disadvantage in exporting processed tomato products.

Utkulu and Dilek (2004) analysed the competitiveness of Turkey’s agricultural exports within the EU market, using time series data from 1990 to 2003. The results showed that Turkey was competitive in its many exports, fruits and vegetables included, within the EU market, while some sectors registered a comparative disadvantage. It is worthwhile to note that although the fruits and vegetables sector presented the highest RCA values, the results were unstable, given that their level of comparative advantage was on a declining trend.

Carraresi and Banterle (2008) investigated the competitiveness of the agric-food and agricultural sectors in European Union (EU) countries during the 1991- 2006 period, using a number of RCA indices. Their findings revealed a mixed level of competitiveness across the countries. For instance, Denmark, France, Greece, Ireland, Luxembourg, the Netherlands and the United Kingdom exhibited a declining trend in export competitiveness, while countries such as Belgium, Finland and Portugal registered increasing competitiveness in the agriculture sector. Germany, Italy, Spain and Sweden revealed increasing competitiveness throughout the entire period.

Palit and Nawani (2012) used Balassa's Index (RCA) for individual sector groupings to measure the competitiveness of Indian exports to China for the period 2004–06. Their findings reveal that India is more competitive in the Chinese market, relative to other Southeast Asian economies in some product categories such as vegetable products and food preparations.

With the aim of examining the export competitiveness of the canned tuna export industry in Thailand between 1996–2006, Kulapa *et al*. (2013) employed Balassa's index approach to estimate RCA indices for both exporters (Ecuador, Spain, the Seychelles, Mauritius, Indonesia, and the Philippines) in the world market and for contenders in individual export markets. Despite the fact that empirical results show that Thailand's comparative advantage deteriorated markedly in Australia, it still commands high and stable comparative advantage in all major export markets, such as the United States of America (USA), the Middle East, Japan and Canada.

Török and Jámbor (2013) analysed the competitiveness of fruit spirits in six Central and Eastern European countries (CEECs) following the enlargement of the EU market. With the exception of Hungary and Poland, their findings show that all countries were competitive in the EU-15 beverages market. The authors argue that despite the weakening drift in competitiveness since the EU accession, CEEC fruit spirits were equally competitive and had a comparative advantage in the EU-15 beverages market.

### 2.4.2 Empirical studies of some African economies

With the exception of Laibuni *et al.,* (2012), Shinyekwa and Othieno (2011), Sebaggala (2008), and Esterhuizen and Van Rooyen (2000), there has been limited research using the RCA index in the East African region. For instance, Esterhuizen and Van Rooyen (2000) investigated the competitiveness of Rwanda's agricultural exports for the period 1990–99. Their study applied the adjusted Balassa index and the results revealed that Rwanda's agricultural sector was competitive in exporting beans, coffee, tea and frozen vegetables, among other products. Commodities such as maize, sugar and beer were positioned at a competitive disadvantage.

Sebaggala (2008) assessed the competitiveness of Uganda’s exports to the rest world over a period of two years (2000 and 2005) while using aggregated data at SITC Revision 1. Empirical results showed that Uganda was generally competitive in food and live animal exports. At sub-sector level, fruits and vegetables exhibited a low level of export competitiveness.

Shinyekwa and Othieno (2011) evaluated the competitiveness of Uganda’s exports relative to the East African Community (EAC) member nations. The authors used various indices to measure Uganda’s revealed comparative advantage (RCA) on all products at Harmonized System (HS)-4-digit product levels. The findings revealed that Uganda had an increasing RCA, hence export competitiveness, in leguminous vegetables, shelled or unshelled, fresh or chilled; frozen vegetables; pineapples, mangoes, avocadoes, guavas over Kenya; in manihoc, arrowroot salem (yams) over Burundi and Rwanda; and in dried vegetables over all East African states (Burundi, Kenya, Rwanda and Tanzania).

In order to ascertain the competitiveness of Morocco's fruit and vegetable sector exports to the European Union over its trading partners, Pappalardo *et al* (2012) used the revealed comparative advantage (RCA) approach for a period of 11 years (2000–2010). Empirical findings showed that Morocco was competitive in the fruits and vegetable sector over its major EU trade competitors. The most significant types of goods for which Morocco held a global advantage over the EU included tomatoes, pulses; preserved vegetables; other vegetables; melons, watermelons and papayas; and citrus.

Laibuni *et al.* (2012) used the International product specialization index to evaluate the export competitiveness of Kenyan cut-flowers and fruits and vegetables in the EU-25 market. The study used SITC-rev.3 disaggregated data and the empirical results indicated that Kenya’s exports of flowers, fruits and vegetables were very competitive in the EU-25 market. Boansi (2013) used Balassa's index and its derivative, the Revealed Symmetric Comparative Advantage index, to assess the competitiveness of Ghana's cocoa exports during the 1960s, 1980s and 2000s. Study results showed that Ghana was more competitive in exporting cocoa beans than cocoa processed products, especially during the 1960s. Esterhuizen (2006) assessed the competitiveness of South Africa's agribusiness sector while using Balassa's methodology. The results divulged that the agribusiness sector was marginally competitive, relative to its competitors.

## 2.5 Climate change - Agriculture - International trade nexus

Climate scientists seem to have reached a consensus that the Earth's climate will change at a unique rate over the 21st century, especially in the form of global warming, with an estimated temperature increase of 5.8 °C by 2050 (IPPC, 2007). The IPPC (2007) shows that the global average temperature has increased by approximately 0.76 °C on average over the last 100–150 years. It is postulated here that African countries which are largely reliant on agriculture seem to be vulnerable to this phenomenon (Hope, 2009; Muller *et al.,* 2011). With reference to Sub-Saharan Africa, Traore *et al.* (2013) note that a temperature rise of about 3.3 °C is anticipated within this region by the end of the 21st Century. However, it remains unclear whether rainfall will increase or decrease within Sub-Saharan Africa. The various simulation models used by the IPPC so far provide divergent results, depending on the scenario under consideration (Cooper *et al.*, 2008; Berg *et al.*, 2013; Traore, *et al.*, 2013).

According to Derksen and Jegou (2013), the nexus between climate change, agriculture and trade consists of four categories: (*i*) when climate change physically distorts trade volumes and trade patterns; (*ii*) through the effects of climate change policies on trade; (*iii*) through the interactions of trade policies as a means of addressing climate change; and (*iv*) through the effects of trade on climate change, especially via aircraft emissions. For the agricultural sector, for instance, climate change fluctuations negatively alter the productive capacity of firms during the production phase (Berg *et al*., 2013; Roudier *et al*., 2011).

Productivity is hampered through a number of aspects and this culminates in limited availability of agricultural produce, hence hampering trade both at local and international level in general. In this regard, the country's or region's export competitiveness and trade patterns also change. Moreover, in cases of extreme weather catastrophes, like floods, infrastructure necessary for trade is also adversely affected. Thus, in a bid for countries to adjust and adapt to the alterations imposed by climate change, trade volumes and trade patterns are also affected.

On the other hand, linkages between agriculture, climate change and trade can be explained through policies that aim to mitigate the climate change phenomenon. For instance, Derksen and Jegou (2013) mention that these policies can have both social and economic negative impacts on trade, if not adequately designed and implemented. Such policies include carbon taxes, national promotion of low-carbon technologies and clean energy, emissions trading schemes, border carbon adjustments, standards and labelling schemes, the allocation of emissions allowances free of charge, technical requirements, and the regulation of bunker fuels.

With reference to the interaction of trade policies as a means of addressing climate change, trade policies can act as drivers in containing the global problem of climate change. This school of thought argues that this could be achieved through promotion of adaptation and mitigation mechanisms. For instance, Derksen and Jegou (2013) remark that the removal of trade barriers, especially on climate-smart goods, would inevitably promote climate change adaptation and countries would be in position to curb Green House Gas (GHG) emissions. Finally, through direct and indirect means, trade has been known to influence climate change, especially through transport-related emissions. Transport is noted to be one of the major components of trade, through which a significant level of GHGs are directly emitted (Derksen and Jegou, 2013).

In agriculture both temperature and precipitation are key climate factors in influencing crop productivity (Lobell and Field, 2007; Hansen, 2002; Alexandrov and Hoogenboom, 2001), hence trade flows. For example, climate change may disrupt trade flows through a sudden disaster, like floods, which may destroy crops and other facilities or through some gradual changes to an ecosystem which also incapacitate production. According to Brockett *et al.* (2005), the significance of temperature alone as a climatic factor across all sectors accounts for over 90 per cent in influencing productivity, followed by rainfall, among others.

According to Drine (2011), climate change is responsible for low agricultural productivity, given the fact that uncertainty inhibits innovation and imitation. In addition, it is argued that uncertainty about agricultural production is bound to increase as severe climate events, such as droughts and floods, are anticipated to recur more frequently and to cause more catastrophes. Therefore, given the pervasive risky environmental effects on farming practices and farm performance, the increasing uncertainty may perhaps dishearten farmers from adopting new production technology, thus affecting productivity.

Marchiori *et al*. (2010), World Bank (2010), IPCC (2007), and Deschenes and Greenstone (2007) argue that climate change has fewer detrimental effects on the manufacturing industry than on the agricultural sector, which is vulnerable to this phenomenon. The adverse effects are also more likely to be present among the poor economies which are reliant on agrarian activities.

The direct effects of climate change may be exhibited in form of rural-urban migration (Marchiori *et al*., 2010), which culminates in the reallocation of scarce labour from the agricultural sector in rural areas to the non-agricultural sectors in urban areas. Although the populace may have a genuine cause to change from one sector to another, Collier *et al.*(2008) and Barrios *et al.* (2006) argue that this reallocation of labour is simply a mechanism of adapting to climate change. As a result, this is likely to transform into reduced production on farms, thereby causing deficits in agricultural produce, thus causing a dent in trade flows.

Given that many Sub-Sahara African (SSA) countries rely mainly on small-scale, subsistence, rain-fed agriculture (i.e. farmers produce mainly for home consumption and only sell in instances of surpluses), reduced farm production due to rural-urban migration will inevitably curtail trade in agricultural commodities. The effect of rural-urban migration, thus the reallocation of scarce labour, is actually greater in communities characterized by non-functioning rural markets, like Uganda.

In instances where rural markets are functional, households affected by rural-urban migration would probably be in position to hire labour to substitute for what would have been provided by out-migrants on the farm. Alternatively, such households would also borrow money for agro-inputs to boost production. However, labour and credit markets are not functional, which affects farm production (Barrios *et al.*, 2006), and hence trade flows also decline. Ogang (2013) argues that accessing loans to finance agriculture related activities is very low in Uganda, accounting for only 7 per cent of the total private sector credit.

According to Barrios *et al.* (2006), unpredictable rainfall has an extensive assortment of commercial repercussions in developing economies, given that it is the main source of water. For instance, water shortages are associated with detrimental effects such as hunger, and in extreme cases, death. In Africa *per se*, variability in rainfall is important because of its significance in the agricultural sector. In most of SSA, agriculture depends on rainfall to provide crops with water, as only a small proportion of arable land is irrigated.

The productivity of various crops has been shown to reduce owing to variability in temperature and precipitation (FAO, 2001; Kumar *et al.*, 2004; Parry *et al*., 2004; Schlenker and Lobell, 2010; Tao *et al*., 2003; 2008; Sivakumar *et al*., 2005; Xiong *et al*., 2007). In

Uganda for example, annual crops like maize and beans are more susceptible to climate change than perennial crops, such as tea, coffee and bananas. Maize is generally most sensitive to drought, while beans tend to be most sensitive to excessive rainfall (UNDP and BCPR, 2013). The higher vulnerability of annual crops is attributable to the fact that intense events can wipe out the annual crop, leaving farmers with no harvest, while perennial crops might often survive, but with lower yields or reduced quality. Thus, these drastic changes in climatic conditions can impact on the length of a crop's growing period, and therefore yields, among other aspects.

Temperature as a climatic factor also presents a number of effects on trade through various avenues. According to Dell *et al.* (2008), temperature can also affect agriculture through its effects on investments or institutions that influence productivity growth. These in the long run affect a country's economic activities, where trade is inclusive. For instance, higher temperatures are known to lead to conflict and political insecurity in poor countries (Dell *et al.*, 2008; Field, 1992; Jacob *et al*., 2007; Miguel *et al*. 2004; Boyanowsky, 1999) and during such periods of unrest, there is limited agricultural production.

Dello *et al.*, (2008) goes further to show that a 1 °C increase in temperature in developing economies leads to approximately 2.37 per cent loss in the growth of agricultural output. This decline then affects the total GDP, which is a key determinant for trade according to the gravity model theory. Furthermore, it is affirmed that for every increase in 100 mm of annual precipitation, there is an accompanying 0.24 per cent increase in agricultural output growth in developing countries, and a 0.14 per cent rise in agricultural output in developed countries.

### 2.5.1 A review selected empirical effects of temperature and precipitation as determinants of agricultural productivity

McCandless *et al*. (2012) used an ecophysiological crop model called the Decision Support System for Agrotechnology Transfer (DSSAT) to study the impacts of temperature and precipitation on the yield of maize and bean crops in the Rakai and Kapchorwa districts of Uganda. Their empirical results project that bean production in Kapchorwa district will decline by approximately 6 per cent, while maize production may experience an 8 to 10 per cent decrease by 2050. With regard to Uganda's major cash crop (coffee), Simonett (1989) shows that a 2 °C increase in temperature would lead to a significant fall in the production of Robusta coffee in the country.

Berg *et al.* (2013) employed the agro-Dynamical Global Vegetation Model (DGVM) and two SRES scenarios to simulate the impact of climate change on the productivity of C4 crops over Africa and India from 1960 to 2100. In general, the empirical findings divulge that a discernible yield decrease, ranging from -10 to -20 % is anticipated by the end of the century. Moreover, the authors also mention that long-term impacts are more than twice those of the short-term basis.

Traore, *et al.* (2013) analysed the effect of temperature and rainfall on the productivity of a number of crops in Southern Mali using a dataset spanning from 1965 to 2005. Their findings show that there was a declining trend in cotton yields, attributable to the unreliable precipitation pattern. For instance, a 24 kg/ha yield loss of cotton was registered for every 0.08 °C increase of the maximum temperature during the rainy season.

### 2.5.2 A review of empirical studies relating to climate change effects on international trade

For over a decade, the climate change phenomenon has attracted increasing attention at various levels and a number of reports quantifying the economic effects of climate change in Africa have been produced, for example by the World Bank and the Centre for Environmental Economics and Policy in Africa (CEEPA). In the international trade domain *per se*, scholars like Folfas *et al*. (2011), Aichele and Felbermayrz (2010), Kim and Koo (2010), Kee *et al.* (2010), and McKibbin *et al. (*1998) have used one or a combination of Green House Gas (GHG) emissions, environmental permits, environmental regulations and permits, emission trading certificates and tradable renewable energy certificates to quantify the effects of climate change on international trade. Therefore, the literature presented in this sub-section is grouped according to the quantification measure, or combinations thereof, used.

#### 2.5.2.1 Literature based on policies that regulate Greenhouse Gas (GHG) emissions

According to the United Nations Framework Convention on Climate Change (UNFCC) (2009), regulation of GHG emissions is based on two policies*, viz,* the carbon tax and the cap-and-trade scheme. These policies were agreed upon under the first international agreement on GHG emissions, the Kyoto Protocol, which took effect in February 2005. However, owing to the limited access to comprehensive and comparable information about countries' specific climate policies and how they relate to the ratification of the Kyoto

Protocol (Aichele and Felbermayrz, 2010), some studies simply use a binary variable of 1 if both members of a country pair commit to the agreement.

For instance, Kim and Koo (2010) evaluated the impact of regulating greenhouse gas emissions on livestock trade flows among member countries of the Organisation for Economic Co-operation and Development (OECD). They used dummy variables if a given country had enacted any GHG emission regulating policy. Their findings indicate that regulating greenhouse gas emissions has a deterring effect on the flow of livestock from all countries (regulating and non-regulating) into regulating countries.

Kee *et al. (*2010) investigated the effects of a carbon tax and energy efficiency standards on competitiveness in trade of a number of industries among OECD countries. Their findings show that a carbon tax, imposed by either importing or exporting countries, boosted trade competitiveness in energy-intensive industries, while energy efficiency standards deter trade competitiveness, irrespective of which country imposes them.

According to Ma and Keating (2011), the Australian Chamber of Commerce and Industry (ACCI) argues that imposing a carbon tax would potentially curtail the Australian economy. ACCI reckons that “The fact is that carbon tax will have a negative impact on all trade-exposed industries which actually can't pass on the costs associated with a carbon price, because they're competing internationally either through import or through exporting competitions.”

The International Centre for Trade and Sustainable Development (ICTSD) (2007) notes that:

> … the effects of some of the climate policies such as measures addressing energy efficiency have resulted in several challenges for developing country exporters in terms of being able to comply swiftly with changing and increasingly stringent market access requirements. In the absence of a clear regulatory forum for addressing these emerging tensions –as they relate both to the trade and climate policy arenas –there is a fear that countries may increasingly recourse to unilateral approaches through measures such as antidumping and border measures in order to solve perceived competitiveness concerns.

#### 2.5.2.2 Studies based on environmental permits and embodied carbon content or carbon dioxide equivalent in traded products

Aichele and Felbermayrz (2010) assessed the influence of Kyoto policies on the bilateral imports into countries that have ratified to the Kyoto Protocol. To quantify the GHG emissions, they used the total carbon content embodied in imported goods. Their results indicate that the policies had had non-negligible effects on the quantity of bilateral import flows. Folfas *et al*. (2011) also assessed the impact of GHG emissions on trade flows from steel and cement industries among developed economies. The findings show that countries with low GHG emissions had intense export trade in steel products with economies characterized by a high level of GHG emissions.

McKibbin *et al*. (1998) estimated the potential effects of the Kyoto Protocol policies (particularly international permit trading) on international trade under different scenarios. Their study used the G-cubed multi-region, multi-sector, inter-temporal general equilibrium model of the world economy. Their findings reveal varying results, depending on the scenario under consideration. For example, under the assumption that no other region other than the USA meets its commitment under the Kyoto Protocol, exports of durable goods would be negatively affected through the appreciation of the exchange rate. Similarly, under the assumption that all countries within a given region impose the policy, durable export flows from developing countries would decline as they become very expensive to produce, unlike for developed economies. Overall, the results reveal that the USA, and to a lesser extent Australia, would experience a decline in their exports of durable goods as a result of the policy.

#### 2.5.2.3 Literature based on meteorological data (temperature and precipitation)

Notably, only one study that used meteorological data has been found. Jones and Olken (2010) examined the effects of temperature and precipitation on the annual growth rate of exports between developing and developed economies. Their results reveal that, unlike in developed economies, an increase in temperature negatively affects developing countries' export flows, while precipitation fluctuations showed no significant deterrent effects in export growth. A unit rise in temperature would cause a drop in a developing country's export growth ranging between 2.0 and 5.7 percentage points.

## 2.6 The European Union's Generalized System of Preferences (EU-GSP) scheme

The GSP is an autonomous non-reciprocal trade arrangement through which the European Union (EU) provides non-reciprocal preferential access to 176 developing countries and territories into the EU market. The EU-GSP scheme was adopted following the second United Nations Conference on Trade and Development (UNCTAD) held in 1968, during which the idea of establishing a generalized, non-reciprocal, non-discriminatory system of preferences in favour of the developing countries was presented (UNCTAD, 1968). The initiative aimed at increasing export earnings, promoting industrialization and accelerating the rates of economic growth among these countries.

The EU-GSP scheme was first introduced in 1971 and since then, it has evolved from time to time, with the European Commission (EC) making changes in product coverage, tariff treatment and differentiation among beneficiary countries. For instance, the EC has been reducing its Most Favoured Nation (MFN) tariffs, thereby narrowing the preference margin under the GSP Scheme. Between 1981 and1991, the GSP was reviewed annually and this involved changes in product coverage, quotas, ceilings and their administration, beneficiaries and depth of tariff cuts for agricultural products. Particularly, the 1981–91 scheme was extended until early 1995 when another 10 year GSP Scheme was initiated (UNCTAD, 2001).

According to UNCTAD (2008) and European Communities (EC) (2001), the third phase of GSP came into effect from 1 January 2002 until 31 December 2005. Changes that took centre stage in the 3$^{rd}$ phase include, among others, the introduction of special incentive arrangements for the protection of labour rights, special incentive arrangements for the protection of the environment, special arrangements to combat drug production and trafficking, and special arrangements for LDCs: the "Everything but Arms" initiative for the Least Developed Countries (LDCs). On 27 June 2005, the subsequent EU-GSP scheme was adopted and was enacted on 1 January 2006, to endure until 31 December 2008.

The number of arrangements under this phase was reduced from five to only three, *viz*, the general arrangements, special incentive arrangements for sustainable development and good governance ("GSP Plus"), and the Everything but Arms initiative for LDCs (EU, 2005). As put by the EU (2008), the structure of this GSP scheme was meant to be extended to cover the 2009–2011 period. The EU-GSP scheme has three key features, namely: tariff modulation, country/sector graduation, and special incentive arrangements, among other control structures, such as temporary withdrawal of scheme benefits and rules of origin. For the purpose of this study, tariff modulation is accorded more attention.

Originally, the 1971 GSP Scheme accorded different tariff treatments to agricultural and non-agricultural products. Agricultural commodities enjoyed selective preferential treatment until 1995 when all commodities modulated according to product sensitivity. At this time, four product categories were established, *viz,* Very sensitive products were subjected to a preferential tariff 85 % of the MFN rate; Sensitive products were accorded 70 %; while for Semi-sensitive products, a 35 % preferential tariff was granted. Non-sensitive products were subjected to duty-free entry into the EU market. However, by adopting EC (2001), the foundation of the 2001 EU-GSP Scheme, preferential tariffs were then restructured basing on two product groups, *viz,* sensitive and non-sensitive products. Thus, all non-sensitive products were to enjoy duty-free entry into the EU market, except where the MFN tariff had an agricultural component.

On other hand, with the exception of textile products, all sensitive products with ad valorem duty were granted a reduction of 3.5 percentage points. Generally, sensitive products with specific duties were subjected to a 30 per cent reduction, while for sensitive products with mixed tariffs, the specific duty component was not reduced (UNCTAD, 2001). Interestingly, the 2009–2011 GSP Scheme retained the basic features of the 2001 scheme with regard to tariff treatment, though it was adjusted by differentiating the beneficiaries into three categories. That is, the general GSP beneficiaries; the 'GSP Plus' scheme specifically for vulnerable countries with special development needs; and the Everything But Arms (EBA) initiative. Commodities from the 'GSP Plus' scheme beneficiaries enter the EU market duty-free, while beneficiaries of the EBA initiative are granted duty-free access to the EU market without any restrictions.

### 2.6.1 The theoretical framework of preferential treatment effects on international trade

In basic terms, the analytical framework of preferential tariffs is presented as a partial equilibrium model of three country groupings and one traded good. Following the work of Low *et al.* (2005), this theoretical framework is based on two general assumptions, (*i*) That the preference-receiving country group is not the most competitively advantaged producer of the traded commodity for which preferential treatment is granted, and (*ii*) that the initial Most

Favoured Nation (MFN) tariff rate is not prohibitive. Let us consider a bloc of developed economies (European Union (EU)) granting a preference on a given set of imported agricultural commodities (e.g. Citrus), a set of developing countries benefiting from this preferential treatment (e.g. Kenya, Uganda and Tanzania (KUT)), and the rest of the world (RoW) which encounters the Most Favoured Nation (MFN) tariff rate. Initially, let us suppose that irrespective of any changes in the demand for citrus imports in the EU, the RoW supplies citrus at a fixed price, while KUT supply more citrus at even higher prices.

Assuming that the RoW has a competitive advantage in producing citrus while the EU has a competitive disadvantage, in the absence of preferential treatment the EU would obtain citrus imports from both KUT and RoW at a fixed price. However, the introduction of preferential treatment alters the relative prices in favour of citrus produced in KUT. This will inevitably cause the import demand for citrus in the EU to shift from RoW to KUT. In this scenario, the EU incurs a loss in tariff revenue from citrus; the RoW faces a loss in the volume of citrus exports; and KUT benefits from the losses incurred by the other two country groups. The change in sourcing of citrus imports into the EU from RoW, which has a competitive advantage in producing citrus to KUT, leads to a negative allocative efficiency effect (Low *et al.,* 2005).

Particularly, exporters in KUT will earn a better price, higher by the margin of preference between the MFN and the preferential tariff rate, which results in an increase in the supply of exports from the KUT region. It is, however, argued that the extent to which exports increase depends more on KUT's export supply elasticity, *viz,* the export supply response in relation to the price change. Hence, the higher the elasticity, the greater the trade effects, which results in larger gains for KUT. For the non-benefiting country group (RoW), preferential treatment of citrus imports from KUT makes RoW imports into the EU more costly. This inevitably causes a decline in the demand and production of citrus in RoW.

All in all, preferential treatment results in a shift from competitively advantaged producers of a given tradable commodity and the government in the preferential treatment granting country/region to producers in the preferential treatment receiving country/region. Markedly, preferential treatment may also alter trade from non-beneficiary countries/regions, thus lessening their welfare. In instances where the above assumptions do not hold, preferential treatment non-receiving countries may not necessarily lose out because of the preferences.

### 2.6.2 Measures of preferential treatment value: The Preference Margin (PM)

The value of preferential treatment can broadly be categorized into two measures, that is, the traditional preferential treatment value measures and the adjusted preference value measures. Generally, traditional measures estimate the value of the preferential treatment accruing to the beneficiary country in terms of the Preference Margin (PM). The term Preference Margin (PM) refers to the difference in percentage points between the Most Favoured Nation (MFN) rate and the preferential tariff rate (Cipollina *et al.*, 2013; Low *et al.*, 2005) and it is computed at tariff line level.

According to Cipollina *et al. (*2013) and Low *et al*. (2005), this approach is limited by the fact that it does not address the concern of whether the treatment boosts the benefiting countries' exports; and in the event that the preferential tariff excludes Ad Valorem Equivalents (AVEs), the actual value of preferential treatment may be under- or over-estimated. The erroneous estimation of the PM may also be attributed to the fact that the value of preferential treatment to a given country or region practically depends on other competing countries within the same market. Nicita (2011) argues that it is a less accurate measure, given that it does not account for the composition of exports.

The trade-weighted PM is another traditional measure of preferential treatment. It is defined as the product of the margin of preference per unit of imports and the bilateral value of imports (Low *et al.,* 2005). This measure takes into account bilateral trade flows between any two trading partners. The major drawbacks of this measure are: (*i*) it is assumed that all countries supplying the same market are subjected to the same MFN rate, yet the rates vary depending on the trade agreement under consideration and given the fact that these agreements often overlap across countries. Also, given that a given country's PM depends on other competing countries in the same market, this would be an inappropriate approach of computing the value of preferential treatment. (*ii*) The assumption is utilized that preferential treatment exists for all exports. In reality, it is noted that utilization rates vary greatly across countries and sectors (Low *et al.,* 2005).

Adjusted preferential treatment value measures include the competition-adjusted preference margin and the utilization-adjusted preference margin (Low *et al*., 2005), as well as others based on domestic competition within a given market (Carrère and de Melo, 2010; Carrère, 2011). The competition adjusted preference margin is defined as the weighted average tariff rate applied to the rest of the world minus the preferential rate applied to the preferential treatment receiving country. It takes into account competition from other countries exporting into the same market while considering the overlapping nature of other unilateral and bilateral agreements. On the other hand, the utilization-adjusted preference margin takes into account that the granted preferential treatment may not be fully utilized by the benefiting country. Thus, the value of the measure of preferential treatment is weighted by the volume of trade that actually benefits from the preferential treatment.

According to Low *et al. (*2005), the values of the adjusted preferential treatment measures may not duly reflect the actual margins. given that "Actual gains from preferences enjoyed by exporters may be lessened if monopolistic distributors are operating in the importing market, or if third parties not receiving preferences strategically cut their prices." Furthermore, it is noted that while adjusting preferential treatment value measures, particularly the utilization-adjusted preference margin, to take into consideration other preferential treatments, one could mistakenly assume that the other preferential treatments are maximally harnessed, yet in reality they are not. According to Carrère (2011), the major limitation of these adjusted measures of the preferential treatment value is their lack of microeconomic foundations.

Other adjusted measures include: the Import Competition-Adjusted (ICA) Preferential Margin (ICA-PM) (Carrère and de Melo, 2010); the Domestic and Import Competition Adjusted (DICA) Preferential Margin (Carrère, 2011); the Relative Preferential Margin (RPM); and the Potential Preferential Margin (PPM) proposed by Nicita (2011). The ICA-PM measure is adjusted for competition among exporters but it does not consider trade flows among EU member countries, while the DICA measure was derived under the imperfect competition framework to take into consideration competition across competitors and within the EU.

On the other hand, the RPM quantifies the comparative value of preferential treatment on a country's observed exports and shows the advantage offered to particular imports from a certain country in comparison to those exports from other competing countries. With regard to the PPM approach, this predicts the potential or anticipated value of a given preferential treatment, depending on the future market tradable commodities (Nicita, 2011). The main limitation of the RPM measure is that it focuses on a given country's exports and it does not spell out the particular instruments through which the preferential treatment benefiting country could gain advantage. On the contrary, the PPM measure is limited by the fact that it is based only on tariffs (Nicita, 2011) and does not consider other policy instruments that could be embedded within the preferential trade agreement.

### 2.6.3 The effect of the EU-GSP scheme on agricultural exports

This sub-section presents the existing literature that evaluates the effect of the EU-GSP Scheme in enhancing imports from developing countries into the European market. From the scholarly point of view, this topic has received considerable attention. Some studies discussed below have focused on the textiles and the manufacturing industry, and others on the agriculture sector. Both econometric and non-econometric methods have been used on various datasets, *viz*, either cross-sectional, time series or panel data.

The literature presented in the following sub-section is limited to studies that focus on agricultural commodities. Secondly, only those studies that capture the effect of the EU-GSP scheme as a continuous variable within the gravitational framework are considered. The literature is grouped by the type of measures used to quantify the value of preferential treatment.

#### 2.6.3.1 Empirical studies based on the traditional measures of Preferential Margin (PM)

Cardamone (2010) employed a gravity flow model to assess the effect of preferential trade agreements on monthly exports of fresh fruits to the European Union (EU) during 2001–2004. The study employed preferential margins (expressed in absolute terms as the difference between the applied MFN duty minus the preferential tariffs) to capture the effect of the GSP scheme on fruit and vegetable exports to the EU. From the findings, it is evident that the Generalized System of Preferences (GSP) only benefits exports of fresh grapes to the EU.

During the evaluation of the performance of oranges, mandarins, apples and fresh grapes using highly disaggregated monthly data, Cardamone (2009) calculated the preferential margin used to capture the effect of preferential treatment as the difference between the highest tariff applied by the EU and the duty paid by an exporter for a given product. The results show that the impact of unilateral trade preferences varies depending on the commodity under consideration. In that regard, the author notes that the GSP scheme effectively increases exports of apples and mandarins to the EU market.

Aiello and Demaria (2009) used the preference margin to evaluate the impact of the EU-GSP Scheme in enhancing twelve agricultural exports from 169 developing countries to EU markets over a period of four years (2001–2004). The preference margin was captured in relative terms, as the ratio between the preference margin and the Most-Favoured Nation (MFN) tariff. Noticeably, the margin of preference was denoted as the difference between the MFN tariff and the preferential tariff. Their empirical findings reveal that the EU-GSP scheme positively impacts on fruit and vegetable exports from developing countries to the EU market.

#### 2.6.3.2 Literature based on adjusted measures of Preference Margin (PM)

Among other policies, Cipollina *et al. (*2013) investigated the impact of the EU-GSP scheme on disaggregated trade flows from developing counties into the EU market. They used relative preference margins, obtained as the ratio of the reference tariff to the applied tariff rate subjected to each exporter by the EU. The reference tariff was estimated as duties paid by all exporting countries. The findings suggest that the EU-GSP scheme plays a role in boosting the volume of import trade into the EU.

Raimondi *et al.* (2011) evaluated the effects of the Everything But Arms (EBA) initiative on rice imports from developing countries. The researchers computed the preference margin as the percentage difference between the tariff encountered by an MFN exporter and the Tariff Rate Quota Equivalent faced by the beneficiary country when it exports to the EU. They find that preferential treatment had a significantly positive impact on rice imports into the EU from some developing countries.

Cirera *et al,* (2011) evaluated the impact of the non-reciprocal GSP/EBA scheme on developing country exports. The researchers used a number of competition-adjusted measures of the value of preferential treatment. Their findings generally indicate that preferential treatment has had a relatively small but positive impact in promoting trade flows from developing economies.

Philippidis *et al. (*2011) evaluated the impact of EU preferences on European Union imports based on 20 agro-food sectors during 2 specific years (2001 and 2004). The EU preference variable was measured as a factor of the import tariff rate applied by the importer in terms of ad valorem equivalents. The results show that increasing import tariff rates deters exports of fruits and vegetables from developing countries into the European market.

Under the gravity model framework, Cipollina and Salvatici (2010) assessed the impact of European Union (EU) trade policies on agricultural trade flows from developing countries. They used an explicit measure for relative preference margins, defined as the ratio of the maximum applied duty to the applied duty to capture the preferential treatment effects. Their results reveal that the largest coefficients of the impact of PTAs on trade are registered by tropical products, most especially the fruits and vegetable sectors.

Cipollina and Salvatici (2008b) examined the impact of the EU-GSP Scheme on disaggregated agricultural trade flows from 161 developing economies. They used the relative preference margin measure to proxy for the EU-GSP scheme. Specifically, the relative preference margin was measured as the proportion of the maximum applied duty factor subjected by the importer in the EU on a given commodity to the actual duty factor faced by a specific exporting country. The results reveal that preferential trade schemes have a significant positive impact on agricultural trade flows, with over nine (9) per cent influence on the fruit and vegetable sector.

Emlinger *et al. (*2008) computed the weighted value of preferential margins as a measure of the level of gains linked to these granted preferences with the aim of evaluating the advantages accruing to Mediterranean countries resulting from the EU preferential treatment. The authors considered actual tariffs applied by the EU to its trading partners. This indicator compares the amount of custom duties paid by countries supplying the EU with the amount of customs duties these countries would have paid if they did not benefit from tariff preferences. Emlinger *et al. (*2008) found that Lebanon and Turkey do not benefit from large preferential margins for access to the European market, despite the fact that they enjoy tariff concessions for most products. On the other hand, Egypt, Morocco and Jordan enjoy large preferential margins from the European Union, given that their exportable products have high MFN duties on which the EU grants significant tariff reductions. This improves their already highly favourable access to the European market.

## 2.7 Predicting trade potential and performance

### 2.7.1 Trade potential and trade performance measures

The term ‘trade potential’ refers to the maximum possible trade that can be achieved (Armstrong, 2007). It is used to predict the hypothetical level of trade under assumption of frictionless and free trade under given conditions at a certain time. Within the gravitational framework, there are two measures for predicting potential trade flows (Gul and Yasin, 2011; Karagoz and Saray, 2010; Helmers and Pasteels, 2003; Egger, 2000; Nilsson, 2000, Baldwin, 1994). These are:

(*i*) **The within-sample predictions measure**, also known as the “*Out-of-sample*”. This measure is based on coefficient estimates obtained from the gravity model. Under the gravity model framework, the measure is executed in two steps, first by estimating the determinants of trade flows, and secondly, the estimated coefficients of the determinants are used in the simulations so as to predict the trade volume between any given pair of trading partners.

Thereafter, the predicted trade volumes are compared with the actual trade flows so as to deduce trade performance. A country’s trade performance can be inferred using either absolute or relative indicators. The absolute indicator is defined as the absolute difference between the predicted potential and actual trade flows. Strikingly, positive values suggest there exists untapped trade that could be harnessed (trade expansion), while negative values imply that actual trade flows exceed the predicted trade potential. On the other hand, the relative indicator is defined as the ratio of predicted trade potential to the actual trade flows. Relative values of greater than one imply that a country under consideration has a good trade performance with the partners, while the opposite is also true (Gul and Yasin, 2011).

(*ii*) **The relative residual measure**. This also known as the “*In-Sample approach*” (Egger, 2000) and it uses residual values of the estimated gravity model and ranges between −100 and +100. Thus, an approximate value close to zero denotes that the predicted trade potential is almost equal to the observed/actual trade flows, while a value greater than 30 % implies that there exists unreleased trade potential. That is, there exists more room to conduct trade, given that the prevailing conditions are unchanged. On the contrary, if the relative residual value lies below −30 %, it means that the actual trade flows by far exceed the predicted trade flows. Worthwhile to note, Egger (2000) argues that the in-sample approach leads to misleading results, since no systematic variations in residuals can be obtained, even in an econometrically well-specified model. This challenge presents a major drawback of this approach.

### 2.7.2 Review of empirical studies that predict trade potential and performance

A plausible volume of studies aiming to predict trade potential and performance have been carried out in different regions of the globe. However, much of the literature focuses on aggregated trade flows and few studies focus on particular commodities, particularly in East Africa. Taking this into consideration, therefore, literature presented in this sub-section is categorized based on the measure used to predict trade potential and performance, irrespective of the geographical region and the level of data disaggregation.

#### 2.7.2.1 Literature based on the "In-sample" approach

As a preamble, it is worth mentioning that only one study using the *in-sample* approach has been found in the existing literature. Egger (2000) simulated the trade potential between countries of the Organization for Economic Co-operation and Development (OECD) and the Central and Eastern European countries (CEEC) for the 1986–97 period. The study aimed at comparing the influence of various estimators in predicting trade potentials while using the in-sample methodology. Unfortunately, the author was indeterminate in providing the information about the trade potential, but concluded by emphasizing that, "The in-sample approach to the prediction of trade potentials is inappropriate."

#### 2.7.2.2 Literature based on the "Out-sample" approach

Batra (2006) used the augmented gravity model to estimate India's trade potential in a two-step (*out-of-sample*) approach. In the first step, determinants of India's trade flows with the rest of the world were ascertained. In the second step, the estimated coefficients were then used to predict India's trade potential as a proportion of predicted trade to actual trade. Empirical results divulged that India had the highest trade potential with countries like China, the United Kingdom, Italy, France, Pakistan, the Philippines and Cambodia.

Rojid (2006) used panel data over 21 years to estimate unilateral trade flows from 147 exporting countries with the aim of estimating trade potentials of COMESA member countries within the COMESA region. The estimated coefficients were then employed to simulate the trade potentials. Empirical results revealed that there was limited trade potential within the region, owing to the fact that most COMESA member states were actually trading more than they ought to have been. However, the author opines that Angola and Uganda still had room to expand their trade horizon within the region.

Rahman (2009) investigated Australia's trade potential by employing the augmented gravity models and cross-sectional data from 50 countries for 2001 and 2005. He used the estimated coefficients from the model to predict Australia's trade potential. The results showed that Australia had remarkable trade potential with Austria, Argentina, Singapore, the Russian Federation, New Zealand, Turkey, Portugal, Greece, Chile, the Philippines, Norway, Israel, Brazil and Bangladesh.

While using the gravity model approach, Karagoz and Saray (2010) employed a sample of 23 APEC countries, with the exception of Laos, Cambodia and Myanmar, to estimate Turkey's trade potential over a period of five years. The scholars used the *out-of-sample methodology* to determine Turkey's trade potential. Firstly, the determinants of Turkey's trade flows were analysed. The obtained coefficients were then used to predict trade potential by means of the absolute indicator. According to the findings, Turkey had a high potential of expanding its trade with Papua New Guinea, Peru, Myanmar, Mexico, Laos, and Brunei.

Gul and Yasin (2011) estimated Pakistan's trade potential under the gravity model framework using panel data for 15 years across 42 countries. They also used the *out-of-sample methodology,* by first estimating the determinants of Pakistan's trade flows and then using the obtained coefficients to predict global trade potential by using the relative indicator. At regional level Pakistan had very high trade potential with the Asia-Pacific region, the European Union (EU), the Middle East, Latin America, and North America. At country level, Japan, Sri Lanka, Bangladesh, Malaysia, the Philippines, New Zealand, Norway, Sweden, Italy, and Denmark registered the highest trade potential.

## 2.8 Conclusion

There are various trade related measures used to quantify a country's export competitiveness. There is no commonly agreed upon scientific approach regarding the most efficient measure of export competitiveness, or reliable indicators that are able to reflect the country's export competitiveness. However, Balassa's index is a commonly used measure of a country's export competitiveness. From the perspective of the East African states, little work has been done to assess the export competitiveness of their fruits and vegetables. The few studies either focused on a single country within the region, or did not use highly disaggregated data, resulting in generalized policy recommendations.

The major drawback of such recommendations is that they may not be fruitful in explaining commodity specific trade flows, yet effective trade-related policies should be based on specific commodities rather than on a generalized basket of goods. Therefore, there exists a knowledge gap about the export competitiveness of highly disaggregated commodities under the fruit and vegetables sector among East African states. The current study intends to use Balassa's index (RCA) and highly disaggregated data at HS-6 digit level to assess export competitiveness of horticultural commodities from East African states.

In international trade, climate change influences trade flows through various mechanisms, such as through the imposition of climate change policies, like carbon tax and environmental permits, among others. Climate change as a factor affecting international trade flows has received very limited attention from scholars. Most of the existing literature on trade uses Kyoto Protocol policies, like the carbon tax and tradable permits, to proxy for climate change, especially while assessing the trade flows of manufactured goods, such as cement, steel and iron. This may lead to misleading generalized recommendations that are of less relevance to developing economies reliant on agriculture, especially those south of the Sahara.

The use of Kyoto Protocol policies as climate change proxies is not appropriate for agricultural-based economies, given that the composition of exports from these economies is skewed towards agricultural products, and that Green House Gas (GHG) emissions are very difficult to quantify in the agriculture sector. One study used meteorological data to assess climate change impacts on international trade, but the study was based on aggregated data. This implies that general results and recommendations were obtained. However, different agricultural commodities have specific optimum temperature and precipitation ranges within which minimal damage is caused. Therefore, the generalized results and recommendations could also be misleading. Moreover, average meteorological values were used. The major drawback of using average values is based on the fact that the values do not account for the likelihood of the higher variance in the data for the more arid countries and such data is susceptible to potential scale effects.

Therefore, climate change proxies based on Kyoto Protocol policies are not appropriate for agricultural-based economies when assessing the impact of climate change on trade. In addition, to fill this knowledge gap, the current study intends to develop meteorological indices, that is, temperature and precipitation anomalies to be used as proxies for climate change. The indices will be used within the gravity flow model framework, based on disaggregated horticultural data, to assess the influence of climate change on international trade flows. Temperature and precipitation are key factors that directly influence the agriculture sector, while the use of anomalies enables one to overcome the limitations associated with average meteorological data values.

With regard to the EU-GSP scheme, preference margins can be measured either in absolute or relative terms. Despite the fact that adjusted preference margin measures are the most commonly used, they lack microeconomic foundations. Various policy instruments embedded within the EU-GSP scheme are used to compute the value of preference margin. These are MFN, tariff rates, tariff rate quotas and specific duties. Different approaches are used to calculate the margin and this may be associated with the mixed results about the influence of the EU-GSP scheme on exports from developing countries into the EU market. None of the studies which have been traced used a combination of all the instruments (MFN, tariff rates, specific duties and tariff rate quotas) embedded in the EU-GSP scheme to quantify the value of preference margin, yet ignoring any of these could overestimate the value of the preference margin. In addition, generalized results and recommendations were obtained by various scholars, either because they used aggregated data or fruit and vegetable commodities that are of less relevance to the three East African states.

Therefore, there is inconclusive knowledge regarding the impact of the EU-GSP scheme on agricultural export flows from developing countries into the EU market. In this study, this knowledge gap will be filled by using the competition-adjusted PM measure. The measure will be based on a combination of trade-weighted applied MFN rates, tariff rates, specific duties and Tariff Rate Quotas within the gravity model framework.

There are two approaches to predicting potential trade flows, *viz,* the “Out-of-sample” and the “In-sample”, but literature argues that the latter leads to misleading results. With the “Out-of-sample” approach, trade potential is computed either as the difference between the simulated trade potential and the actual trade flows, or as the ratio of the simulated trade potential to the actual trade flows. Existing literature leads to generalized results and recommendations being given that are based on either data that is aggregated across sectors, or cross-sectional data in a given economy.  Thus, the actual insight into potential markets for trade expansion based on highly disaggregated commodities is lacking.  Analysis based on cross-sectional data leads to inconsistent estimates, thus implying that the trade potentials simulated based on such estimates may also be misleading.  Therefore, there exists a general knowledge gap about East African economies' trade potentials with their trade partners.  It is thus prudent to suggest that the use of recent and highly disaggregated panel data at sector level, particularly for the fruit and vegetable sub-sector, may provide an insight into sector-specific results upon which commodity-specific markets for East African economies' may be identified so as expand their global trade potential.

# CHAPTER THREE:
# AN OVERVIEW OF EAST AFRICA'S HORTICULTURE SECTOR

## 3.1 Introduction

This chapter provides a description of the fruits and vegetable sector in Kenya, Tanzania and Uganda. Specifically, it presents a focus on the acreage covered under fruits and vegetables, production trends, the major export destinations of fruits and vegetables, net export trends across the globe, and the export trends in relation to temperature and precipitation.

## 3.2 Fruit and vegetable production in East Africa

Over the past 2 to 3 decades, it has been argued that the fruit and vegetable sector in Kenya, Tanzania and Uganda has the potential to draw the rural populace out of poverty. For instance, Bear and Goldman (2005) put it that "Fruits and vegetables are among the sectors where Uganda can achieve growth in coming years." In light of the above, many small-scale farmers have embarked on the production of these commodities, and in some cases with technical and financial support from donor agencies such as the United States Agency for International Development (USAID), the British Department for International Development (DFID), and the Europe-Africa-Caribbean-Pacific Liaison Committee (COLEACP). Many development-oriented programmes, such the Pesticides Initiative Programme (PIP), have also been introduced in the East African region.

Such initiatives have generally boosted the production of fruits and vegetables, to the extent where they have become recognized as income generating crops, e.g. pepper, bananas, asparagus, beans, pineapples and French beans, on top of the traditionally grown crops, such as coffee, tea, cotton and tobacco (in Uganda); coffee, tea, cotton, cashew nuts and tobacco (in Tanzania); and coffee, tea, cotton, maize, sorghum and millet (in Kenya). Figure 3.1 below shows the trend in the area harvested under fruits and vegetables in Kenya from 1970 to 2012.

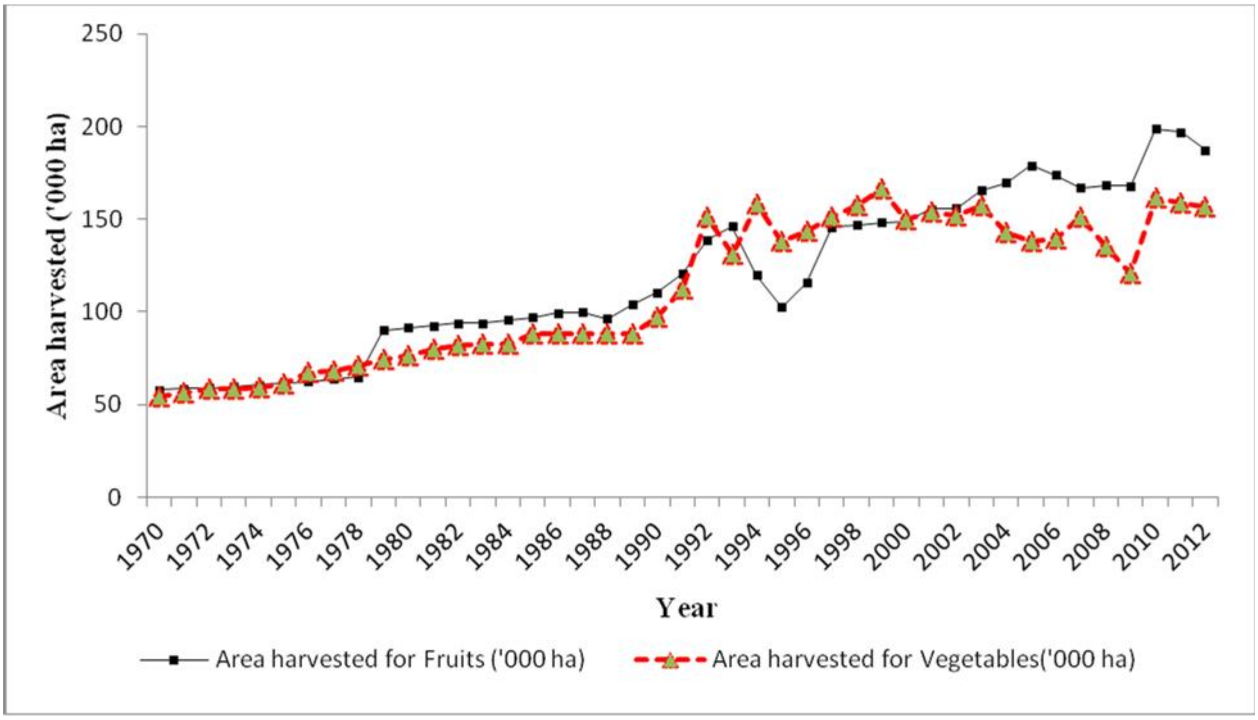


**Figure 3.1: Area harvested under fruits and vegetables in Kenya**

***Source:*** *FAO database* (2013)

Figure 3.1 illustrates that there has been a gradual increase in the area harvested under fruits and vegetables in Kenya. Fruits generally assume a larger proportion of area harvested than do vegetables. On average, fruits assume 119,354 hectares (ha) while vegetables account for 111,511 ha. During the late 1970s and the period from the mid-1990s until the early 2000s, the acreage under fruit production declined below that for vegetables. For Tanzania, Figure 3.2 below also shows that fruits cover a larger acreage than vegetables do. However, Tanzania's trend in acreage is characterized by drastic fluctuations for both fruits and vegetables.

For instance, fruits covered more than twofold the acreage (397,475 ha) relative to vegetables (159,318 ha), but exhibit more sharp fluctuations along the trend, particularly during the 1982–85, 1989–91, 1997–1999 and 2009–12 periods. The lowest acreage in fruit production was observed in 1990 (40,931 ha) while the highest was 885,182 ha in 2009. Generally, vegetables assumed the lowest acreage in 1994 (18,638 ha), followed by 19,091 ha in 1985. The largest acreage (348,694 ha) under vegetable production was observed in 2011, followed by 316,472 ha in 2009.

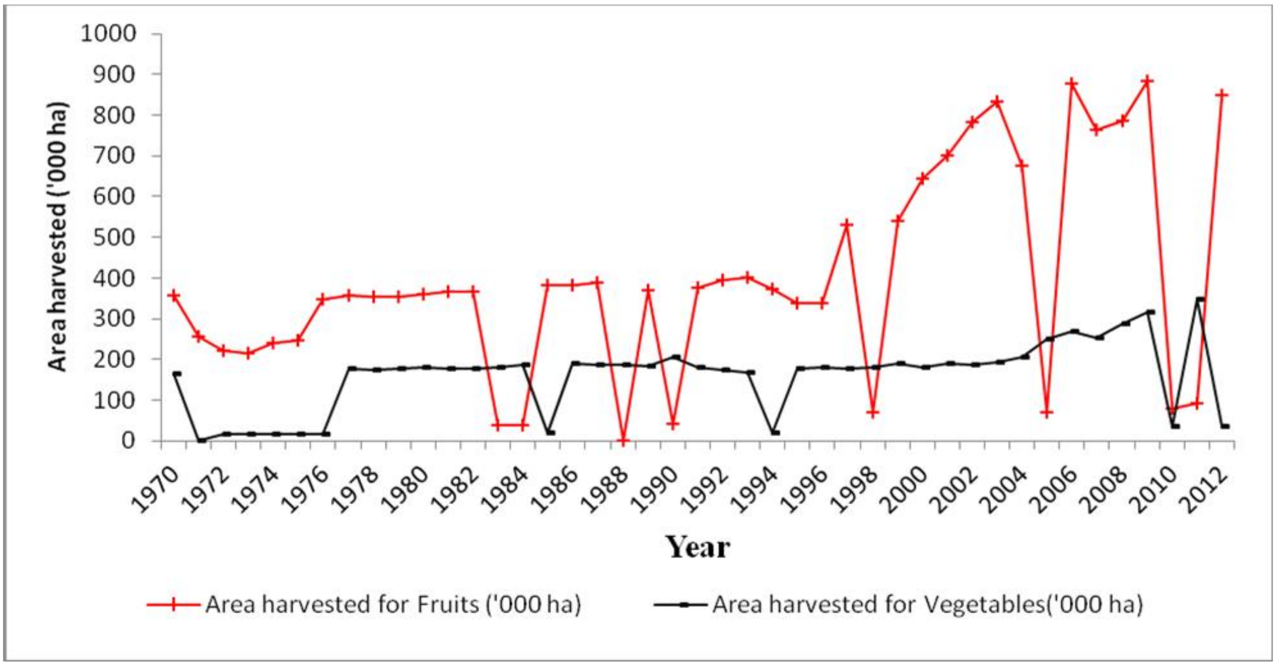


**Figure 3.2: Area harvested under fruits and vegetables in Tanzania**
**Source: FAO database (2013)**

In Uganda, trends presented in Figure 3.3 below show that fruits assume more acreage than vegetables. Acreage under fruit production gradually increased over the years with hardly any drastic fluctuations. On average, acreage fruit production was 1.52 million ha, while vegetables accounted for 51,835 ha only. Between the early 1970s and the early 1980s, the acreage under vegetable production was very low, ranging between 50 ha in 1978 to 595 ha in 1984.

Since then, the acreage under vegetables has drastically fluctuated, with the sharpest decline (99 %) during the 2011–2012 and 2009–2010 periods. During the 2011–2012 period, the acreage dropped from 195,475 ha to 204 ha and from 186,624 ha to 200,5 ha between 2009 and 2010. Other periods characterized by drastic changes in acreage under vegetable production are between 1991 and 2001. However, despite the drastic fluctuations in acreage under vegetable production, there is an increasing trend in general.

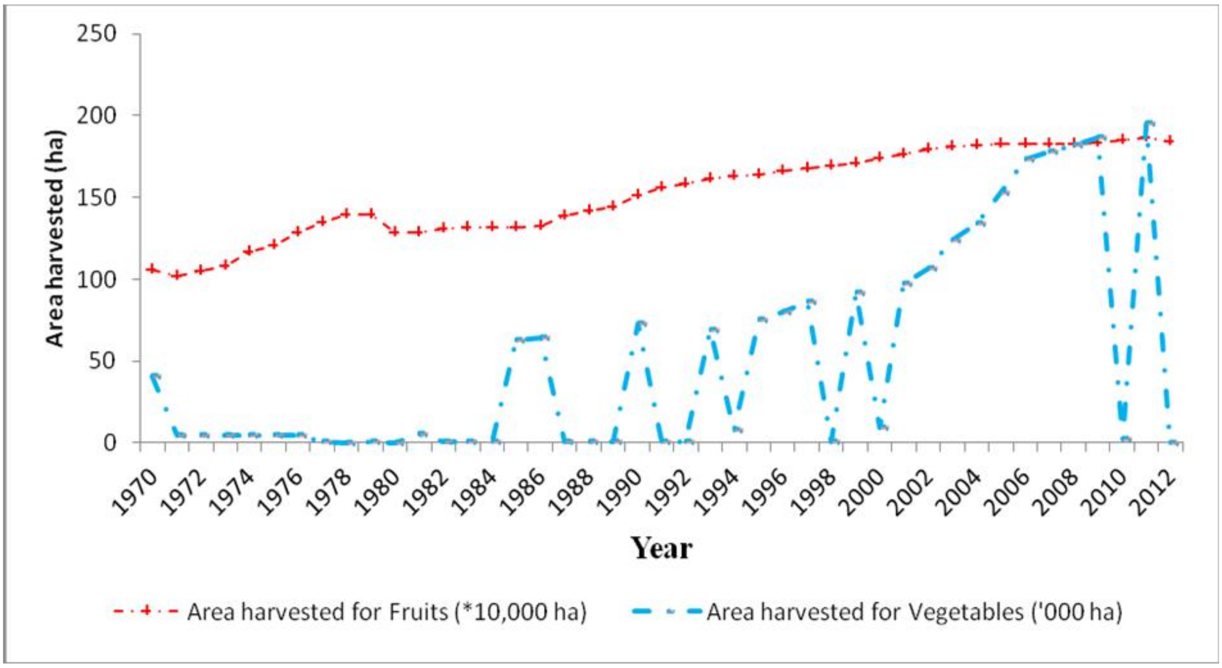


**Figure 3.3: Area harvested under fruits and vegetables in Uganda**
***Source:*** *FAO database* (2013)

Trends presented in Figure 3.4 below show that Kenya has experienced an increase in fruit and vegetable production over the years, with a sharp rise in 1991 for vegetables, while fruit production drastically increased in 1979 and 2012. The 1991 fluctuation accounts for a 92.8 per cent increase in vegetable production from 1990 (743,08 tonnes) to 1991 (1,029,450 tonnes), while the changes in fruit production account for 95.3 per cent and 46.4 per cent for the 1978–79 (from 52,616 tonnes to 1,121,810 tonnes) and 2011–12 (from 2,876,276 tonnes to 5,364,506 tonnes) periods, respectively. Kenya produces more fruits than vegetables. Between 1970 and 2012, Kenya produced 1.6 million tonnes of fruits and 0.93 million tonnes of vegetables.

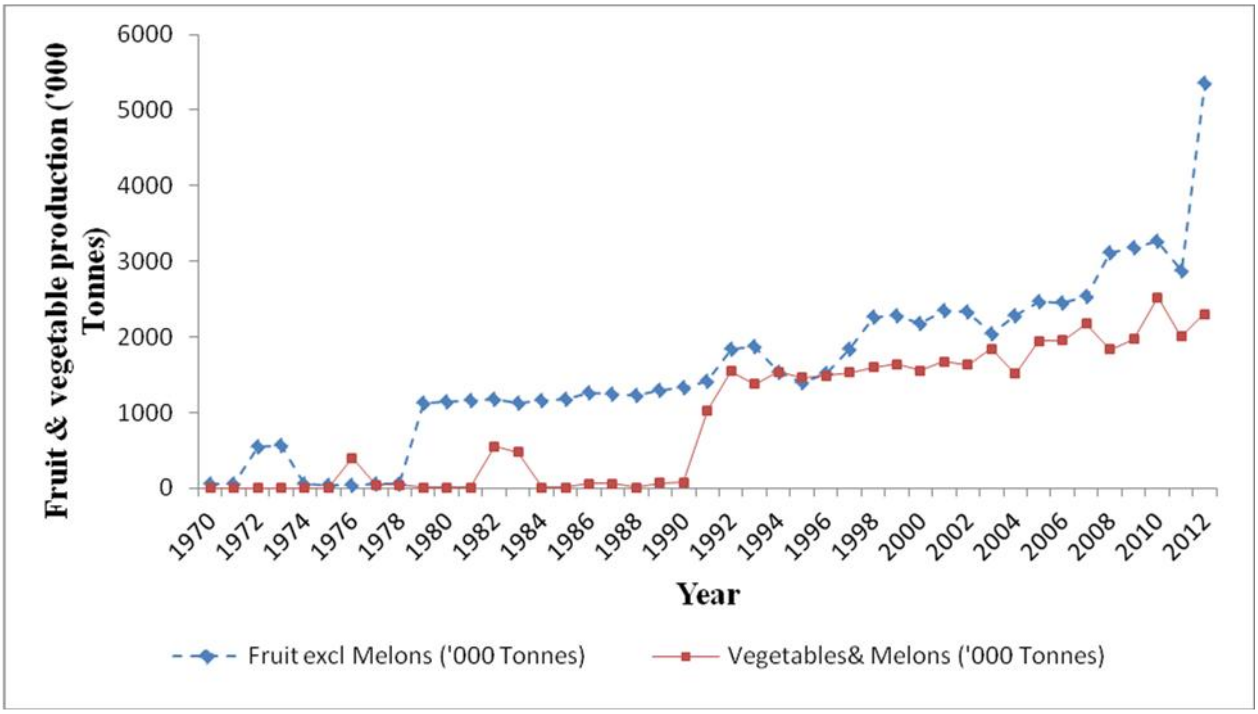


**Figure 3.4: Kenya's trend in fruit and vegetable production**
***Source:*** *FAO database* (2013)

Figure 3.5 below shows Tanzania's trend in the production of fruits and vegetables. In general, trends show that fruit production outweighs vegetable production. However, both trends show that Tanzania experienced a gradual increase in the production of fruits and vegetables over the years. Drastic increases in production were observed after late 1996. After the mid-1990s, Tanzania's highest fruit production was estimated at 4.9 million tonnes in 2006, followed by 4.5 million tonnes in 2011. On the other hand, the lowest volume of fruit production (1.85 million tonnes) was registered in 2000, followed by 1.91 million tonnes in 1999. For the entire period between 1970 and 2012, Tanzania produced 1.98 million tonnes of fruits. Vegetable production was highest in 2012 (2.2 million tonnes) and in 1973 (885 tonnes), while the average volume produced during the 1970–2012 period was 1.11 million tonnes.

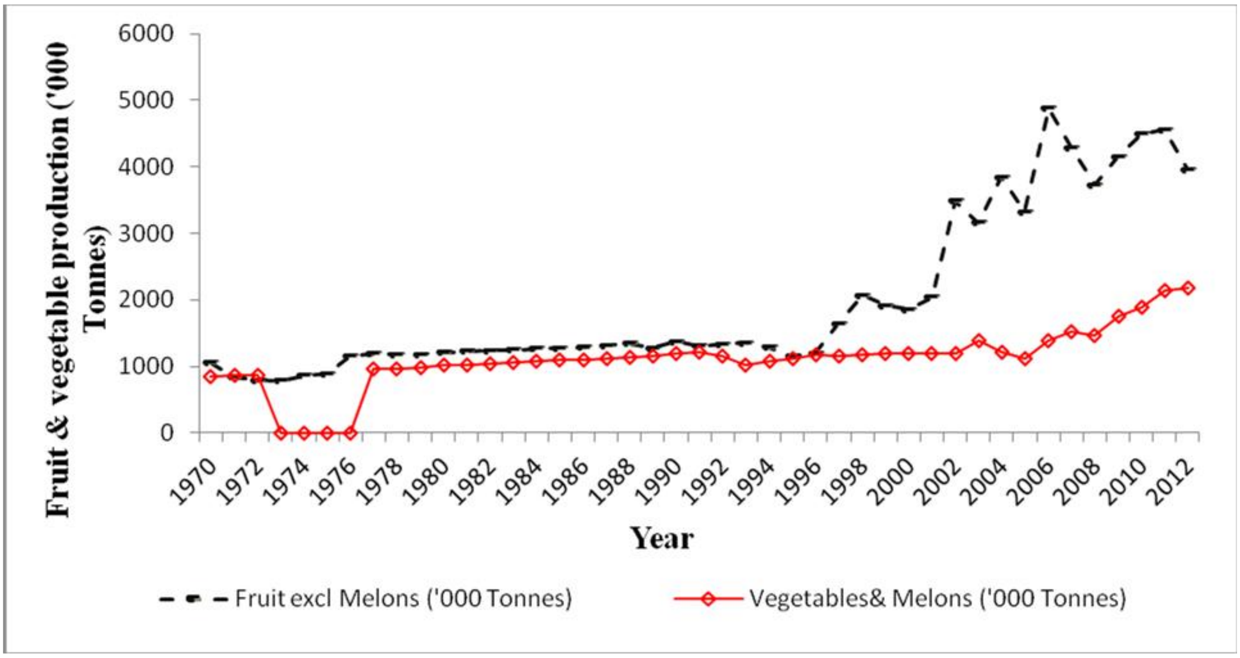


**Figure 3.5: Tanzania's trend in fruit and vegetable production**

***Source:*** *FAO database* (2013)

Figure 3.6 below illustrates that Uganda mainly produces fruits, as compared to vegetables.

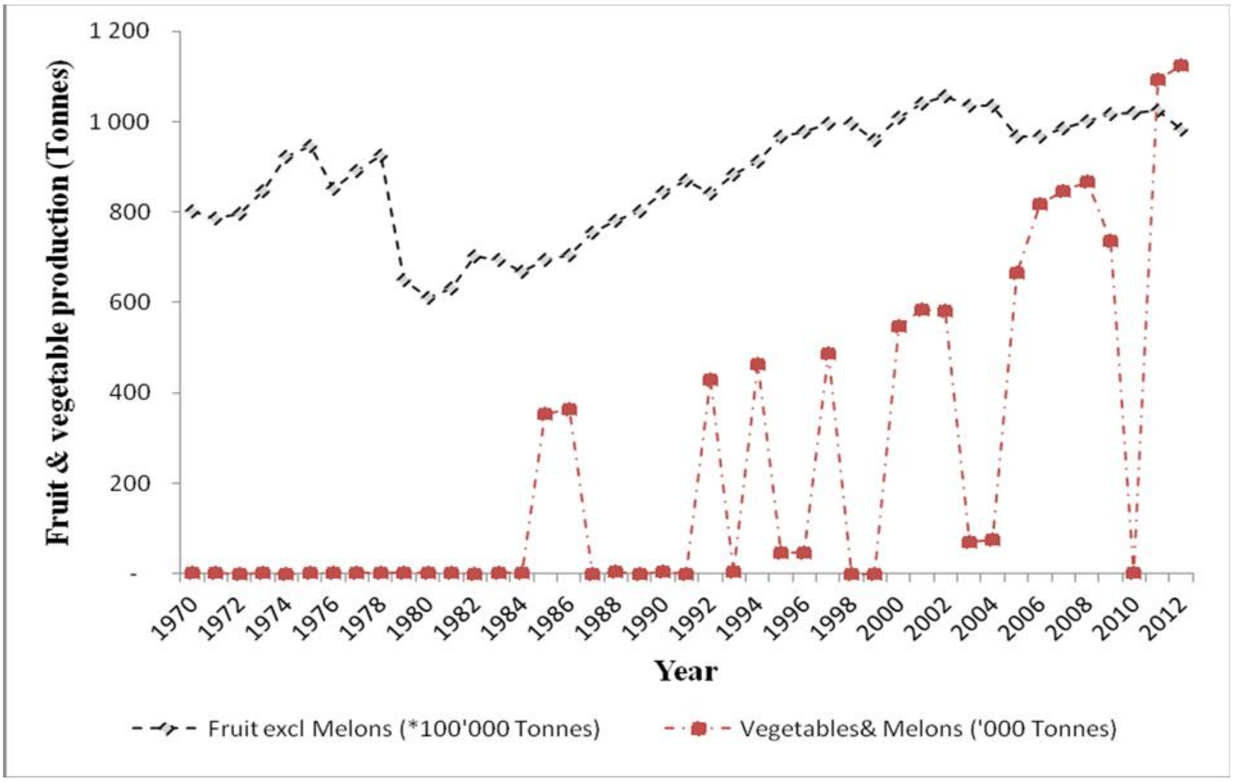


**Figure 3.6: Uganda's trend in fruit and vegetable production**

***Source:*** *FAO database* (2013)

Despite the general increasing trend, fruit production experienced fluctuations, particularly from the late 1970s until the early 1980s. The drastic decline in fruit production occurred from 92.4 million tonnes in 1978 to 61.1 million tonnes in 1980. Overall, the average fruit production between 1970 and 2012 is estimated at 88 million tonnes. The trend for vegetables also shows that production fluctuated more after 1990. Vegetable production drastically fell from 0.74 million tonnes in 2009 to 986 tonnes in 2010, and thereafter increased by about 100 times to 1.1 million tonnes in 2011. Other periods during which vegetable production registered drastic fluctuations include 1997–2000 and 2002–2005.

Overall, Uganda produced 0.24 million tonnes of vegetables between 1970 and 2012. Based on the average values between 1970 and 2012, Uganda is the leading producer of fruits (88 million tonnes), followed by Tanzania (1.98 million tonnes) and then Kenya with 1.59 million tonnes. In the case vegetables, Tanzania, Kenya and Uganda produced 1.11 million tonnes, 0.93 million tonnes and 0.24 million tonnes, respectively.

### 3.3 East Africa's fruits and vegetables trade statistics and the major trade partners

Over the past two decades, the value of global agricultural trade from the East African economies has been increasing (FAOSTAT database, 2014). The constitution of trade shows an increasing trend in high-value, non-traditional cash agricultural commodities, such as fruits and vegetables in world agricultural trade among the traditional cash crops. The increase in agricultural exports may generally be attributable to the topical climatic conditions that enhance production throughout the whole year, as well as to the technical and financial support from donor agencies, among other factors. According to Figure 3.7 below, Kenya is the number one exporter of fruits and vegetables, followed by Tanzania and then Uganda. Between 1990 and 2011, Kenya exported fruits and vegetables worth US$ 232.5 million, while the value of Tanzania's and Uganda's exports were valued at US$ 97.1 million and US$ 13.5 million, respectively.

For Kenya, the increase in the value of fruit and vegetable exports drastically rose after 2002 (US$ 260.7 million) and by 2008 (US$ 453.2 million) the growth rate in exports was 66 per cent. The sharp rise may be attributable to the fact that Kenya uses advanced technology, such as green houses, in the production of some horticultural commodities. Tanzania experienced fluctuations in the value of fruit and vegetable exports over the years.

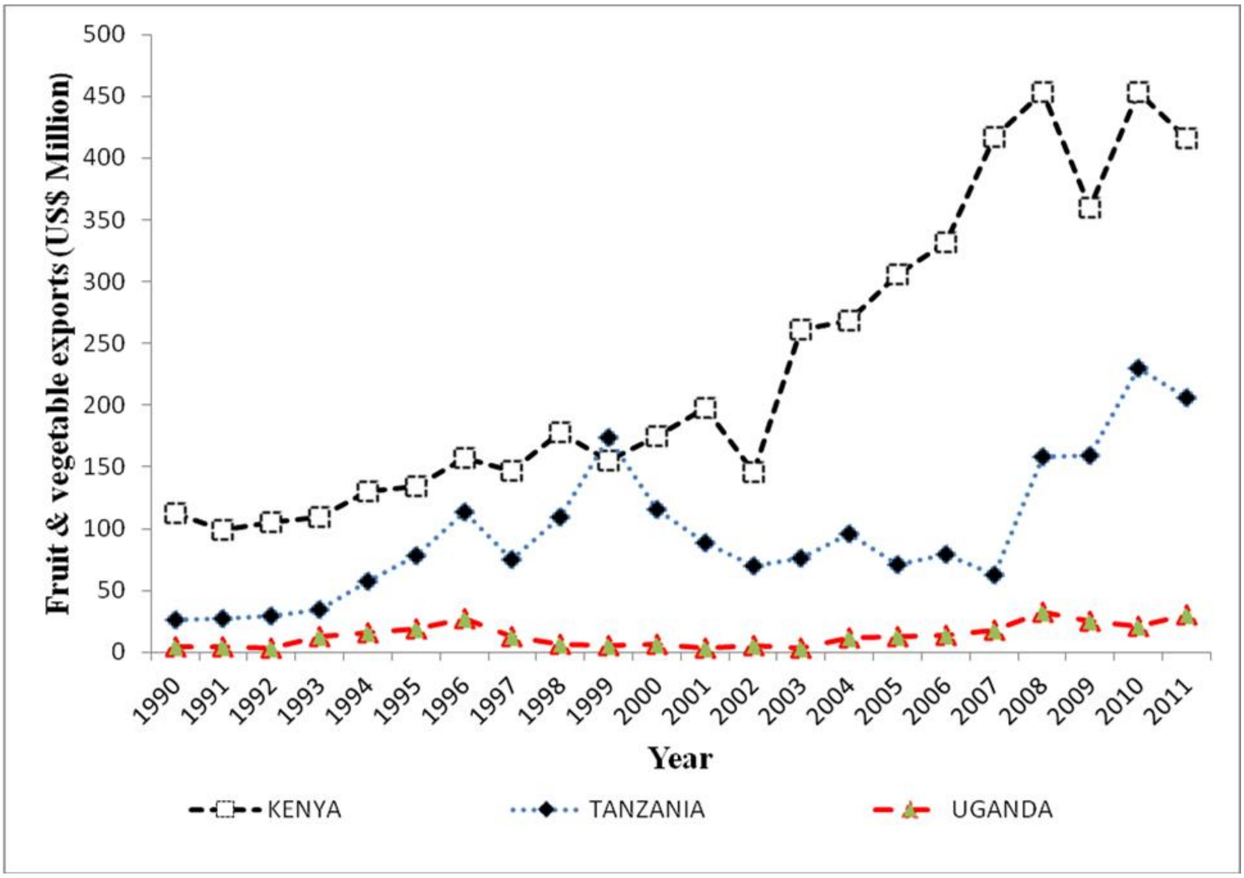


**Figure 3.7: Aggregated fruit and vegetable exports from Kenya, Tanzania and Uganda**

***Source*****:** FAOSTAT database (2014)

A 57 per cent increase in the value of exports was observed between 1997 (US$ 74.7 million) and 1999 (US$ 173.4 million), probably due to the full liberalization of the economy during the mid-1990s. Thereafter, the trends show that the values of exports declined, probably due to the drought that affected the country from late 1999 until 2000. Uganda's low value of fruit and vegetable exports in comparison with Kenya and Tanzania may be associated with the fact that the country is landlocked.

According to Agribusiness East Africa (2013), the European Union (EU) remains the key export market for fruits and vegetables from all the East African region member countries. Fresh fruit and vegetable exports are mainly destined to specific ethnic buyers within the EU. Figure 3.8 below shows the trend in the value of fruit and vegetable exports from Kenya to the EU. Unlike vegetable exports, fruits exhibit a lower gradual increase. A drastic rise in the value of vegetable exports was observed between 2002 (US$ 134.8 million) and 2008 (US$

289.1 million), representing a 53.4 per cent increase. The highest value of vegetable exports, worth US$ 289.1 million, was registered in 2008.

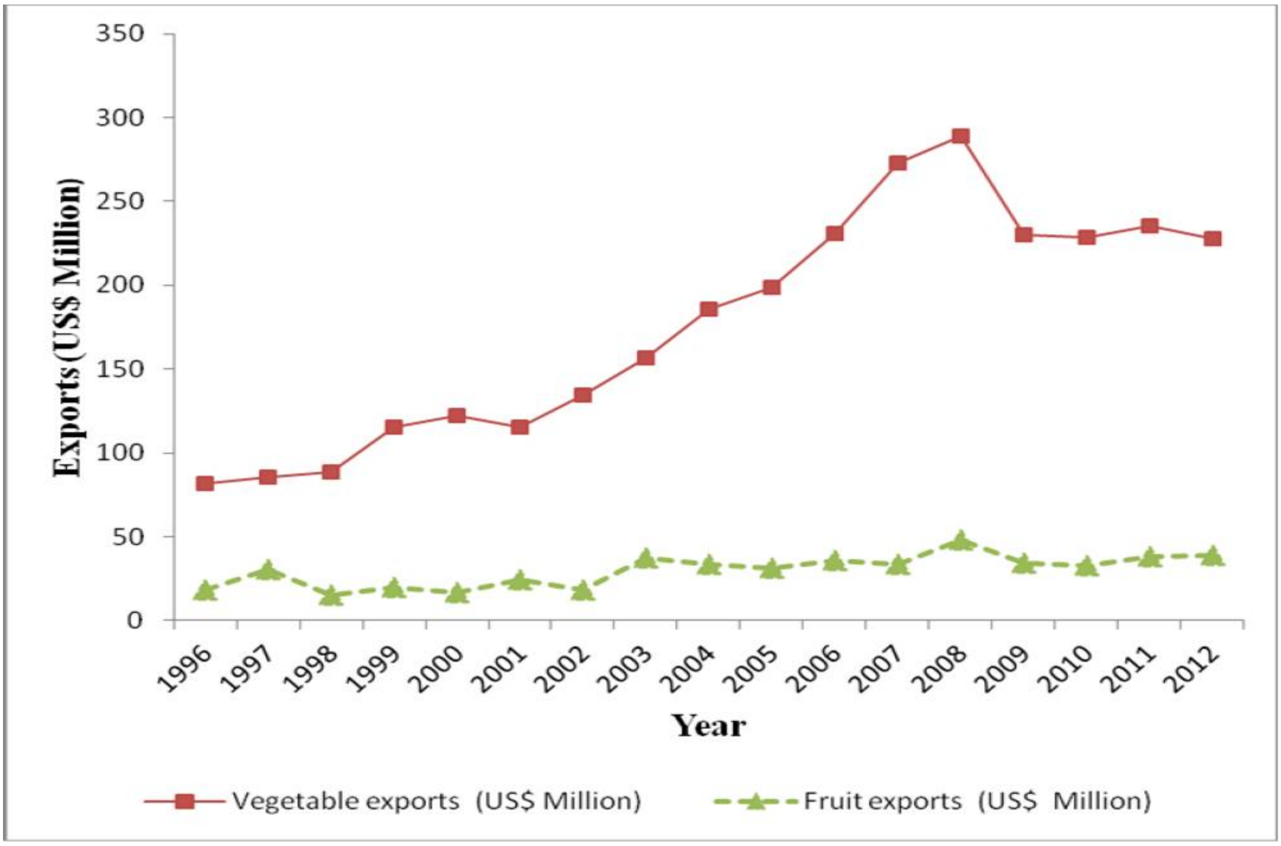


**Figure 3.8: Kenya's fruit and vegetable exports to the EU, by value**

***Source*****:** COMTRADE database (2013)

In general, vegetables destined for the EU market generate more foreign exchange than fruit. The value of Kenya's fruit exports to the EU was also highest in 2008 (US$ 48.4 million), while the lowest (US$ 15.5 million) was experienced in 1998. By 2009, exports in both fruits and vegetables declined by 41.9 per cent and 25.5 per cent, respectively.

For Tanzania, Figure 3.9 below shows that EU-bound fruit exports gradually increased over the years, with a sharp rise between 2006 and 2009. During the 1996–2012 period, Tanzania exported fruits worth US$ 4.3 million, on average, with the lowest value in 1996 (US$ 0.45 million) and highest value in 2009 (US$ 14.2 million). From 2007, fruit exports brought more foreign currency into Tanzania than vegetables did. Between 2007 and 2012, EU-bound fruit exports were worth US$ 11.1 million, on average, while vegetables were worth

US$ 7.5 million only. The figure also shows that the value of Tanzania's vegetable exports fluctuated highly between 1996 and 2012.

Generally, the value of Tanzania's vegetable exports to the EU varied greatly between 1996 and 2012. The highest value of vegetable exports was registered in 2004 (US$ 14.1 million) while the lowest was US$ 2.2 million in 2000. The declining trend for vegetable exports during the late 1990s may be associated with the drought that affected the country at the time, while the increasing trend in fruit exports during the 2000s may be attributable to the investment ventures by donor agencies, such as DFID, COLEACP and USAID.

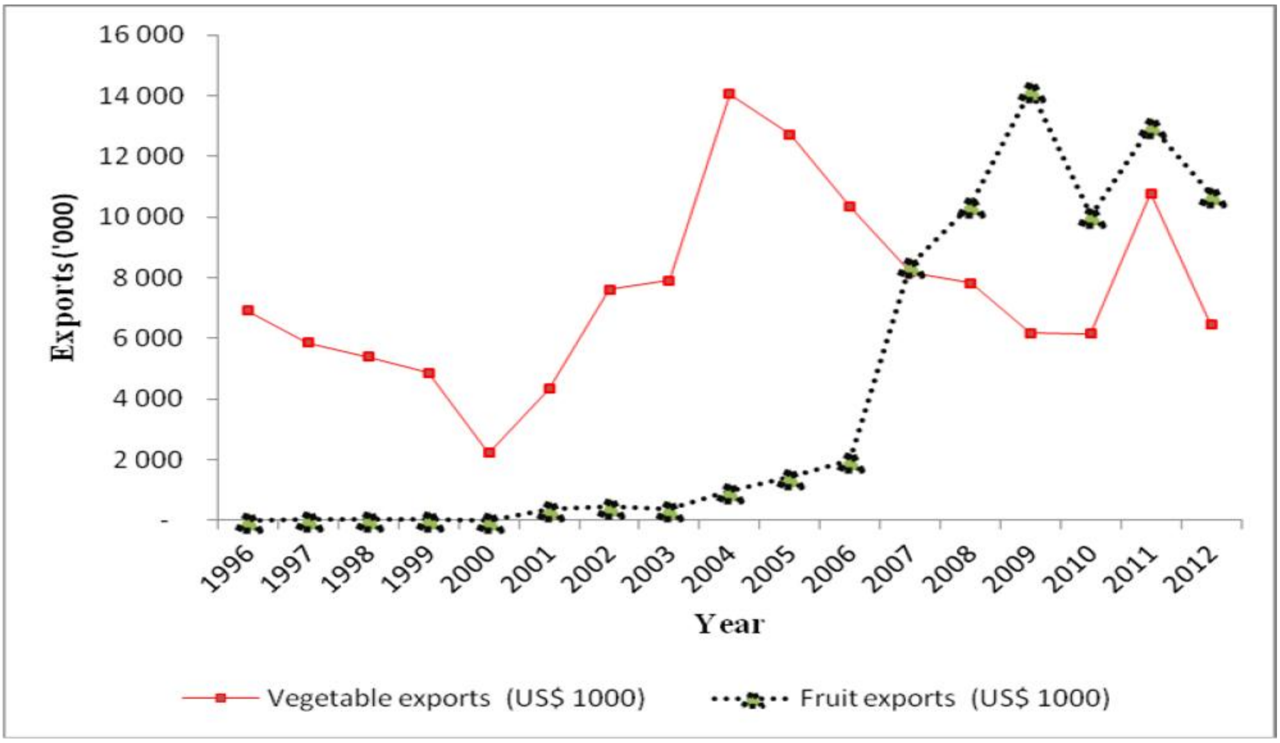


**Figure 3.9: Tanzania's fruit and vegetable exports to the EU, by value**
***Source*: COMTRADE database (2013)**

Figure 3.10 below shows that the value of Uganda's fruit and vegetable exports to the EU has increased over time. Based on mean values, Uganda received more foreign currency from vegetable (US$ 4.71 million) than fruit exports ( US$ 2.41 million) between 1996 and 2012. Vegetable exports were highest in 2011 (US$ 7.32 million) and lowest in 1996 (US$ 1.41 million). Despite the general increasing trend, the value of vegetable exports dropped sharply from US$ 6.8 million in 2005 to US$ 4.9 million in 2006, probably due to the strict certification requirements needed to meet the private standards such as the GLOBALG.A.P.

On the other hand, the value of fruit exports rose sharply from US$ 0.572 million in 2003 to US$ 6.32 million in 2008, but by 2010 (US$ 4.4 million), a drastic 30 per cent decline had been registered.

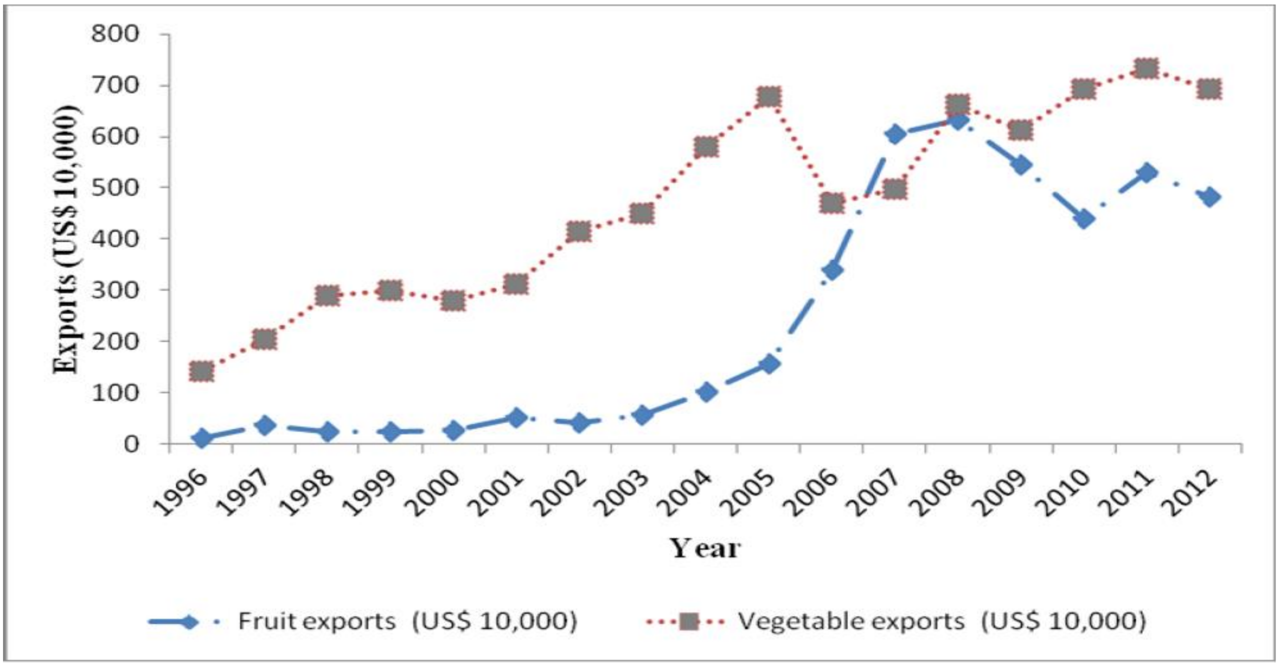


**Figure 3.10: Uganda's fruit and vegetable exports to the EU, by value**
***Source*:** COMTRADE database (2013)

The other major destination markets for fruit and vegetable exports from East Africa include the Common Market for Eastern and Southern Africa (COMESA), East Asia community countries, and the Middle East. More often than not, owing to the perishability of these commodities, shipment is done by airlifting the produce to the destination markets. Table 3.1 below shows the main fruit and vegetable exports destinations, disaggregated by the monetary value of imports by the leading trade partners as at the end of 2011.

**Table 3.1: Major export markets for fruits and vegetables from East Africa in December 2011**

| Export market | Exporter | Top partners in the market | Value of trade ('000 US$) | | Total value ('000 US$) |
|---|---|---|---|---|---|
| | | | HS-07 | HS-08 | |
| EU-27* | Kenya | United Kingdom | 150,384 | 5,107 | 155,491 |
| | | France | 15409 | 10,166 | 25,575 |
| | | Netherlands | 32,752 | 5,559 | 38,311 |
| | Tanzania | Netherlands | 4,139 | 7,396 | 11,535 |
| | | United Kingdom | 661 | 1,715 | 2,376 |
| | Uganda | United Kingdom | 3,644 | 121 | 3,765 |
| | | Netherlands | 859 | 1 | 860 |
| Middle East | Kenya | UAE | 5,429 | 14,124 | 19,553 |
| | | Saudi Arabia | 203 | 4,198 | 4,401 |
| | Tanzania | United Arab Emirates | 5,119 | 1,507 | 6,626 |
| | | Saudi Arabia | 62 | 689 | 751 |
| | Uganda | Oman | 115 | 2 | 117 |
| | | Bahrain | 13 | 46 | 59 |
| COMESA | Kenya | Uganda | 651 | 293 | 944 |
| | | Sudan | 409 | 104 | 513 |
| | Tanzania | Kenya | 24,469 | 25,735 | 50,204 |
| | | Rwanda | 1,179 | 115 | 1,294 |
| | Uganda | Kenya | 10,473 | 654 | 11,127 |
| | | Sudan | 2,676 | 29 | 2,705 |

EU-27* denotes the 27 members of the European Union. UAE denotes United Arab Emirates

***Source:*** International Trade Center (ITC) database (2013)

The East African states also import some fruits and vegetable commodities from other countries. For instance, the International Trade Center (ITC) database (2013) shows that in 2012 Uganda imported fruits and vegetables, amounting to about 73, 63 and 24 thousand US dollars, from France, the Netherlands and Italy, respectively. Kenya also imported fruits and vegetables, estimated at 2.4 million US dollars, from France, the Netherlands, Italy and the United Kingdom, among other European Union (EU) countries. Similarly, an estimated 0.41 million US dollars' worth of horticultural commodities were imported by Tanzania from the EU, mainly from Belgium, the Netherlands, the United Kingdom and Italy.

In 2012 alone, Kenya also imported fruits and vegetables from the Middle East, amounting to US$ 4.73 million, mainly from Egypt, Saudi Arabia, Turkey and the United Arab Emirates. Such commodities mostly comprised citrus fruits and grapes. For Uganda, fruit and vegetable imports from this group were estimated at about US$ 1 million, and were mainly citrus fruits, grapes and dried vegetables from Egypt, Turkey and the United Arab Emirates. In the case of Tanzania, horticultural produce worth about US$ 16.6 million was imported from the Middle East. Outstandingly, dates, figs, pineapples, mangoes, avocadoes, guavas and grapes dominated the imported fruits, mainly from the United Arab Emirates and Saudi Arabia, while onions, garlic and leeks were the key vegetable imports, solely from the United Arab Emirates (ITC database, 2013).

Within the COMESA trade bloc, to which the three East African states ascribe, there also exists cross border trade in fruits and vegetables. In 2012 Rwanda and Uganda supplied Tanzania with vegetables (potatoes in particular) while Kenya supplied Tanzania with fruits (dates, pineapples, mangoes, avocadoes, guavas, Brazil nuts, cashew nuts and coconuts). In total, US$ 2.9 million worth of horticultural produce were imported into Tanzania. Uganda imported fruits and vegetables from within the COMESA region worth US$ 1.9 million.

A large proportion of vegetables (mainly carrots, turnips, salad beetroot, onions and leeks) were obtained from Kenya, while Egypt supplied citrus fruits. On the other hand, more than 85 % of Kenya's fruits and vegetable imports were sourced from Uganda in 2011. For instance, of the total US$ 21.5 million worth of vegetable imports into Kenya, US$ 21.2 million worth of produce was supplied by Uganda, while about US$ 1.2 million worth of fruits was also sourced from Uganda. All in all, Kenya imported fruits and vegetables worth US$ 25.2 million in the year 2011(ITC database, 2013).

In general, statistics for the 1997–2013 period show that trade balances for the three East African states were not in a deficit, *that is*, countries exported more fruits and vegetables than what was imported. With the exception of Uganda (See Figure 3.11), Kenya and Tanzania were net exporters of fruits and vegetables. Kenya's and Tanzania's mean net export value were US$ 165 million and US$ 132 million, respectively. Uganda has the lowest mean net export value (US$ 5 million). During 2003, 2004, 2005 and 2007, Uganda was a net importer of fruits and vegetables and net imports were valued at US$ 1, US$ 7, US$ 9 and US$ 4, respectively. However, since 2007, the country has become a net exporter of fruits and vegetables. By 2013, Uganda's net exports of fruits and vegetables were valued at US$ 20 million.

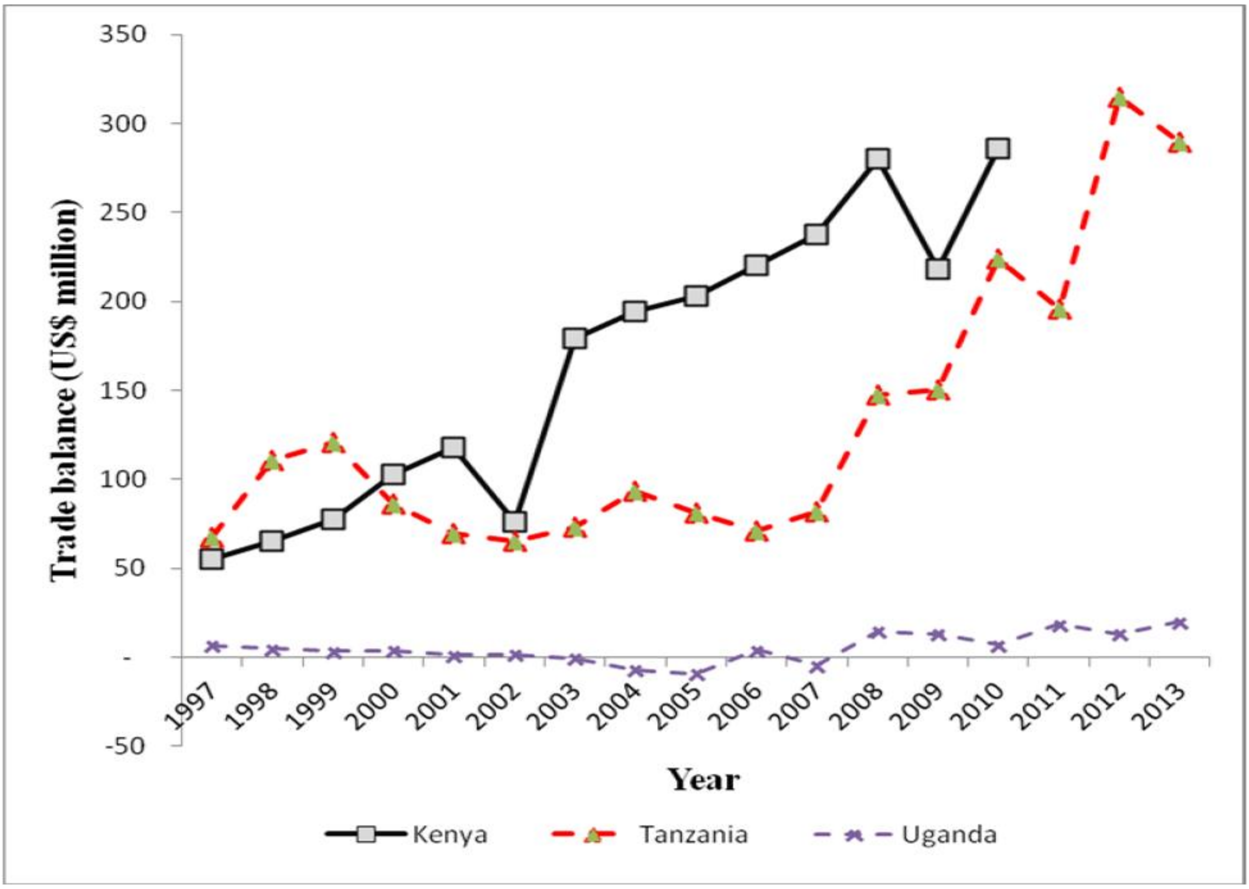


**Figure 3.11: Fruit and vegetable net exports from Kenya, Tanzania and Uganda**
***Source*: COMTRADE database (2013)**

## 3.4 Fruit and vegetable export trends against temperature and precipitation

Derksen and Jegou (2013) argue that changes in climate may physically distort trade patterns. Distortions in agricultural exports arise when climatic factors, particularly temperature and precipitation, affect the production phase (Berg *et al*., 2013; Roudier *et al*., 2011). According to Figure 3.12 below, Kenya's vegetable exports to the EU continued to increase, despite a 22 per cent reduction in precipitation between 1999 and 2000. However, the value of fruit exports appeared to decline by US$ 2.6 million during the same period.

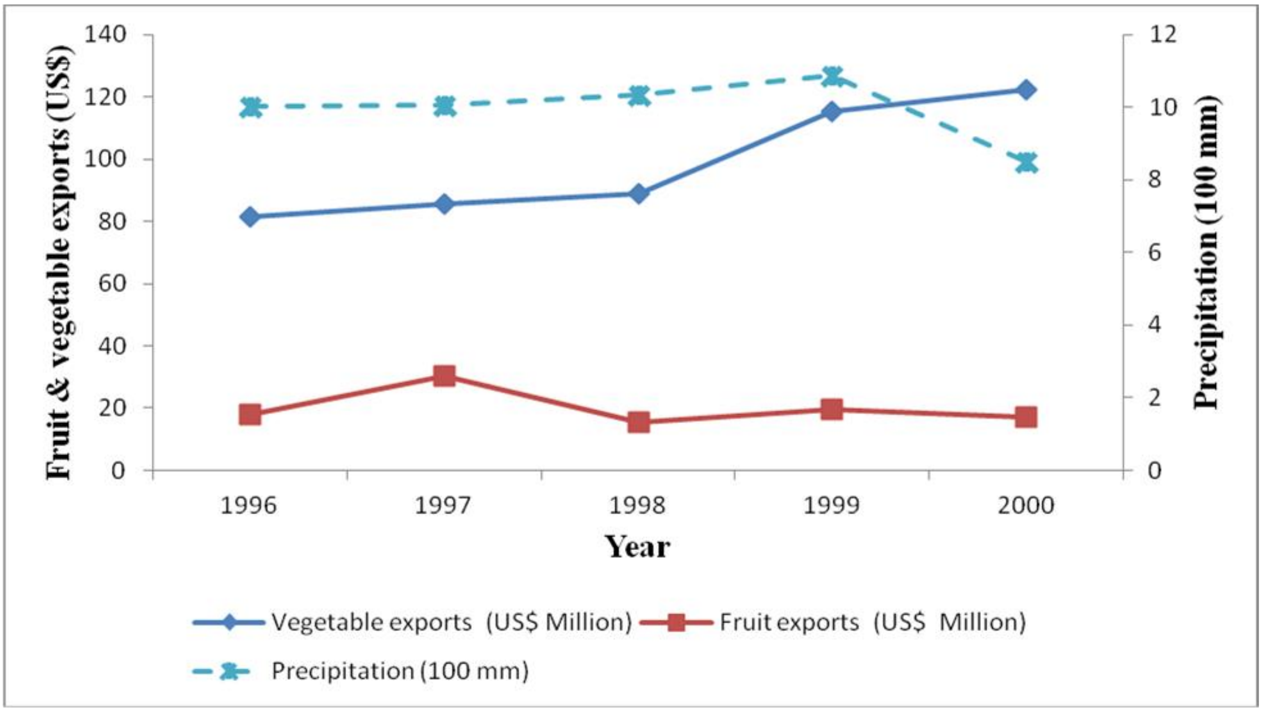


**Figure 3.12: Trend line of Kenya's fruit and vegetable exports into the EU in relation to precipitation**
***Source*:** COMTRADE database (2013) and TYN CY 1.11 database (2013)

On the other hand, Figure 3.13 below shows that a 0.04 per cent increase in temperature from 22.9 degrees Celsius (°C) in 1997 to 23 degrees Celsius in 1998 may have influenced the 49 per cent fall in fruit exports to the EU from US$ 30.3 to US$ 15.5 million. Moreover, the increase in temperature by 0.1 degree Celsius also seems to be associated with the 13.4 per cent decline in fruit exports from US$ 19.6 million in 1999 to US$ 16.9 million in 2000. Increases in temperature, however, seem not to have influenced Kenya's vegetable exports.

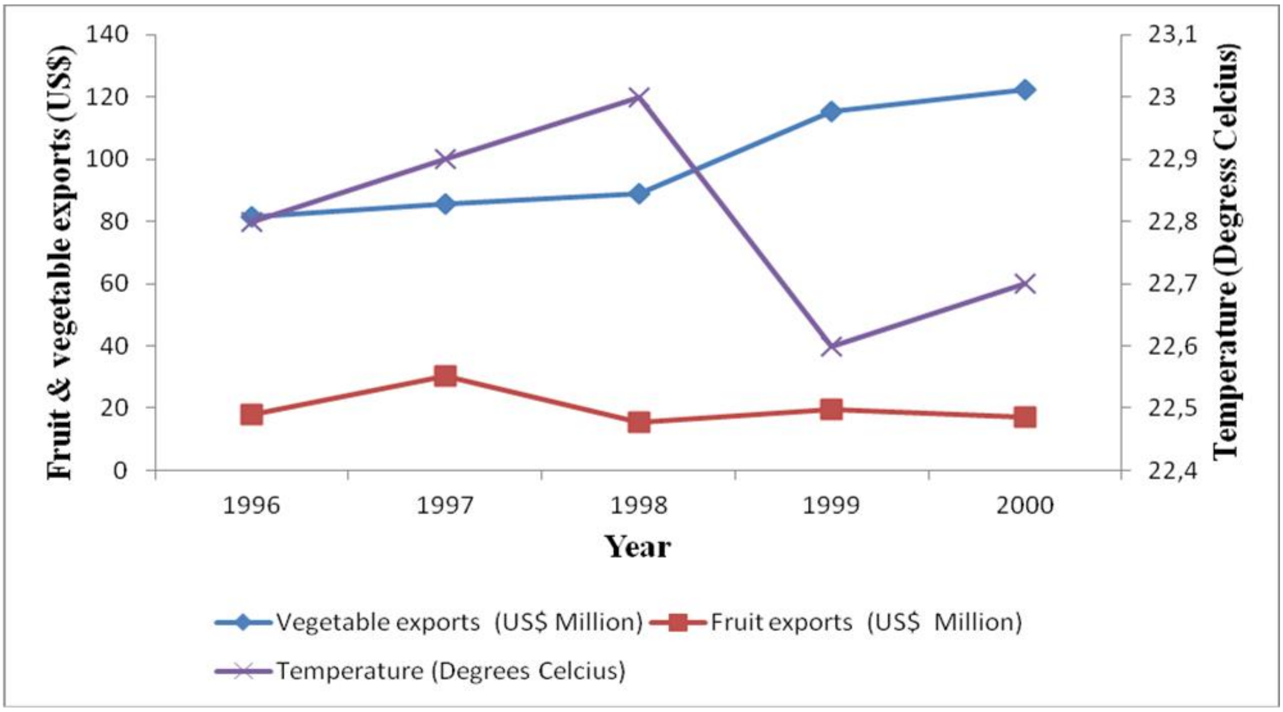


**Figure 3.13: Trend line of Kenya's fruit and vegetable exports into the EU in relation to temperature**
***Source*****:** COMTRADE database (2013) and TYN CY 1.11 database (2013)

In Uganda's case, Figure 3.14 below shows that fluctuations in temperature may have tendencies for distorting fruit export trends. The general trend shows that when temperatures are high, fruit exports seem to decline, but as the temperature fall, fruit exports tend to increase. However, the graph for vegetables exports reveals an increasing trend, irrespective of the fluctuations in temperature.

During the , a 7.1 per cent decline in the value of vegetable exports was observed between 1999 (US$ 2.9 million) and 2000 (US$ 2.8 million).

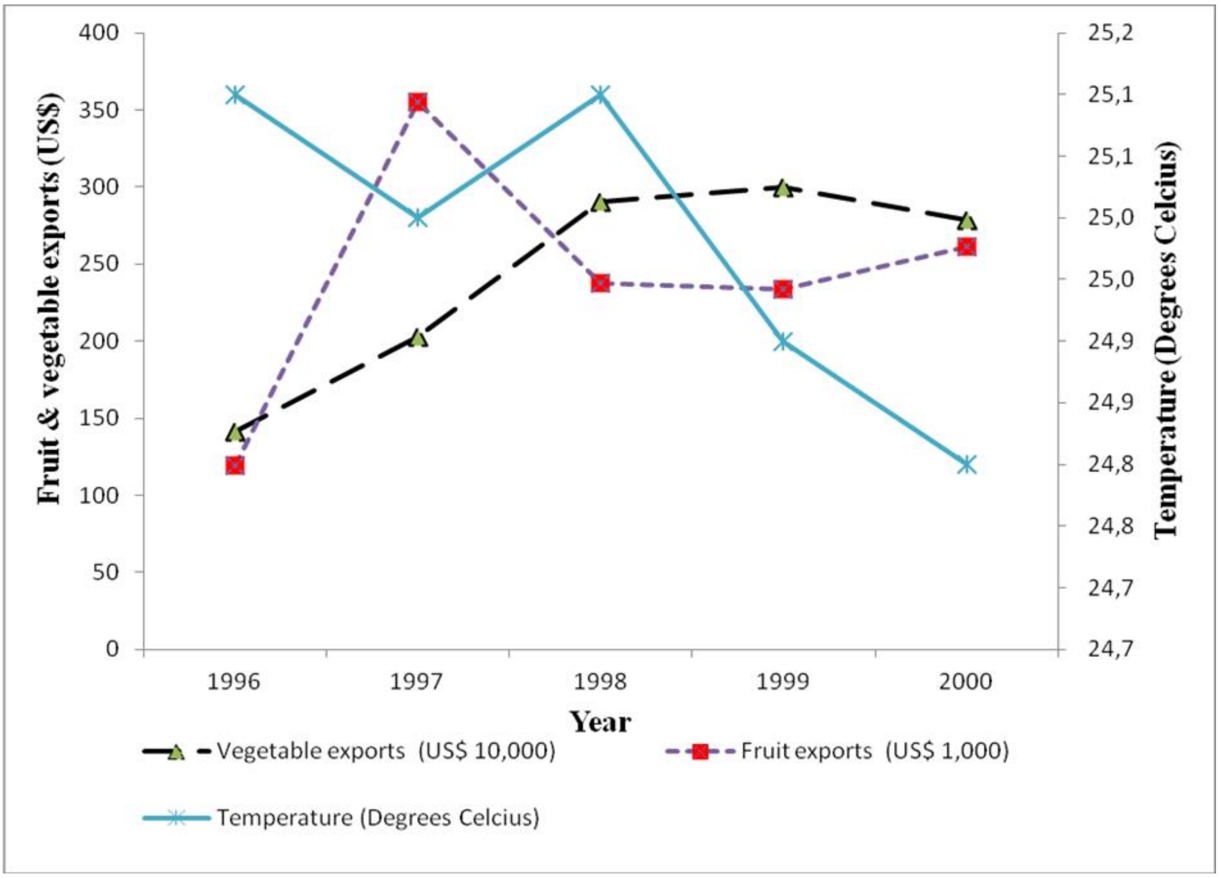


**Figure 3.14: Uganda's fruit and vegetable exports into the EU in relation to temperature**
***Source*****:** COMTRADE database (2013) and TYN CY 1.11 database (2013)

In the case precipitation, Figure 3.15 below shows that changes in this climatic factor may be associated with trends for fruit and vegetable exports. For instance, both fruit and vegetable exports increased as precipitation also increased, but between 1997 and 1998, fruit exports declined sharply. This decline may probably be linked with the 1997 floods that occurred in Uganda. During that period, the value of fruit exports declined by US$ 0.12 million. The Figure also shows that the value of fruit exports dropped by US$ 4.1 million when precipitation declined between 1998 and 1999. EM-DAT (2013) argues that it was this prolonged period of drought that affected the economy.

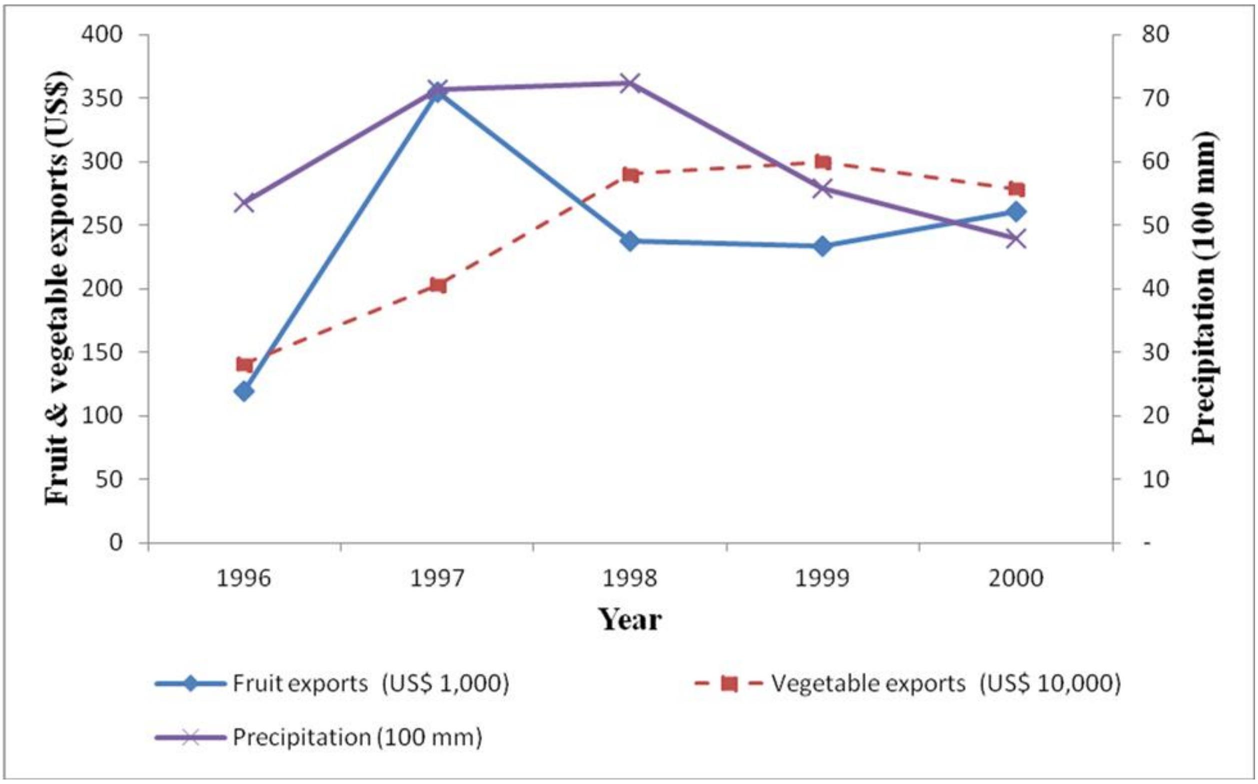


**Figure 3.15: Uganda's fruit and vegetable exports into the EU in relation to precipitation**

***Source*: COMTRADE database (2013) and TYN CY 1.11 database (2013)**

For Tanzania, Figure 3.16 below shows a general declining trend for the value of vegetable exports, while fruit exports increased until 1998, and dropped sharply thereafter until 2000. Vegetable exports fell by 54 per cent during the 1999–2000 period when precipitation dropped by 22 per cent from 1,088 mm to 850 mm.  During the same period, the value of fruit exports also dropped by 70 per cent, from US$ 25,409 to US$ 7,616.

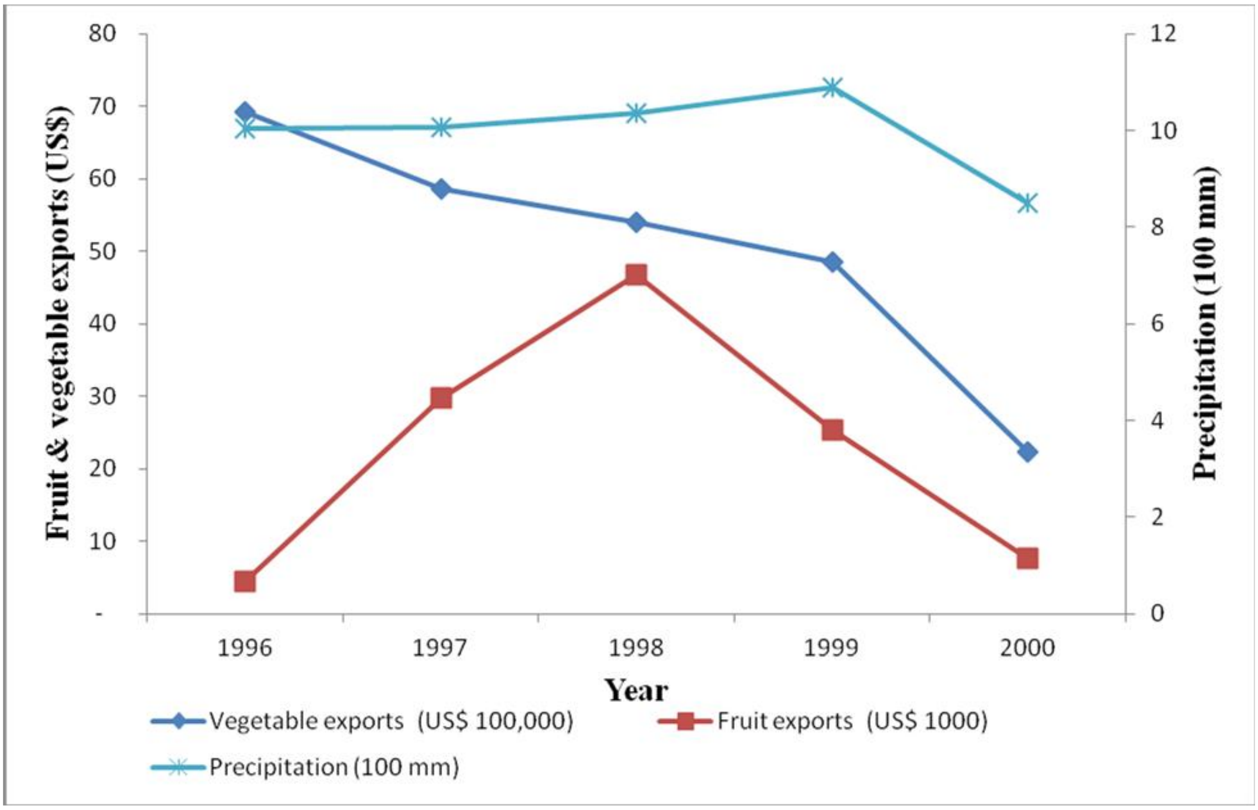


**Figure 3.16: Tanzania's fruit and vegetable exports into the EU in relation to precipitation**

***Source*:** COMTRADE database (2013) and TYN CY 1.11 database (2013)

In the case of temperature, Figure 3.17 below shows that changes in temperatures may, to a little extent, be associated with Tanzania's trend in fruit exports to the EU. For instance, the increase in temperature between 1996 and 1998 reveals that the value of fruit exports also increased. When temperatures dropped 0.4 degrees Celsius between 1998 and 1999, the value of fruit exports also declined. However, when temperature increased thereafter, the value of fruit exports continuously declined until 2000. The value of vegetable exports dropped throughout the period between 1996 and 2000, irrespective of the fluctuations in temperature.

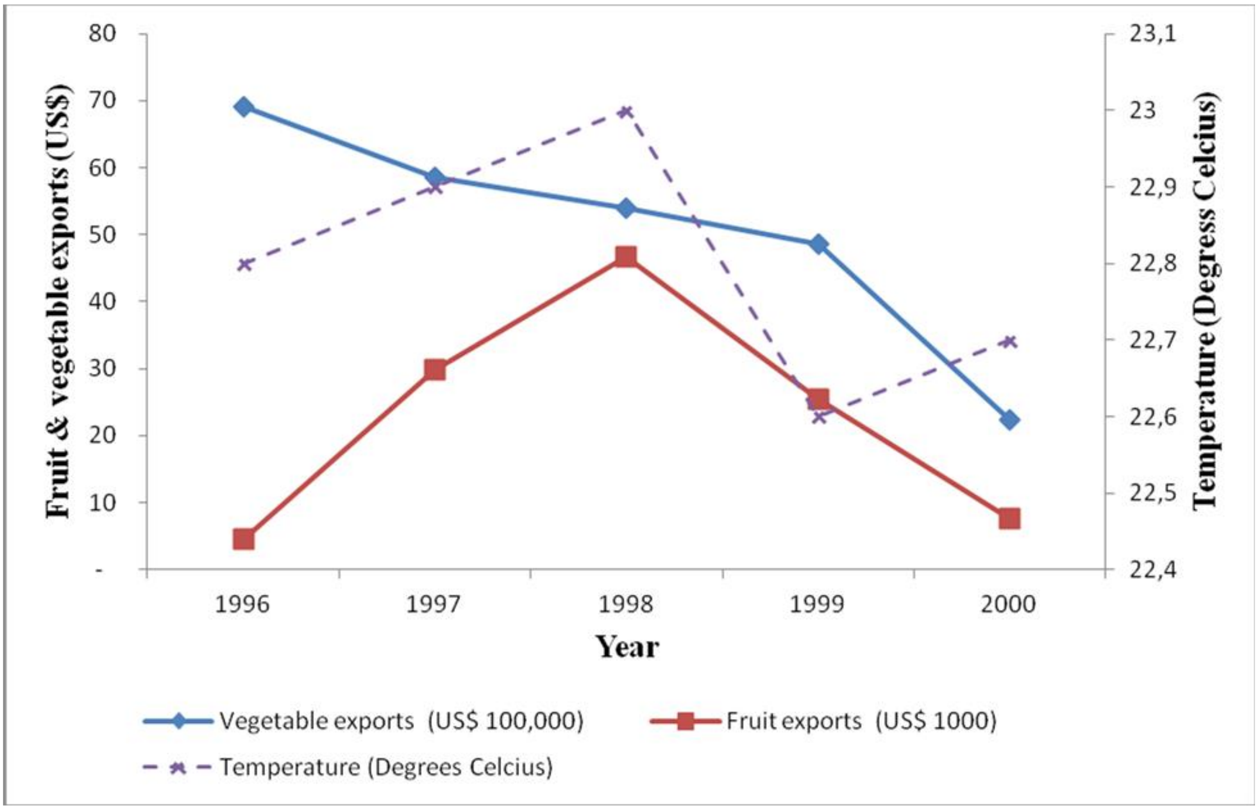


**Figure 3.17: Tanzania's fruit and vegetable exports into the EU in relation to temperature**
***Source*****:** COMTRADE database (2013) and TYN CY 1.11 database (2013)

### 3.5 Conclusion

The main aim of Chapter Three was to present an insight into the fruits and vegetable sector in Kenya, Tanzania and Uganda, with focus on trends in acreage, production, and exports, as well as on major trade partners. The three East African countries exhibit increasing trends for acreage, production and exports of fruits and vegetables. The trends for acreage, production, and exports of fruits and vegetables vary greatly from one country to another. When climatic factors such as temperature and precipitation fluctuate, EU-bound fruit and vegetable exports also appear to vary across the three East African countries. Kenya, Tanzania and Uganda are net exporters of fruits and vegetables, in that order. In conclusion, it is prudent to mention that the fruits and vegetable sector plays a contributory role in generating foreign currency for East African states. Fruits and vegetable exports from all three East African are influenced differently by changes in temperature and precipitation.

# CHAPTER FOUR:
# RESEARCH METHODOLOGY

## 4.1 Introduction

This chapter presents the methods, data, data management procedures and the data sources used to achieve the set objectives. Given that each objective has specific data requirements and estimation techniques, methodological details are presented in such a way that each objective has a designated section detailing the data issues and estimation techniques. The chapter begins with a general overview of the trading parties considered in this study, followed by procedures used to measure export competitiveness and the influence of climate change on the horticulture sector. The chapter also describes the approaches used to analyse the impact of the EU-GSP scheme on East Africa's fruits and vegetable commodities, as well as the estimation procedures employed to predict trade potential and performance. The chapter dwells much on how key variables are transformed from raw data and on how to deal with zero trade flows within a matrix. The chapter wraps up with a general conclusion.

## 4.2 Focus of the study

With regard to trade in fruits and vegetable commodities, the study generally focuses on three East African states (Kenya, Tanzania and Uganda) and their European Union (EU) trade partners, the largest world importer of fruits and vegetables (Cardamone, 2010; COMTRADE Database, 2012). The number of EU member states considered under each of the objectives differs owing to the different data requirements. Details about the EU member states considered are provided under each objective.

The research focuses on the fruits and vegetable sector, given that for about three decades now, fruits and vegetable exports have become a strong trade item among the East African economies. Additionally, despite the fact that the EU grants developing countries non-reciprocal preferential treatment on their exports into the EU market, fruits and vegetables are among the most sensitive products and are subjected to a number of tariffs and regulations which may be seen as barriers to trade.

## 4.3 Determining East Africa's export competitiveness in the fruits and vegetable sector in the EU market

This sub-section describes the kind of data, its sources and the method of analysis used to ascertain East Africa’s competitiveness in exporting fruits and vegetable to the European Union (EU) market. For this particular objective, the EU market entails all the 27 member countries (EU-27), while East African states refer to Uganda, Kenya and Tanzania. Inclusion of all the EU member states gives a true picture of export competitiveness of fruit and vegetable products from the East African states.

### 4.3.1 Data and data sources

This analysis focuses on chapter 7 and chapter 8 of the Harmonized System (HS) of nomenclature. These chapters are basically devoted to Vegetables (fresh, chilled or frozen) and Fruits, respectively. This system of nomenclature was established in 1988 by the United Nation (UN) so as to ensure uniformity in the recording of cross border trade flows. Data on the monetary value of exports for the period 1997–2011 on all fruits and vegetable exports at HS 4-digit and HS 6-digit level tariff lines to the EU-27 market by Uganda, Kenya and Tanzania were extracted from the COMTRADE database of the United Nations. This database provides detailed trade flow data for all commodity groupings up to the HS 6-Digit level of disaggregation for all reporting countries.

### 4.3.2 Data analysis

Evaluation of East Africa’s export competitiveness was achieved through the use of Balassa’s Index, i.e. The Revealed Comparative Advantage (RCA). This is the most commonly used measure of export competiveness globally (Palit and Nawani, 2012; Gilbert, 2010). Furthermore, Vollrath (1991) and Fertő and Hubbard (2002) show that government intervention, especially through trade-related policies, does not affect the RCA index, given that computation of the index relies only on export data. The distortion of trade flows attributable to government intervention is more evident at the import side than the exporters' side. Finally, the use of Balassa's index was also supported by the arguments of Capalbo *et al*. (1990) who noted that export competitiveness should be based on highly disaggregated data, upon which this study is founded. The index uses actual trade flows to ascertain the comparative advantage of exporters in fruit and vegetable products. At country level, the export competitiveness of fruits and vegetable commodities from East Africa into the EU market was measured using the monetary value of traded commodities disaggregated at two levels, namely (*i*) at HS 4-Digit, and (*ii*) at HS 6-Digit levels. Data analysis was carried out using an MS-Excel package. Balassa's index (RCA) was calculated at two levels.

Firstly, at HS 4-Digit level, the analysis aimed at reducing the number of tariff lines that would later be focused on at the highest level of disaggregation. At this level, 27 tariff lines (commodities) were considered for analysis, fourteen (14) of which are under Chapter 7 for vegetables, while the other thirteen (13) tariff lines represented Chapter 8 (fruits). After taking note of each East African country's annual exports and the world annual export for the entire period (1997–2011), Balassa's Index was then computed following Kulapa *et al*. (2013), Török and Jámbor (2013), and Shinyekwa and Othieno (2011).

Mathematically, Balassa’s index is computed as:

$$RCA_k = \left(\frac{x_{ik}}{X_{ip}}\right) \bigg/ \left(\frac{x^*_{wk}}{X^*}\right) \qquad (13)$$

Where the variables $x_{ik}$ and $X_{ip}$ denote the value of exports of product *k* from country *i* and total exports (p) from country *i*, respectively. The variables $x^*_{wk}$ and $X^*$ represent the value of the world’s exports of product *k* and total world exports, respectively. The monetary value of exports is expressed in thousand US dollars. These variables are exclusive of the exports of country *i*. The RCA ranges from zero to infinity. As a rule of thumb, a value of greater than one (1) implies competitiveness in exporting a given horticultural commodity. However, to ensure comparability over time, the average RCA Index for each commodity at country level was computed for the most recent four years, *viz*, from 2008 until 2011. Because of data limitations for 2011, the average RCA index for Kenya was computed using the 2007–2010 period.

At HS 6-Digit level (second stage), only the top two commodities that revealed export competitiveness in the EU-27 market at the first stage of analysis (HS 4-Digit level) were selected for further analysis. However, non-sensitive commodities , as categorized by the EU-GSP scheme, were not considered for analysis at this stage because such products are not highly protected (Bouët *et al.*, 2004) within the EU-27 market, relative to the sensitive ones.

Again, to ensure comparability of RCA values over time, averaging for each commodity at country level as described above in stage one (at HS 4-Digit level) was done. Selected commodities that were found to have export competitiveness in the EU market were then considered for further analysis.

## 4.4 Determining the influence of climate change on East Africa's horticultural trade flows

This sub-section presents the data and estimation techniques that were employed to develop a set of climate change indices based on meteorological data and how these indices were thereafter used to ascertain the influence of climate change on horticultural trade flows into the EU market. To achieve this, the study builds on the classic gravity flow model that is briefly described in the following subsection.

### 4.4.1 A brief overview of the gravity model framework

The gravity model was first conceptualized by Tinbergen (1962) and Pöyhönen (1963) during the late 20th century. Leamer and Levinsohn (1995), Bergstrand (1985; 1989), Deardorff (1998), Eichengrean and Irwin (1997) and Luca and Vicarelli (2004) argue that it is the workhorse of international trade because of its capability to correctly estimate trade flows. It originates from Newton’s “Law of Universal Gravitation”, which states that the attractive force (F) between two objects *i* and *j* is a positive function of their respective masses ($M_i$ and $M_j$) and a negative function of the distance (R) between them. It can be expressed as:

$$F_{ij} = G\left(\frac{M_i \sim M_j}{R_{ij}^{¥}}\right) \quad \text{.......................................................(14)}$$

where G is a constant proportion. The basic gravity model has, however, been modified with several additional variables (Linnemann 1966; Bergstrand, 1985; 1989; Oguledo and Macphee, 1994; Deardorff, 1998). Saltatici (2013) argues that the model was initially criticized for lacking sound theoretical foundations. However, Linnemann (1966), Anderson (1979), Bergstrand (1985; 1989), Frankel *et al* (1995) and Le *et al* (1996) used various approaches to validate the theoretical foundation of the model.

#### 4.4.1.1 Empirical success in the estimation of the gravity model

Matyas (1997), Cheng (1999), Wall (2000) and Glick and Rose (2001) argued about the influence of the heterogeneous nature of relationships between trading partners, noting that heterogeneity between partners leads to biased results. According to Aiello and Demaria (2009) and Blasi *et al.* (2007), heterogeneity arises owing to differences in cultural, political, ethnic, geographical and historical factors, which are often difficult to observe and quantify, yet those factors play a significant role in explaining trade flows between trading partners.

It was agreed that heterogeneity across countries should be controlled while estimating the gravity model in order to minimize instances of biased estimates. Aiello and Demaria (2009) argue that heterogeneity is associated with both observable and non-observable factors. Furthermore, they note that unobserved heterogeneity is attributable to omitted variables, which if not taken into account, will result in the estimates becoming inconsistent and inefficient. When specifying the model, heterogeneity due to observable factors is overcome by introducing a set of dummy variables, while unobservable heterogeneity models are controlled by using country-fixed effects.

Therefore, by introducing the country-fixed effects term, the linear analytical form becomes as illustrated in equation 15:

$$\ln F_{ij} = \sim \ln M_i + \ln M_j - \text{¥} \ln R_{ij} + {}^{\circ} \ln G_j + \text{«}_{ij} + \text{£}_{ij} \qquad (15)$$

where $\text{«}_{ij}$ is the specific country-pair effect, while ${}^{\circ} \ln G_j$ (hereafter, $\mu_0$) denotes the intercept common to all countries. Because of the lack of concrete evidence regarding the actual causes of heterogeneity in such analysis, Cheng and Wall (2005) argue that each country pair is represented by a unique dummy variable within the dataset so as to capture the effect(s) within a given pair of trading partners.

While using panel datasets, the gravity model also provides room to capture linkages of the different variables over time. According to Blasi *et al.* (2007), this can be achieved through the inclusion of a term to capture "time-invariant specific effects".

Equation (16) represents this advancement:

$$\ln F_{ij} = \sim \ln M_i + \ \ln M_j - ¥\, R_{ij} + «_0 + g_t + «_{ij} + £_{ij} \text{ ........................(16)}$$

where $\vartheta_t$ denotes a time invariant effect that occurs in each year and common to all country pairs.

### 4.4.1.2 Disaggregated data challenges and econometric issues

Recent analytical trends within the gravity model framework show a drift from the use of aggregated data towards the use of highly disaggregated data. However, estimating a linearized gravity model based on disaggregated data becomes more difficult because of the high proportion of zero trade flows. This presents a problem in executing the log-linear form of the gravity equation since the logarithm of zero is undefined, coupled with the fact that the zero trade flows are not randomly distributed (Saltatici, 2013).

To deal with the zero trade flows within the matrix, various estimation methods have been proposed and explored. For instance, Linders and De Groot (2006) note that an arbitrarily small positive number (usually 0.5 or 1) is added to all trade flows to ensure that the logarithm becomes well defined. However, given the fact that it is arbitrary means that it lacks both theoretical and empirical justification. According to Saltatici (2013), this approach concurs with the econometric theory if it is based on the assumption that data is censored. However, the approach is based on restrictive assumptions that do not hold, given that the censoring of data at zero is not a due to the fact that trade cannot be negative.

Saltatici (2013) argues that zero trade flows are a result of economic decisions based on possibilities of undertaking profitable bilateral trade between partners. Thus, zero trade flows do not necessarily show unobservable trade values but may be a result of a decision not to trade because the venture is not profitable. The use of arbitrarily small positive numbers leads to inconsistent estimates. Flowerdew and Aitkin (1982) and King (1988) demonstrated that the arbitrary numbers also distort parameter estimates and can be manipulated to generate any estimates to suit the modeller's liking.

In some cases, analysts simply drop the country-pairs with zero trade flows from the dataset so as to create room for estimating the log-linear form of the gravity model using the

Ordinary Least Squares (OLS) estimator. Cipollina and Pietrovito (2011) Eichengreen and Irwin (1998) and Saltatici (2013) argue that exclusion of the zero trade values leads to a reduced number of observations, as well as loss of important information, which causes a problem of selection bias. This problem is highly prevalent when the zero trade flows are non-randomly distributed. To control for this bias, various econometric approaches, such as the Tobit model, the Heckman two-step estimator and Poisson models, have been suggested.

As an example, Cipollina and Pietrovito (2011) commend the use of Tobit models, especially when the dependent variable exhibits a significant proportion of zero flows within the sample and positive flows for the smaller part of the sample. However, according Cipollina and Salvatici (2007), Tobit models are unfit for this kind of analysis because they are founded on interim and idealistic assumptions. It is further opined that these assumptions do not essentially hold, given that censoring at zero may not necessarily be correct because of the fact that trade cannot be negative. In detail, scholars unequivocally put it that zero trade flows are as a result of economic decision making established on the possibility of making profits when bilateral trade has occurred, rather than unobservable trade values.

Helpman *et al*. (2008) have argued that the “Heckman two-step estimator" best addressed the problem of zero trade flows, but Cipollina and Pietrovito (2011) discredit the procedure because it is susceptible to the presence of heteroskedasticity. Moreover, authors mention that estimates of the log-linear form of the gravity equation obtained by use of this estimator are biased and inconsistent. In light of the above-mentioned limitations of the Tobit model and Heckman two-step model procedures, the use of the standard Poisson model and its extended derivatives has been proposed.

#### 4.4.1.3 The Poisson model and its modifications

The Poisson model and its modifications are derived from the analysis of count data. This family of estimators can be used on non-negative continuous variables and the estimators are not susceptible to heteroskedasticity, as well as to zero valued flows (Wooldridge, 2002). The model’s invulnerability against such major drawbacks associated with highly disaggregated trade data arises from the fact that it generates actual estimates of trade flows using the log-linear rather than the log-log function. In this context, a generic gravity model is specified as:

$$TX_{ijt} = \mu_0 + \beta K_{ijt} + \vartheta_t + \mu_{ij} + \varepsilon_{ijt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(17)$$

where $TX_{ijt}$ denotes trade flows from county *i* to *j*; $\mu_0$ denotes the constant; $K_{ijt}$ is a vector of independent variables; and β is the vector of the corresponding coefficients of the independent variables. $\vartheta_t$ and $\mu_{ij}$ denote the time invariant and country-pair fixed effects, respectively, while $\varepsilon_{ijt}$ denotes the idiosyncratic error term.

Martijn *et al. (*2009) argues that the use of the log-linear rather than the log-log function prevents the under-prediction of large trade flows and total trade volumes. The predicted values estimated by this model are almost identical to the actual input data, probably because the Poisson model is estimated by use of the maximum likelihood model. Irrespective of the presence of heteroskedasticity, Martijn *et al. (*2009) and King (1988) posit that estimates obtained by the Poisson model are consistent and relatively more efficient.

Andersen and Van Wincoop (2003) argue that the Poisson estimator is built on two assumptions; (*i*) that the actual trade volume between countries *i* and *j* has a conditional mean ($\eta_{ijt}$) which is a function of the independent variables, and (*ii*) that the conditional variance of the dependent variable equals to its conditional mean (equidispersion). Thus, given that trade flows from country *i* to *j* ($TX_{ijt}$) are assumed to have a non-negative integer value, the exponential of the independent variables can be taken, such that the conditional mean ($\eta_{ijt}$) between country *i* and *j* is zero or positive. Mathematically, this is expressed in equation (18).

$$\Pr\left[TX_{ijt}\right] = \frac{\exp\left(-\eta_{ijt}\right)\eta_{ijt}^{TX_{ijt}}}{K_{ijt}!}, \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(18)$$

The conditional mean ($\eta_{ijt}$) is associated with the exponential function of a vector of regression variables, $K_{ijt}$.

Thus,

$$\eta_{ijt} = \exp\left(\mu_0 + \beta K_{ijt} + \vartheta_t + \mu_{ij} + \varepsilon_{ijt}\right) \ldots\ldots\ldots\ldots\ldots\ldots (19)$$

where $\mu_0$ denotes the constant, $K_{ijt}$ is a vector of independent variables and β is the vector of the corresponding coefficients of the independent variables. $\vartheta_t$ and $\mu_{ij}$ denote the time invariant and country-pair fixed effects, respectively, while $\varepsilon_{ijt}$ denotes the idiosyncratic error term.

However, the standard Poisson model is susceptible to two problems, that is, over-dispersion and an excess number of zero trade flows. Over-dispersion refers to a condition where the conditional variance deviates strongly from the conditional mean. Under the Poisson model framework, over-dispersion leads to consistent but inefficient estimates (Martijn *et al.*, 2009). According to Gourieroux *et al*. (1984) and Cameron and Trivedi (1986), this is usually exhibited as large spurious z-values and spuriously small p-values. However, modifications of the standard Poisson model, namely; the Negative Binomial Regression (NBR) and the Zero Inflated Poisson (ZIP) address these problems.

**The Negative Binomial Regression (NBR) model**

Despite that fact that the Poisson model is grounded on the equidispersion assumption, more often than not, this condition is not realized. In order to account for this drawback, scholars such as Greene (1994) recommend the use of the Negative Binomial Regression (NBR) model (See generic equation 20 below).

$$\Pr\left[TX_{ijt}\right] = \frac{\Pr\left(TX_{ijt} + \infty^{-1}\right)}{TX_{ijt}^{!\,\cdot\cdot}\left(\infty^{-1}\right)}\left(\frac{\infty^{-1}}{\infty^{-1} + \text{¦}_{ijt}}\right)^{\infty}\left(\frac{\text{¦}_{ijt}}{\infty^{-1} + \text{¦}_{ijt}}\right)^{TX_{ijt}}, \text{ .................................(20)}$$

where $\text{¦}_{ijt} = \exp\left(\text{«}_0 + K_{ijt} + g_t + \text{«}_{ij} + \text{£}_{ijt}\right)$, φ denotes the gamma function and (∞) is the dispersion parameter.

The dispersion parameter reveals the extent to which estimates are dispersed and the larger it is, the larger the degree of over-dispersion in the data. Unlike the Poisson model, the variance under the NBR model depends upon both the conditional mean ($\eta_{ijt}$) and a dispersion parameter (∞). Accordingly, Martijn *et al. (*2009) show that under this specification, unobserved heterogeneity is introduced into the conditional mean. Thus, when the dispersion parameter (∞) is allowed to assume values other than 1, then over-dispersion is catered for by explicitly modelling between subject heterogeneity. However, just like the standard Poisson model, the major drawback of the NBR model lies in the existence of a larger number of observed zero trade flows, which by far outweigh the quantity of zeros that the model can competently predict (Martijn *et al.,* 2009). In this instance, the modified version of the standard Poisson model (Zero Inflated Poisson model) was developed. It takes this drawback into account.

**The Zero Inflated Poisson (ZIP) estimator**

The ZIP estimator is best used where there is an excessive number of zero trade flows within the dataset, hence rendering the standard Poisson and NBR estimators inadequate. The Zero Inflated model accounts for two latent groups within the population; that is, a group with strictly zero counts and a group with a non-zero probability of having counts other than zero (Martijn *et al.,* 2009). The estimation process also consists of two parts. The first is the logit or probit regression which indicates the probability of complete non-existence of trade flows.

Mathematically, it is expressed as specified in equation 21.

$$\Pr\left[TX_{ijt}\right] = \omega_{ij} + \left(1 - \omega_{ij}\right)\exp\left(-\lambda_{ijt}\right), \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(21)$$

The second is shown in equation 22 and consists of a Poisson regression of the probability of each count for the group that has a non-zero probability or interaction intensity other than zero.

$$\Pr\left[TX_{ijt}\right] = \left(1 - \omega_{ij}\right)\frac{\exp\left(-\lambda_{ijt}\right)\lambda_{ijt}^{TX_{ijt}}}{K_{ijt}!}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(22)$$

Where $\lambda_{ijt} = \exp\left(\beta_0 + K_{ijt} + \gamma_t + \beta_{ij} + \varepsilon_{ijt}\right)$ and $\omega_{ij}$ is the proportion of observations with a strictly zero count ($0 \leq \omega_{ij} \leq 1$

#### 4.4.2 Selected trade partners

Of the 27 EU member states, only 15 states (see Appendix A) are considered at this level in order to evaluate the effect of climate change on fruit and vegetable trade flows from East African states owing to the paucity of comparable meteorological data. Omitted countries include Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia, which joined the EU in 2004 while Bulgaria and Romania joined in 2007.

### 4.4.3 Data description and data sources

The empirical analysis is based on panel data collected over a period of 13 years (1988–2000) basically attributable to time series data limitations. Choice of this time period was specifically limited by the availability of both comparable climatological data and the trade flow dataset based on the Harmonized System of nomenclature. The climatological dataset (TYN CY 1.11 dataset) provided by the Tyndall Centre for Climate Change Research spans the period 1901 to 2000, while the trade flow dataset from Trade Analysis and Information System (TRAINS) database only begins from 1988. Therefore, this period is designated for ascertaining the effect of climate change on East Africa's horticultural trade.

Five databases were used to obtain all the required data. These include the TRAINS database (2013), World Bank Development Indicators (WBDI) database (2012), the Food and Agricultural Organization (FAO) database (2013), the African Growth and Development Policy Modelling Consortium (AGRODEP) database (2013) and the TYN CY 1.11 database (2013). The United Nations Statistics Division Common database (COMTRADE) provides a dataset on trade flows. The COMTRADE database (2013) is used to gather data regarding the imports into the EU on a country basis with reference to the exporting country. Although products are classified according to different international classifications, under this study net imports for the EU members at HS 2-Digit level are used.

Climatological data (temperature and precipitation) were obtained from the TYN CY 1.11 database elaborated by Mitchell *et al*. (2004, 2005). This database comprises nine variables, *viz,* daily mean, minimum and maximum temperature (degrees Celsius); daily temperature range (degrees Celsius); frost day frequency (days); precipitation (millimetres); wet day frequency (days); vapour pressure (hectaPascals); and cloud cover (percentage). Meteorological observations were modelled on a 0.5° latitude by 0.5° longitude grid that covers the world land surface (New *et al*., 1999, 2000). For transforming the gridded data into country-level mean values, each grid box was allocated to a single territory and the weighted mean calculated. Mitchell *et al. (*2002) candidly note that weights were chosen according to climatological reasons. In instances where data were insufficient to acquire a value, it was relaxed towards the 1961–1990 mean (Mitchell *et al*., 2002). The value represents the long-run climatological mean (IPCC, 2007). Accordingly, these data transformations result in a dataset with country level climatological information from 1901 to 2000 (Mitchell *et al*., 2002, 2004, 2005).

The existing literature (Barrios *et al.*, 2010; Deschenes and Greenstone, 2007; and Kurukulasuriya *et al.*, 2006) identifies other meteorological data sources, such as the Parameter-Elevation Regressions on Independent Slopes Model (PRISM) dataset which was developed by the Spatial Climate Analysis Service at Oregon State University for the National Oceanic and Atmospheric Administration; the Africa Rainfall and Temperature Evaluation System, created by the Climate Prediction Center of the US National Oceanic and Atmospheric Administration and the US Department of Defense satellites, where data are measured by a Special Sensor Microwave Imager (SSMI), to mention but a few. However, the TYN CY 1.11 database was selected because of two reasons; (*i*) the dataset has no missing values, and (*ii*) unlike other databases, the dataset is availed after aggregation of monthly averages into annual averages at country level, hence making it more user-friendly.

Data relating to Gross Domestic Product (GDP), per capita GDP, air transport (registered carrier departures worldwide), the crop production index (2004–2006 = 100), and inflation were obtained from the World Bank Development Indicators (WBDI) databases. As measured by the consumer price index, inflation reveals the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals (WBDI, 2012).

To proxy for crop production in the importing EU member states, the crop production index based on the production mean of 2004–2006 was used as the base. Notably, Belgium and Luxembourg had missing data between 1981 and 1999. To fill the missing gaps, the annual average of the crop production indexes of neighbouring countries sharing a common border was used. That is, for Belgium, the annual averages for Spain, Germany, Italy and France were used, while for Luxembourg, this index was based on data for France and Germany. Use of this approach was based on the argument that climatic conditions of closely neighbouring countries may not differ so much as to significantly affect agricultural production much differently (Cardamone, 2011). The direct use of production data was curtailed by unavailability of data over long periods.

For the exporting East African states, two sets of data sources were used. In the case of Kenya and Tanzania, data for the total volume of fruits and vegetables produced was used to proxy for the relevance of this sub-sector in international trade of horticultural produce with the EU member states. The fruits and vegetable production data were obtained from the Food and Agricultural Organization (FAO) database. The use of the fruits and vegetable production data, rather than the general crop production index (as done for the importing countries), was motivated by the desire to particularly capture whether fruits and vegetable production influences trade flows in these commodities. However, in the case of Uganda, production data was obtained from the African Growth and Development Policy Modeling Consortium (AGRODEP) database.

Despite the fact that many studies have used the cardinal "great circle" formula which estimates the earth's shape as a sphere and computes the minimum distance along the surface, this study uses distances acquired using the geographical distance. This was motivated by the ease with which the data can be accessed. Distance data is measured as the air distance between the economic centres of selected trade partners with reference from Nairobi (Kenya), Dodoma (Tanzania) and Kampala (Uganda). These data were taken from www.mapcrow.info/distance and www.worldatlas.com.

### 4.4.4 Data management

The data was managed in MS Excel and the Statistical Package for Social Scientists (SPSS) computer program, and thereafter transferred to STATA 12 for further empirical analysis. With the exception of the dependent variable (imports into the EU market) and the dummy variable, all other variables were transformed into natural logs. Imports of fruits and vegetables into the EU were used in a semi-log form so as to take into account zero trade flows. As a rule of thumb, time series were subjected to a number of diagnostic tests as described below.

#### 4.4.4.1 Multi-collinearity

A number of tests can be used to ascertain if a specified model is susceptible to multi-collinearity. Commonly used tests include: Variance Inflation Factor (VIF), Tolerance (TOL), Pearson's correlation, and Klein's test (Gujarati, 2003). For the purpose of this study, three tests (VIF, TOL and Pearson's correlation) were used to check for multi-collinearity between model variables.

#### 4.4.4.2 The Tolerance (TOL) test

According to Belsley *et al. (*1980), the TOL test for any given dependent variable $X_m$ can be expressed as:

$$(TOL)_m = 1 - R_m^2 \quad m = 1, 2, \ldots\ p\text{-}1, \qquad (23)$$

where $R_m^2$ is the R-square, when $X_m$ is regressed on all independent variables, with the constant term inclusive. If the TOL value is less than or equal to 0.1, this then implies that there is supporting evidence for the existence of collinearity.

#### 4.4.4.3 Variance Inflation Factor (VIF) test

With regard to the VIF test for the dependent variable $X_m$, it is computed as the inverse of the tolerance $(TOL)_m$.

$$(VIF)_m = [1 / (TOL_m)]$$

$$= [1 / (1 - R_m^2 \quad m = 1, 2, \ldots\ p\text{-}1)], \qquad (24)$$

The VIF test quantifies the extent to which the variance of the standardized regression coefficient $b_m$* is inflated as a result of collinearity (Belsley *et al.*, 1980). The term *standardized regression model* refers to a regression model in which both the dependent and independent variables are standardized into z-scores with mean 0 and standard deviation 1, and divided by $(n - 1)^{1/2}$.

In a standardized regression model framework, it is postulated that the normal equations **X'Xb** = **X'Y** turn out to be

$$\mathbf{r}_{\mathbf{XX}}\mathbf{b}^* = \mathbf{r}_{\mathbf{YX}}, \qquad (25)$$

where $\mathbf{r}_{\mathbf{XX}}$ is the correlation matrix of **X**, $\mathbf{r}_{\mathbf{YX}}$ are the correlations of **Y** with the **X**, and **b*** is the vector of standardized regression coefficients (Belsley *et al.*, 1980). Hence, it can be proven that $(VIF)_m$ is the $k^{th}$ diagonal element of $(\mathbf{r}_{\mathbf{XX}})^{-1}$. This then implies that

$$s^2\{b_m^*\} = (s^*)^2(VIF)_m = (s^*)^2/(1 - R_m^2), \qquad (26)$$

where $(s^*)^2$ is the error variance of the standardized model (Belsley *et al.*, 1980). As a rule of thumb, a VIF value greater than 10 implies that there is supporting evidence for the existence of multi-collinearity which may be problematic while running regressions.

#### 4.4.4.4 Correlation matrix test

The correlation matrix test is a measure used to show the relationship between any two variables. According to Walker and Madden (2008), multi-collinearity between any two different variables ranges between −1 (perfect negative correlation) and +1 (perfect positive correlation), while the relationship between a variable with itself is +1. Correlation values equalling to zero imply that there is no linear relationship between the two variables. As a rule of thumb, scholars (Anderson *et al.*, 2008, Walker and Madden, 2008, Griffiths *et al*., 1993) note that if the value is not greater than the threshold value of 0.7, then the available data poses no statistical estimation problems.

#### 4.4.4.5 Stationarity (Unit root) test

Before estimating the models, the stationarity properties of the series were examined to establish the order of integration of the variables. A univariate analysis of each of the time series was carried out by testing for the presence of a unit root. When time series are non-stationary or exhibit a unit root, the conventional econometric procedures may not be appropriate (Engle and Granger, 1987; Enders, 1995). Notably, Granger and Newbold (1974) posit that in the presence of non-stationary variables, ordinary least squares regression (OLS) might result in a spurious regression; hence leading to biased and meaningless results. It was therefore important to test for stationarity of the series data so as to set up an appropriate methodology in the development of econometric models.

There is a variety of tests that can be used to test for unit roots of panel datasets. According to StataCorp (2013), stationarity tests can be grouped into two categories, if one uses the criterion based on the null hypothesis being validated by a given tests. The first category comprises tests that have the null hypothesis that all the panels contain a unit root. Such tests include the Levin–Lin–Chu (2002), Harris–Tzavalis (1999), Breitung (2000; Breitung and Das 2005), Im–Pesaran–Shin (2003) (hereafter, IPS-test), and Fisher-type (Choi, 2001) (hereafter, Choi-test). The second category comprises tests that are based on the null hypothesis that all the panels are stationary. For example, Hadri (2000) uses the Lagrange multiplier (LM) test. With the exception of the IPS-test and Choi-test which permit for testing unbalanced panels, all of the other tests assume that the dataset has well-balanced panels.

In that regard, two panel data tests were used to check for unit roots in the series, *viz*, (*i*) the Levin–Lin–Chu (2002) test (hereafter, **LLC-test**) and (*ii*) the Harris–Tzavalis test (hereafter, **HT-test**). Choice of these tests is based on the fact that the dataset consists of strongly well-balanced panels. Secondly, it was desirable to explore the consistence of test results, given the fact that the two tests are grounded in different asymptotic assumptions with regard to the number of panels in the dataset and the number of time periods in each panel. According to StataCorp (2013), the LLC-test requires that the ratio of the number of panels to time periods tends to zero asymptotically, while the HT-test assumes that the number of panels tends to infinity while the number of time periods is fixed.

Notably, these tests are constructed on the *t*-statistic which corresponds to the least-squares (LS) estimator of the autoregressive parameter. As suggested by Dickey and Fuller (1979), the tests are panel data versions of the unit root test in single time series. A variable is said to be integrated of order I(1) if it must be differenced once to become stationary I(0). The integration test is based on the following supporting equation:

$$\Delta y_t = \quad + \text{¢} t + \cdot\ y_{t-1} + \Sigma\, \text{¸}_i \Delta y_{t-1} + \text{¦}_t \quad \text{...............................(27)}$$

where ($y_t$) is the relevant time series variable, (t) is a linear deterministic trend and ($\eta_t$) is an error term with zero mean and constant variance. The general regressions are based on the Ordinary Least Squares (OLS) estimator. Thereafter, the estimated error terms from the final co-integration regressions are tested for unit roots using the tests. The lagged term ($\Delta y_{t-1}$) is included to make certain that the residuals are white noise.

#### 4.4.4.6 Normality and Over-dispersion tests for disaggregated data

Given that this analysis was grounded on disaggregated (count) data, it was necessary to establish the nature of the distribution of the data (Normality test). According to Stata FAQ (2013), normally-distributed data can appropriately be analysed by the Ordinary Least

Squares (OLS). However, in the event that data symmetry abrogates the normal distribution assumption, the OLS estimator would then be an unsuitable estimator. Following Stata FAQ (2013), a simple histogram was used to show the distribution pattern of the data.

As disaggregated (count) data is associated with over-dispersion (Martijn *et al.*, 2009), it was imperative to determine the level of dispersion within the dependent variable series. Over-dispersion refers to a condition where the conditional variance deviates strongly from the conditional mean. The existence of such a discrepancy leads to consistent but inefficient estimates. Inefficiency in coefficient estimates is usually exhibited as large spurious z-values and spuriously small p-values (Gourieroux *et al*., 1984; Cameron and Trivedi, 1986). According to Stata FAQ (2013), statistical theory under the Poisson distribution, which is also associated with disaggregated (count) data, assumes that the mean and variance are the same. Therefore, a large deviation between the mean and the variance provides adequate supporting evidence for the existence of over-dispersion within the series. In order to ascertain if the data was overly dispersed, descriptive statistical analysis was carried out.

### 4.4.5 Computation of anomalies from meteorological data to proxy for climate change

In order to analyse the influence of climate change on East Africa's fruits and vegetable imports into the EU, two measures (temperature and precipitation anomalies) derived from meteorological data were used to proxy climate change. The use of anomalies from meteorological data is grounded on the fact that the commonly used Kyoto Protocol policies, such as the carbon tax, do not ably reflect issues pertaining to developing economies reliant on agriculture (Hoekman and Nicita, 2011; Bineau and Montalbano, 2011). Thus, this renders such policies being apt for industrious economies. Secondly, such measures often ignore the fact that climate change is a complex phenomenon, characterized by interdependence between climatic- and weather-related natural factors.

From another point of view, Bettin and Nicolli (2012) argue that there exists no consensus about the best indicators of climate change to be fitted in models, amidst a set of 23 aggregate environmental indexes which could be used to proxy climate change. Furthermore, it is postulated that most of these environmental indexes are inappropriate in explaining the trend of climate change at a global level. Worse still, authors mention that these environmental indicators are grossly limited by their incapability to cover many countries and cannot distinguish local effects of climate change. Notably, IPCC (2007) shows that climate change manifests itself through temperature and precipitation fluctuations (among others ways), thus affirming that environmental indexes and Kyoto Protocol policies, as climate change proxies may not be limited to being mutually inclusive.

In light of the above-mentioned challenges, the trend in empirical research has moved towards the use of meteorological data, from which anomalies used to proxy climate change have been generated. The proxies were computed at country level following the earlier work of Bettin and Nicolli (2012), Barrios *et al. (*2010), Marchiori *et al*. (2010), and Barrios *et al*. (2006). However, with due acknowledgement, it is prudent to mention that none of the above scholarly works focuses on international trade per se.

Anomalies were computed as expressed in the general formula below:

$$T_{n,t} = \left[ \frac{T_{i,t} - T_i}{SD_{i,t}} \right] \qquad (28)$$

where $T_{n,t}$ denotes temperature anomaly in degrees Celsius (°C) of country *n* at time *t*. Country *n* represents either an exporter *I*, or importer *j*, $T_{i,t}$ denotes temperature of exporting country *i* at time *t*, $T_i$ is the long-run country average temperature value, while $SD_{i,t}$ denotes the long-run standard deviation of temperature in country *i*. Notably, the same formula applies for computing temperature anomalies in an importing country, except that instead of *i*, symbol *j* is used to denote an importer. A similar approach is used to obtain precipitation anomalies in millimetres (mm/year), denoted as $Pre_{n,t}$. in both the importing and exporting country

Bettin and Nicolli (2012) mention that the use of meteorological data to proxy for climate change is advantageous over other measures because (*i*) it gives a better reflection of the real effects of climate change, and (*ii*) such data are available in long time series for a majority of the economies internationally. Despite the fact that meteorological data could be used in the form of year by year variation to proxy climate change, Barrios *et al*. (2010), Nicholson (1986) and Munoz-Diaz and Rodrigo (2004) argue that the use of anomalies reduces the potential scale effects, which are associated with the year by year variation approach. Secondly, unlike the year-by-year variation in meteorological data as a proxy for climate change, anomalies take into consideration the likelihood of higher variance in the data for the more arid countries. Furthermore, Berg *et al.* (2013) argue that anomalies are methodically appropriate when undertaking large-scale estimation of climate change impacts on agro-ecosystems, given that they eliminate any mean biases from model outputs. The authors further argue that, "It is arguably the only direct method to get around large-scale climate model biases for impact assessments."

### 4.4.6 Specification of the regression model to ascertain the influence of climate change on East Africa's horticultural trade flows

The specified model generally builds on the gravity flow model framework. Over the years, the gravity model has been acknowledged to be the utmost authoritative tool in explaining bilateral trade flows (Anderson, 1979). Mathematically, empirical specification is expressed as:

$$X_{ijt} = \sim_{ij} + {}_1\ln Y1_{it} + {}_2\ln Y2_{jt} + {}_3\ln D_{ij} + {}_4 DT_{it} + {}_5 DT_{jt} + {}_6 \mathrm{Pre}_{it} + {}_7 \mathrm{Pre}_{jt} + {}_8\ln Agri_{it} + {}_9\ln Agri_{jt} + {}_{10}\ln Incom_{ijt} + {}_{11}\ln Infra_{it} + {}_{12}\ln Inflat_{it} + {}_{13} Dlang + \pounds_{ijt}$$

........(29)

where *ln* denotes natural logarithms, $X_{ijt}$ represents net imports of horticultural commodities into the EU market (where *j* denotes a specific country within the EU) from East African states (denoted as *i* if it is either Uganda, Kenya or Tanzania) in year *t* in ('000) US Dollars. $Y_1$ and $Y_2$ represent the Gross Domestic Product (GDP) in current terms (US$) of the exporting and importing country in year *t*, respectively. The term $D_{ij}$ denotes the geographical distance between any two trading partners in miles, while anomalies in temperature in the exporting and importing country at a given time are represented as $DT_{it}$ and $DT_{jt}$, respectively. Variables $Pre_{it}$ and $Pre_{jt}$ denote anomalies in precipitation in the exporting and importing country, respectively. Variables $Agri_{it}$ and $Agri_{jt}$ represent level of crop production in the exporting and importing country, respectively. $Incom_{ijt}$, $infra_{it}$ and $inflat_{it}$ denote Linder's income similarity index (measured as the squared per capita differential between any two trading partners in year t), the level of infrastructure and the level of inflation in the exporting country *i* in year *t*, respectively. Dlang is a dummy variable for a common official language between any two trading partners (= 1 if any two trading partners share a common official language; and Zero otherwise). $\varepsilon_{ij}$ is the error term.

To evaluate the influence of climate change on horticultural trade flows, total net imports of fruits and vegetables into the EU at HS 2-digital level (chapters 7 and 8) were used. The use of imports as the dependent variable instead of exports is motivated by the fact that imports are more reliable since it is easier to check for the incoming flows of goods. Furthermore, given that this study in part evaluates the impact of the non-reciprocal EU-GSP scheme, it is prudent to consider only imports into the EU from EAC countries, rather than exports or total trade flows. The use of combined data for fruits and vegetables rather than dealing with them separately was aimed at overcoming the problem of non-convergence, which is associated with disaggregated data owing to the excessive zero trade flows. The high zero trade flows during this period (1988–2000) can probably be attributed to the fact that the East African states had not fully liberalized their economies by the early 1990s, and this could have played a role in deterring trade with EU member states. Hence, the high proportion of zero trade flows.

Even after the full economic liberalization of East African (EA) states in the mid-1990s, some EU countries, such as Luxembourg, did not trade at all in fruits and vegetables with any of the EA states. Portugal also registered no trade at all with Uganda (for Fruits and vegetables) and Tanzania (for Fruits only). Other EU member countries that registered zero trade flows in either vegetable commodities (07) or Fruits commodities (08) throughout the entire period of 1988–2000 with at least one or two EA states include Austria, Belgium, Denmark, Finland, Greece, Ireland, Italy, Spain and Sweden. Chapter 8 (Fruits) registered a total of nine (9) EU member states with no trade flows with EA states during the 13 year period, while data shows that 8 EU states did not trade at all in vegetable products (chapter 7) with EA states.

Thus, use of combined data would greatly reduce the incidences of zero trade flows, thereby enhancing model convergence during the analysis. Rather than real values, nominal monetary values of both fruit and vegetable imports into the EU market were used as the dependent variable. Trade flows should be measured in nominal terms, given that the use of price indices such as the GDP deflator or the Consumer Price Index (CPI) to deflate trade flows does not appropriately capture the unobservable multilateral resistance terms, leading to misleading results.

#### 4.4.6.1 Other covariates used

*Gross Domestic Product* ($Y1_{it}$ / $Y2_{jt}$): Gross domestic product of trading partners represents both their production and consumption capacity, hence largely influencing the trade flow amongst them. The GDPs are used to proxy for the economic sizes of the countries and it is expected that an importing country's GDP ($Y2_{jt}$) plays a significant role in determining the trade flow originating from exporting countries. Like the income of the consumer, the importing country's GDP determines the demand for the goods originating from exporting countries. An exporting country's GDP ($Y1_{it}$) also helps in ascertaining the productive capacity of the exporting country, *that is*, the amount of the goods that could be supplied. Since it is expected that an exporting country's GDP influences the trade flow of goods and services originating from that country, an increase in the GDP of any two or more trading countries also causes a rise in trade flows. Thus, GDP coefficients are expected to be positive.

*Distance* ($D_{ij}$) is a key variable used to proxy for the associated trade costs between trade partners. Distance is a trading resistance factor that represents trade barriers such as transportation costs, delivery time, cultural unfamiliarity and market access barriers. Among other factors, higher transportation costs reduce the volume of trade and increase information costs. Countries with short distances between each other are expected to trade more than those that are far apart because of reduced transaction costs. Distance can also be used as a proxy for the risks associated with the quality of some of the goods and the cost of the personal contact between managers and customers.

The use of this approach follows Giorgio (2004) and Keith (2003), and is intended to avoid the shortcomings associated with the "great circle" formula. In addition, Qadri (2012) and Christie (2002) mention that alternative variables like "transport time", which could be used instead of geographical distance, do not significantly improve the model's performance. Despite the fact that the coefficient of distance is theoretically expected to negatively influence the flow of trade between countries, some scholars (Andre and Joel, 2012; Marimoutou *et al.*, 2009; and Brun *et al.*, 2005) show that distance may well positively influence trade. However, based on the gravity model framework, the distance coefficient is expected to be negative.

Basing on the work of Carrère (2006), Acosta *et al*. (2005) and Longo and Sekkat (2004), the model was also augmented to capture the effect of infrastructure on trade flows. Unlike the commonly used proxies (average of the road density, railway and the number of telephone lines per capita), the infrastructure variable for the exporting EA states was measured by the number of aircraft departures, following André and Joel (2012). Use of this proxy was motivated by two factors: (*i*) there was limited data on road and railway networks for East African states. For some countries, data is either unavailable or incomplete (WBDI database, 2012). (*ii*) The study commodities (fruits and vegetables) are very perishable and more often than not, they are always airlifted in planes into the EU markets before they go bad. This data was obtained from the WBDI database (2012). Availability of good infrastructure reduces trade barriers, thereby minimizing the associated trade costs. Thus, the coefficients of infrastructure variables are expected to be positive.

The income similarity index ($Incom_{ijt}$) refers to the squared per capita GDP differential. This explanatory variable was developed by Arnon and Weinblatt (1998). In some cases, it is also referred to as the Linder's income similarity. Inclusion of the square of the difference in per capita income between country *i* and *j* follows Philippidis *et al. (*2011) and Tang (2005). In the gravity model framework, the index aims at distinguishing between the Linder hypothesis and Heckscher-Ohlin (H-O) hypothesis effects. The Linder hypothesis states that countries with similar demand patterns (often measured by a small difference in their per capita income levels, Tang, 2005) tend to develop similar industries and these countries end up trading more with each other in similar, but differentiated products. This variable is expected to negatively affect trade flows between the East African region and the EU market. A negative value implies that trade between countries with similar incomes would increase as their income difference decreases. However, this contradicts the traditional Heckscher-Ohlin theories of trade which argue that countries with differing per capita GDP levels tend to trade more than those at the same level do. Thus, the coefficient may well be positive.

In order to capture an exporting country's propensity to trade in fruits and vegetables and to represent the relevance of the agriculture sector, the model was augmented with a variable $Agri_{it}$. The variable denotes the total volume of fruits and vegetables produced in a given EA state *i* during period *t* in tonnes. Fruit and vegetable production data was obtained from the FAO database (2013). According to Alvarez-Coque and Martì-Selva (2006), the coefficient for an exporting country's propensity to trade in fruits and vegetables ($Agri_{it}$) is expected to be positive, given that increased production in exporting countries may result in increased supply of tradable commodities.

On the contrary, EU trading partners' predisposition to import fruits and vegetables was modelled with the use of the crop production index, denoted as $Agr_{ijt}$, and crop production data were obtained from the WDI database of 2012. *Ceteris paribus,* increased crop production, more so in fruits and vegetables in the EU member states, creates a reliable and sufficient supply of such commodities. This renders importation of fruits and vegetables into the EU market undesirable and in lieu to that, a negative coefficient for the importing country's crop production index is expected.

For inflation ($Inflat_{it}$), an exporting country's annual average inflation rate was also added to the gravity model. Inflation data was obtained from the WDI database of 2012. According to the database, inflation was measured by the consumer price index which reflects the annual percentage change in the cost to the average consumer of acquiring a basket of goods and services that may be fixed or changed at specified intervals. Generally, inflation is used to measure a country's state of macroeconomic stability. Low inflation regimes imply that a country is in a more stable economic condition, and this is an incentive for global trade. According to Barro (1991), lower inflation may promote higher economic growth through the development of capital markets and trade amongst others. On the other hand, high inflation deters global trade. Thus, the expected sign of the inflation coefficient is indeterminate.

Dlang is a dummy variable which denotes common language (=1 if share a common language; and = 0 otherwise). This dummy captures the influence of common language on trade flows among the trading partners. Given that countries sharing a common language tend to have common historical ties, among other cultural similarities, this presents more trading opportunities. Thus, the expected sign of the estimated coefficients is positive.

To control for heterogeneity across countries, this study employs a similar approach to that of Aiello and Demaria (2009). A dummy variable (Dlang) and country-fixed effects were used. In this context, other than estimating the effects of having a common official language on trade flows between a country pair, the dummy variable (Dlang) is also used to overcome heterogeneity due to observable factors. On the other hand, the unobservable heterogeneity is overcome through the inclusion of country-fixed effects. In this regard, unobserved heterogeneity was accounted for through the decomposition of the error term of equation (30) as presented below:

$$\varepsilon_{ijt} = \mu_{ij} + \lambda_{ijt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(30)$$

where $\mu_{ij}$ denotes time-invariant country-fixed effects and $\lambda_{ijt}$ is an idiosyncratic error term. Accordingly, Aiello and Demaria (2009) posit that the country-fixed effects capture all unobserved factors that influence trade flows. Thus, the specified model in equation 30 transforms into:

$$X_{ijt} = \alpha_{ij} + \beta_1 \ln Y1_{it} + \beta_2 \ln Y2_{jt} + \beta_3 \ln D_{ij} + \beta_4 DT_{it} + \beta_5 DT_{jt} + \beta_6 \mathrm{Pre}_{it} + \beta_7 \mathrm{Pre}_{jt} + \beta_8 \ln Agri_{it} + \beta_9 \ln Agri_{jt} + \beta_{10} \ln Incom_{ijt} + \beta_{11} \ln Infra_{it} + \beta_{12} \ln Inflat_{it} + \beta_{13} Dlang + \mu_{ij} + \lambda_{ijt} \quad .(31)$$

### 4.4.7 Estimation techniques used

To determine the effects of climate change on East African states' fruit and vegetable imports into the EU market, various estimation techniques were used, depending on the properties of the data at country level. Generally, count data estimation techniques, namely the Negative Binomial Regression (NBR) and the Zero Inflated Poisson (ZIP) estimators were used. For Uganda's case, the NBR estimator was used, while the ZIP was employed on Kenya's and Tanzania's datasets. The use of these count data estimation techniques closely relates to work done by Santos Silva and Tenreyro (2006), Linders and De Groot (2006), Helpman *et al*. (2008), Martin and Pham (2008), Proenca *et al*. (2008), Siliverstovs and Schumacher (2009), and Burger *et al*. (2009). These estimation techniques overcome the challenges of over-dispersion and excessive zero trade flows, which are highly associated with disaggregated data (Greene, 1994; Stata FAQ, 2013). Additionally, these estimation techniques are able to estimate the multiplicative form of the gravity equation, thus giving more reliable results relative to the log-linear specification estimations of the model based on the standard methods.

A quick overview of the expected signs of the coefficients of all variables is presented in the table below.

**Table 4.1: A summary of the expected sign of climate change variables and other covariates on fruits and vegetable imports into the EU market**

| Variable | Expected sign |
|---|---|
| **Dependent variable ($X_{ijt}$)** = Net imports of commodity *k* to a specific country *j* within the EU from East African states (denoted as *i* if it is either Uganda, Kenya or Tanzania) in year t in (000) US$ | |
| Temperature anomalies in the exporting country at a given time in $^0$C **($DT_{it}$)** | **+/-** |
| Temperature anomalies in the importing country at a given time in $^0$C **($DT_{jt}$)** | **+/-** |
| Precipitation anomalies in the exporting country at a given time in millimetres (mm) **($Pre_{it}$)**. | **+/-** |
| Precipitation anomalies in the importing country at a given time in millimetres (mm) **($Pre_{jt}$)**. | **+/-** |
| Exporter's Gross Domestic Product (GDP) in current US$ **($lnY1_{it}$)** | **+/-** |
| Importer's Gross Domestic Product (GDP) in current US$ **($lnY2_{jt}$)** | **+/-** |
| Distance in miles between trading partners **($lnD_{ij}$)** | **-** |
| Crop production (tonnes) in the exporting country **($\ln Agri_{it}$)** | + |
| Crop production (index) in the importing country**($\ln Agri_{jt}$)** | **-** |
| Linder's income similarity index **($Incom_{ijt}$)** | **+/-** |
| Level of infrastructure in the exporting country *i* in year *t* (i.e. the number of registered aircraft carrier departures worldwide) **($\ln infra_{it}$)** | + |
| Inflation level in the exporting country *i* in year *t* **($\ln inflat_{it}$)** | **+/-** |
| Dummy variable for common language (=1, if share common official language; = 0 otherwise) (**$Dlang_{ij}$**) | + |

## 4.5 Estimating the effect of the EU-GSP scheme on East Africa's fruits and vegetable imports into the EU market

This sub-section aims at evaluating the impact of non-reciprocal preferential treatment, particularly the EU-GSP Scheme on fruits and vegetable imports from East African states (Uganda, Kenya and Tanzania). Achievement of this objective was based on the first objective, under which an evaluation of the export competitiveness of the fruits and vegetable commodities from East African states into the EU market was conducted. From each East African state, two commodities were chosen following two basic principles. (*i*) If the commodity exhibited an average export competitiveness index (RCA) of greater than one across all the three countries, and (*ii*) if the commodity revealed the highest RCA amongst all commodities exported from a given country. The gravity model was used, as recommended by Linder (1961), Linnemann (1966) and Anderson and van Wincoop (2003), given that it takes into account a broad spectrum of factors that inevitably influence trade flows.

### 4.5.1 Data and data sources

Evaluation of the effect of the EU-GSP Scheme on horticultural trade flows was grounded on the 15 EU member states (EU-15) which joined before the year 2000. Focusing only on these EU member states was based on the assumption that these states had established adequate trade relations during the 1990s when Uganda, Kenya and Tanzania fully liberalized their economies. Thus, late entrants into the EU were left out (See Appendix A). The research focused on panel data collected over a period of seven (7) years (2005–2011), with the aim of tracking the changes in the tariffs, specific duties and Tariff Rate Quotas (TRQs) of the EU-GSP scheme during this period.

Secondly, the choice of this period was motivated by the fact that it was during this period that the fruit and vegetable sector registered a significant increase in exports from East Africa, coupled with drastic changes in the tariffs, specific duties and TRQs under the EU-GSP scheme. These drastic changes in the tariffs, specific duties and TRQs could probably be associated with the prevalent preference erosion at the time. Given the aim to evaluate a specific policy (EU-GSP scheme) applied at product level, disaggregated data at the HS 6-Digit level was used. These trade flow data were obtained from two databases, that is, the ITC-Market Access Map (MAcMap) database and the TRAINS database. These provide data on imports into the EU on a country basis with reference to the exporting country. Although products are classified according to different international classifications, under this study net imports by EU member states at HS 6 were used.

Data on tariff rates, specific duties and TRQs were also obtained from UNCTAD's Trade Analysis and Information System (TRAINS) and COMTRADE databases, a World Bank initiative which provides information on highly disaggregated products. These databases provide ad valorem equivalents (AVE) transformed from specific and complex duties by using an estimate of unit values based on EU import statistics from the COMEXT database. The databases use UNCTAD method 1 (U1) to convert all tariffs, duties and quotas into AVEs. Data relating to Gross Domestic product (GDP), crop production index (2004–2006 = 100), and inflation were obtained from World Bank Development Indicators (WBDI) databases.

Despite the fact that many studies have used the cardinal "great circle" formula which estimates the earth's shape as a sphere and computes the minimum distance along the surface, this study uses distances acquired using the geographical distance. The choice to use geographical distances is motivated by the ease with which the data can easily be accessed. Distance is measured as the air distance between the economic centres of selected trade partners with reference from Nairobi (Kenya), Dodoma (Tanzania) and Kampala (Uganda).

### 4.5.2 Data management

The data was managed in MS Excel and the Statistical Package for Social Scientists (SPSS) computer program, and thereafter transferred to STATA 12 for further analysis. With the exception of the dependent variable (imports into the EU market) and the dummy variables, all the other variables were transformed into natural logs. Given that the natural log of zero is undefined, imports of fruits and vegetables into the EU were used in a semi-log form to take into account zero trade flows. Panel data was the subjected to a number of diagnostic tests, as described in detail (See section 4.4.3).

### 4.5.3 The preference margin as a proxy for the effects of the EU-GSP Scheme on fruit and vegetable imports into the EU market

More often than not, variables that capture unilateral preferential treatment, such as the EU-GSP Scheme, are measured using dummy variables. However, this is problematic given that dummy variables simultaneously capture a range of other country-pair-specific effects. In addition, dummy variables do not differentiate between the different preferential trade policy instruments (preferential tariff margins, preferential quotas, reduced 'entry prices'), nor do they tell the difference in the level of trade preferences. This therefore implies that dummy variables assume that the level of preference margin across products under a given preferential treatment (like the EU-GSP Scheme) is the same. However, in reality, preferential margins may greatly differ, depending on the commodity under consideration, and may also differ across the various preferential treatments (MAcMap, COMTRADE and TRAINS databases).

Thus, in order to analyse the effects of the EU-GSP Scheme on East Africa's fruits and vegetable imports into the EU, a count variable (preference margin) was used to capture such effects. For each East African state and for each selected commodity, a preference margin was computed. A competition-adjusted Preferential Margin measure proposed by Low *et al.* *(*2005) was used. Following Cardamone (2010), the preference margin was computed as the absolute difference between the trade weighted applied Most Favoured Nation (MFN) rate and the Ad Valorem Equivalents as expressed below:

Preference Margin = Trade-weighted applied MFN rate – AVE ……………..(32)

where AVE denotes the Ad Valorem Equivalent. An ad valorem equivalent tariff refers to a tariff presented as a proportion of the value of goods cleared through customs. It is the equivalent of a corresponding non-ad valorem tariff measure based on unit quantities, such as weight, number or volume.

The measure of preference margin was based on a combination of trade-weighted applied MFN rates, tariff rates, specific duties and Tariff Rate Quotas, which differs from the approach taken by other scholars (Cipollina *et al.*, 2013; Raimondi *et al.*, 2012; Cipollina and Salvatici, 2009). The trade-weighted applied MFN rate takes into account the global competitors at tariff line level and the weights are based on reference group imports. In this context, East Africa’s reference group is the set of all countries categorized as the Least Developed Countries (LDCs). These countries are granted similar preferential treatment within the EU market; hence they are the major competitors with Kenya, Tanzania and Uganda at that level. According to Fugazza and Nicita (2010), the use of a combination of these trade policy instruments enhances the disclosure of other additional advantages or disadvantages that come along with preferential treatment.

#### 4.5.3.1 Computation of the Ad Valorem Equivalents (AVEs)

Agriculture is known to be one of the most protected sectors, globally (Bouët *et al.*, 2004). Agricultural protection is extended to sensitive commodities in the form of various instruments, such as ad-valorem tariffs, specific duties or a combination of the two, antidumping duties and tariff rate quotas (TRQs). These instruments cannot be directly compared or summed, thus implying that they cannot readily be used in large-scale modelling exercises. For this reason they are converted into Ad Valorem Equivalents (AVEs) using various methods.

For the purpose of this study, AVEs were obtained using UNCTAD's three-step method for estimating unit values of the commodities, *viz,* (*i*) the use of tariff line import statistics of the destination country available in TRAINS; (*ii*) but if (*i*) is not available, then HS 6-digit import statistics of the market country from COMTRADE are opted for. In the event that both (*i*) and (*ii*) are not available, then the HS 6-digit import statistics of all OECD countries are employed. Thus, when the unit value has been estimated, it is then used for all types of rates (MFN and preferential rates).

This conversion does not, however, take into account mixed tariffs which involve the use of either a maximum or a minimum operator. The choice of this approach over the others relies on the following facts: (*i*) the revenue method is cumbersome, disregards the question of quality differences, and is clearly unfit in the presence of many preferential agreements; and (*ii*) the price wedge estimation method is hardly tractable when using highly disaggregated data (Bouët *et al.*, 2004; WTO, 2003; Gibson *et al.*, 2001).

### 4.5.4 Specified regression model to capture the effect of the EU-GSP Scheme on East Africa's fruits and vegetable trade flows into the EU market

An augmented gravity model presented in the equation below was used, with total monetary value of commodity *l* from the *i* th East African state to j th EU member state in year t in thousand US Dollars ($M_{ijlt}$) as the dependent variable.

$$M_{ijlt} = \sim_{ij} + {}_1\ln Y1_{it} + {}_2\ln Y2_{jt} + {}_3\ln D_{ij} + {}_4\ln PM_{ijlt} + {}_5\ln Infl_{it} + {}_6\ln COSTEXP_{it} + {}_7\ln GOV_{it} + {}_8\ln FDI_{it} + {}_9\ln COSTBIZ_{it} + {}_{10}Dlang_{ij} + \pounds_{ijlt} \quad (33)$$

$lnY1_{it}$ and $\ln Y2_{jt}$ denote the natural logarithm of current Gross Domestic Product (GDP) of each *i* th EA state and *j* th EU member state, respectively in year t in US Dollars; $lnD_{ij}$ is distance between the economic centres (Nairobi, Dodoma and Kampala) and their $j^{th}$ trading partner's commercial centre in miles. The variable $ln\mathrm{PM}_{ijlt}$ represents the preference margin granted under the EU-GSP scheme (excluding the Drugs Regime and the Everything But Arms (EBA initiative). $\mathrm{Lninflat}_{it}$ is the mean annual inflation rate of each EA state in year t; $ln\mathrm{COSTEXP}_{\mathrm{it}}$ denotes the cost to exporting a 20-foot container in US dollars, while $ln\mathrm{GOV}_{\mathrm{it}}$ captures role of the public sector and government institutions in fostering trade. The variable $ln\mathrm{FDI}_{\mathrm{it}}$ represents net inflows of foreign direct investment of each EA state in year t in current US Dollars. $ln\mathrm{COSTBIZ}_{\mathrm{it}}$ refers to the cost of establishing a business. $\mathrm{Dlang}_{\mathrm{ij}}$ is a dummy variable that values 1 when countries *i* and *j* share the same official language, and 0 otherwise. $\varepsilon_{ijlt}$ denotes the associated error term.

*Gross Domestic Product* ($\mathrm{Y1}_{\mathrm{it}}$ / $\mathrm{Y2}_{\mathrm{jt}}$): The gross domestic product of trading partners represents both the productive and consumption capacity, hence largely influencing the trade flow amongst them. Thus, GDP coefficients are expected to be positive. Similarly, the distance variable ($D_{ij}$) is used to proxy the associated trade costs between trade partners. Theoretically, the coefficient on this variable is expected to negatively influence trade flows. However, scholars (André and Joel, 2012; Marimoutou *et al.*, 2009; and Brun *et al.*, 2005) show that distance may not necessarily deter trade, especially in instances where the importing country's economy is very large relative to the exporter's and depending on the type of commodities being transacted. Based on the gravity model architecture, the coefficient of distance is expected to be negative.

The preference margin variable ($ln\mathrm{PM}_{ijlt}$) captures the effect of the EU-GSP scheme at specific commodity level. Depending on the type of commodity and country of origin, the expected sign of the coefficient on the variable is indeterminate, given that in some instances a higher preference margin may favour other reference group countries (LDCs), thus these outcompete the EA states in the EU market. On the other hand, higher preference margins may boost imports of commodities into the EU, given that Uganda, for example, produces organic agricultural products which are in high demand in developed economies.

To capture the effect of macro-economic stability on trade, the model was augmented with the exporting country's mean annual inflation rate ($\text{Infla}_{it}$). This data was obtained from the WBDI database (2012). Low inflation regimes imply that a country is in a more stable economic condition, and this is an incentive for global trade. According to Barro (1991), lower inflation may promote higher economic growth through the development of capital markets, trade among others. On the other hand, high inflation deters global trade. Thus, the expected sign of the inflation coefficient may be positive or negative.

$ln\text{COSTEXP}_{\text{it}}$ denotes the cost to exporting a 20-foot container in US dollars. The cost entails all the associated fees (documents fees, customs clearance and technical control administrative fees, customs broker fees, terminal handling charges and inland transport) required to accomplish the procedures to export. Notably, the variable does not include tariff or trade costs (WBDI database, 2012). Increasing export costs are a barrier to trade, thus a negative sign is expected for this variable.

The variable $ln\text{GOV}_{\text{it}}$ represents the role of the public sector and government institutions in fostering trade. The average un-weighted Country Policy and Institutional Assessment (CPIA) index for transparency, accountability, and corruption was used. The index ranges between one (1) and six (6) (1 = low, to 6 = high) and data was obtained from the WBDI database (2012). The index evaluates the extent to which public sector administrators can be held answerable for the use of public resources and for the results of their actions by the electorate and by the legislature and judiciary, and the extent to which public employees within the executive are required to account for administrative decisions, use of resources, and results obtained. The estimated coefficient for this variable is expected to be positive.

The net inflow of foreign direct investment ($ln\text{FDI}_{it}$) measures the influence of FDI on international trade flows. Data on FDI was obtained from the WBDI database (2012). On the one hand, FDI may be seen as a means through which to boost trade, given that it may serve the purpose of enhancing the efficient use of the factor endowments in a given country, thereby boosting production and trade. On the other hand, FDI in a country may deter trade flows from a country after a certain time lag, probably due to focusing on producing for the domestic market. Thus, the expected sign on the coefficient of this variable is indeterminate.

The cost of establishing a business (*ln*COSTBIZ$_{it}$), expressed as the proportionate share of per capita Gross National Income (GNI), was obtained from the WBDI database (2012). The existence of many bureaucratic procedures and the associated costs while opening up a business tend to discourage investment in business ventures. Thus, the expected sign of the estimated coefficient is negative. Dlang$_{ij}$ is a dummy variable which denotes common language ( = 1 if sharing a common language; and = 0 otherwise). This dummy captures the influence of common language on trade flows among the trading partners. Given that countries sharing a common language tend to have common historical ties, among other cultural similarities, this represents more trading opportunities. Thus, the expected sign of the estimated coefficients is positive.

To control the heterogeneity across countries, country pair time-invariant effects and a dummy variable were used. Other than estimating the effects of having a common official language on trade flows between a country pair, the dummy variable (Dlang) is also used to overcome heterogeneity due to observable factors. The unobservable heterogeneity is overcome through the inclusion of country-fixed effects. In this regard, unobserved heterogeneity was accounted for through the decomposition of the error term of equation (34), as expressed below:

$$\varepsilon_{ijlt} = \mu_{ij} + \lambda_{ijlt} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(34)}$$

where $\mu_{ij}$ denotes time-invariant country pair effects and $\lambda_{ijlt}$ is an idiosyncratic error term. Accordingly, Aiello and Demaria (2009) posit that the country pair time-invariant effects capture all unobserved factors that influence trade flows. Thus, the specified model in equation 34 becomes:

$$M_{ijlt} = \alpha_{ij} + \beta_1 \ln Y1_{it} + \beta_2 \ln Y2_{jt} + \beta_3 \ln D_{ij} + \beta_4 \ln PM_{ijlt} + \beta_5 \ln Infl_{it} + \beta_6 \ln COSTEXP_{it}$$
$$+ \beta_7 \ln GOV_{it} + \beta_8 \ln FDI_{it} + \beta_9 \ln COSTBIZ_{it} + \beta_{10} Dlang_{ij} + \mu_{ij} + \lambda_{ijlt} \quad \text{....(35)}$$

An overview of the expected signs of the coefficients of all variables is presented in the table below.

**Table 4.2: A summary of the expected sign of the effect of the EU-GSP scheme and other covariates on fruits and vegetable imports into the EU market**

| **Variable** | **Expected sign** |
|---|---|
| **Dependent variable ($M_{ijlt}$)** = Total monetary value of commodity *l* from the *i* th East African state to *j* th EU member state in year *t* in '000 US Dollars ($M_{ijlt}$) | |
| Preference margin of a specific commodity, expressed as a percentage of the product value ($lnPM_{ijlt}$) | +/- |
| Exporter's Gross Domestic Product (GDP) in current US$ ($lnY1_{it}$) | +/- |
| Importer's Gross Domestic Product (GDP) in current US$ ($lnY2_{jt}$) | +/- |
| Distance in miles between trading partners ($\ln D_{ij}$) | - |
| Exporting country's mean annual inflation rate ($lninflat_{it}$) | +/- |
| Cost to exporting a 20-foot container in US$ per container ($lnCOSTEXP_{it}$) | - |
| The role of the public sector and government institutions, expressed as an index (*from 1=low to 6= high*) ($lnGOV_{it}$) | + |
| Net inflow of foreign direct investment in current US$ ($lnFDI_{it}$) | +/- |
| The cost of establishing a business, expressed as percentage of Gross National Income (GNI) per capita ($lnCOSTBIZ_{it}$) | - |
| Dummy variable for common language (=1, if share common language; = 0 otherwise) ($Dlang_{ij}$) | + |

### 4.5.5 Estimation techniques used

To ascertain the effects of the EU-GSP scheme on East Africa's horticultural exports into the EU market, the Zero Inflated Poisson (ZIP) and Negative Binomial Regression (NBR) estimators were used. The use of the NBR estimator follows Green (1994) and Stata FAQ (2013) who argue that it is in most instances an apt estimator of datasets characterized by over-dispersion. On the other hand, the use of ZIP model relates to work done by Santos Silva and Tenreyro (2006), Linders and de Groot (2006), Helpman *et al*. (2008), Martin and Pham (2008), Proenca *et al*. (2008), Siliverstovs and Schumacher (2009), and Burger *et al*. (2009) who urge that it can deal with excessive zero values and over-dispersion. Highly disaggregated data, upon which this analysis is grounded, is very susceptible to over-dispersion of the data and too many zero trade flows (Martijn *et al.*, 2009). Additionally, the estimation techniques are able to estimate the multiplicative form of the gravity equation, thus giving more reliable results relative to the log-linear specification estimations of the model based on the standard methods.

### 4.6 Predicting unilateral Trade Potential and performance

The *out of sample* approach was used to calculate each East African state's potential in exporting a given commodity to the EU market. This approach uses the estimated variable coefficients to predict the trade potential. The specified model below was used to predict the trade.

$$M_{ijlt} = \alpha_{ij} + \beta_1 \ln Y1_{it} + \beta_2 \ln Y2_{jt} + \beta_3 \ln D_{ij} + \beta_4 \ln PM_{ijlt} + \beta_5 \ln Infl_{it} + \beta_6 \ln COSTEXP_{it} + \beta_7 \ln GOV_{it} + \beta_8 \ln FDI_{it} + \beta_9 \ln COSTBIZ_{it} + \beta_{10} Dlang_{ij} + \gamma_{ij} + \varepsilon_{ijlt} \quad \text{....(36)}$$

where $\alpha_{ij}$ denotes the constant and $\beta_1$- $\beta_{10}$ represent coefficients of the variables already defined in equation (34). According to researchers (Wang and Winters, 1992; Hamilton and Winters, 1992; and Brulhart and Kelly, 1999) the difference between the actual and predicted trade flows represent the export potential. Thus, a negative value implies that there exists un-exhausted export potential, hence supporting evidence that there is room for trade expansion. On the other hand, a positive value implies that there is hardly any room for expansion of trade. The same data spanning a seven-year period (2005–2011) that were employed to evaluate the impact of the EU-GSP Scheme were also used in this scenario.

The analysis followed Lubinga (2009), Lie *et al.,* (2002) and Amita (2004). Trade performance was evaluated using two indices, the *Relative difference* (*Rd*) and *Absolute difference* (*Ad*). The *Relative difference* (*Rd*) index was computed as expressed in equation (37). The mean predicted trade value together with the mean actual trade value were used as:

$$Rd_{ijlt} = \left( \frac{\psi_{ijlt} - \hat{\psi}_{ijlt}}{\psi_{ijlt} + \hat{\psi}_{ijlt}} \right) * 100 \text{.......................................................................(37)}$$

where $Rd_{ijlt}$ denotes relative difference of each East African state's trade flows with trade partner j. $\psi_{ijlt}$ denotes mean actual trade and $\hat{\psi}_{ijlt}$ is the mean predicted trade. The relative difference index varies between −1 and 1. Relying on the existing status quo, the *Rd index* is an indicator of the status of trade performance between trade partners and it gives an insight into the future direction of trade (Chen *et al.*, 2007). Positive values imply that there exists good trade performance, an indication of cooperation between the trading parties.

The *Absolute difference* ($Ad_{ijlt}$) Index was also used to analyse trade performance.

$$AD_{ijlt} = \cdot_{ijlt} - \text{¤}_{ijlt} \qquad (38)$$

where $\psi_{ijlt}$ denotes mean actual trade, $\text{¤}_{ijlt}$ is the mean predicted trade, and $Ad_{ijlt}$ is the absolute difference between a given East African state and its EU trading partner j.

The *Absolute difference* index can also be used to analyse the good or bad trade performance between trade partners on top of analysing the future direction of trade of the exporting country. Notably, *Rd* is an opportune index in determining trade performance but its major drawback lies in its failure to explain the relative nexus between actual and predicted trade volumes, given that it does not explain the divergence in volumes between them (Lubinga, 2009). Thus, if $0 < Rd < 1$, it is hard to articulate the un-exhausted trade. Also, when $-1<Rd <0$, hardly will one know the trade potential of East African economies and their trade partners. However, by using *Ad* it is possible to calculate the gain or owned trade potential value to identify the future trade partner of the exporting country (Chen *et al.,* 2007). This study thus employs the *Absolute difference* index to validate the results obtained by the *Relative difference* index.

## 4.7 Conclusions

Chapter 4 has aimed at elaborating the procedures that were used to achieve the objectives of the study. The Revealed Comparative Advantage (RCA), also known as Balassa's index, was used to determine the export competitiveness of various fruit and vegetable products from Kenya, Tanzania and Uganda into the EU market. Generated sets of temperature and precipitation anomalies were used as proxies for climate change to determine the influence of climate change on East Africa's horticultural trade flows within the gravity model framework. Depending on the dataset properties of a given country, two estimation techniques, *viz,* the Zero Inflated Poisson (ZIP) estimator and Negative Binomial Regression (NBR) estimator were used to take into account over-dispersion and excess zeros. The use of meteorological data to proxy for climate change over other measures reveals the real effects of climate change and the data can be obtained over long time series. In addition, the use of anomalies reduces the potential scale effects that are evident if annual variations are used, and anomalies take into account the likelihood of higher variance in the data for arid areas. Finally, the use of anomalies is so far the only direct method of dealing with the large-scale model encountered while undertaking impact assessments.

In order to determine the effect of the EU-GSP Scheme on the various East African fruit and vegetable commodities imported into the EU, the preference margin was used within the gravity model framework. The preference margin is a count variable rather the commonly used dummy approach. Preferential margin was computed as the difference between the average trade-weighted MFN rate and the Ad Valorem Equivalents granted under the EU-GSP scheme. Again, depending on the dataset properties of a given commodity from a given East African state, two estimation techniques (Zero Inflated Poisson (ZIP) and Negative binomial Regression (NBR)) were used to take into account over-dispersion and excess zeros. Over-dispersion and excess zeros are key data problems encountered when dealing with highly disaggregated data.

The "out-of-sample" approach was used to simulate trade potential and trade performance. Two indicators were used, that is, the Relative difference index and the Absolute difference index. Both indicators were used concurrently to validate results obtained from the other index.

# CHAPTER FIVE:
# RESULTS AND DISCUSSIONS

## 5.1 Introduction

This chapter presents the results and discussion of the export competitiveness of East African states in horticultural commodities, the influence of climate change on EA's selected horticultural exports flows, and the effect of the EU-GSP scheme on East Africa’s fruits and vegetable imports into the EU market, as well as the projected unilateral Trade Potential and performance of the selected commodities from EA states. The sub-sections begin with results relating to export competitiveness, followed by the influence of climate change on the horticulture sector and then the findings concerning the impact of the EU-GSP scheme on East Africa’s fruits and vegetable commodities. Results and discussion of the predicted trade potential and performance are presented last.

## 5.2 Export competitiveness of East African states in horticultural commodities

The Revealed Comparative Advantage (RCA) index was used to establish the export competitiveness of fruit and vegetable exports from the East African region into the European Union (EU). At country level, competitiveness was calculated using the monetary value of traded commodities, disaggregated at two levels, namely (*i*) at HS 4-Digit, and (*ii*) at HS 6-Digit levels of data disaggregation.

The results are presented in Table 5.1. All RCA values greater than one (1) depict that a given commodity exhibits export competitiveness within the EU market. Out of the 27 tariff lines considered at HS 4-Digit level for each country (i.e. 81 observations), only 16 tariff lines (*with asterisks in* table 5.1) were observed to have export competitiveness within the EU market for at least one of the EA states. Furthermore, 30 observations exhibited no competitiveness within the EU across the three EA states – potatoes (0701), tomatoes (0702), Lettuce and chicory (0705), Cucumbers and gherkins (0707), Vegetables (0711), grapes (0806), Apples, pears and quinces (0808), Stone fruit (0809), Fruits (0812), Fruit, dried, n.e.s (0813) and Peel of citrus fruit or melons (0814).

**Table 5.1: The mean revealed comparative advantage index at HS-4 Digit level**

| No | CODE (HS-4) | Product description | RCA index (Mean 2008- 2011) | | |
|---|---|---|---|---|---|
| | | | **Kenya** (Av. 2007-10) | **Tanzania** | **Uganda** |
| 1 | 0701 | Potatoes, fresh or chilled | 0.01 | 0.00 | 0.46 |
| 2 | 0702 | Tomatoes, fresh or chilled | 0.23 | 0.00 | 0.34 |
| 3 | 0703 | Onions, shallots, garlic, leeks, etc. | 23.08* | 0.11 | 3.39* |
| 4 | 0704 | Cabbage, cauliflower, kohlrabi & kale, fresh, chilled | 45.49* | 0.01 | 0.12 |
| 5 | 0705 | Lettuce and chicory, fresh or chilled | 0.83 | 0.00 | 0.04 |
| 6 | 0706 | Carrots, turnips, beetroot, etc. fresh or chilled | 1.62* | 0.01 | 3.08* |
| 7 | 0707 | Cucumbers and gherkins, fresh or chilled | 0.04 | 0.00 | 0.15 |
| 8 | 0708 | Leguminous vegetables, shelled or unshelled, fresh | 2,262.37* | 24.86* | 32.12* |
| 9 | 0709 | Other vegetables, fresh or chilled | 364.76* | 0.55 | 3,978.5* |
| 10 | 0710 | Vegetables (uncooked, steamed, boiled) | 42.95* | 0.02 | 3.68* |
| 11 | 0711 | Vegetables provisionally preserved, not ready to eat | 0.00 | 0.00 | 0.73 |
| 12 | 0712 | Vegetables, dried, not further prepared | 3.78* | 0.00 | 2.43* |
| 13 | 0713 | Vegetables, leguminous dried, shelled | 1.99* | 43.41* | 20.57* |
| 14 | 0714 | Manioc, arrowroot, salep, etc. | 0.05 | 0.00 | 259.63* |
| 15 | 0802 | Nuts except coconut, brazil & cashew | 23.49* | 0.08 | 8.24* |
| 16 | 0803 | Bananas, including plantains | 38.03* | 0.12 | 2,265.9* |
| 17 | 0804 | Dates, figs, pineapple, avocado, guava, fresh or dried | 288.67* | 1.13* | 810.98* |
| 18 | 0805 | Citrus fruit, fresh or dried | 0.81 | 0.00 | 6.52* |
| 19 | 0806 | Grapes, fresh or dried | 0.16 | 0.02 | 0.63 |
| 20 | 0807 | Melons, watermelons and papaws | 2.65* | 0.00 | 70.81* |
| 21 | 0808 | Apples, pears and quinces, fresh | 0.43 | 0.00 | 0.17 |
| 22 | 0809 | Stone fruit, fresh (apricot, cherry, etc.) | 0.10 | 0.52 | 0.30 |
| 23 | 0810 | Fruits n.e.s, fresh | 46.90* | 5.37* | 120.25* |
| 24 | 0811 | Fruits and nuts, uncooked boiled or steamed, frozen | 1.41* | 0.00 | 156.23* |
| 25 | 0812 | Fruits, nuts provisionally preserved, not ready to eat | 0.23 | 0.00 | 0.03 |
| 26 | 0813 | Fruit, dried, n.e.s, dried fruit and nut mixtures | 0.06 | 0.14 | 14.10* |
| 27 | 0814 | Peel of citrus fruit or melons | 0.00 | 0.67 | 0.00 |
| **Mean RCA index across all commodities per country** | | | **116.67**** | **2.85**** | **287.38**** |

* Denotes export competiveness at country level.

** Mean RCA Index across all commodities was computed as the average of four years (2008–2011). Owing to limited data for 2011, Kenya's mean RCA index was based on the 2007–2010 period.

***Source***: Author’s own calculations

Generally, Uganda is the most competitive in fruits and vegetables within the EU market, followed by Kenya and Tanzania. According to the mean RCA index across all commodities at country level, Uganda (287.38) surpasses Kenya (116.67) by approximately 2.5 times, while Tanzania lies at the bottom, with an estimated index of 2.89. Among the competitive horticultural commodities, Uganda ranked highest (3,979) in exporting "Other vegetables, fresh or chilled (0709)", followed by Kenya (2,262) in the exports of "Leguminous vegetables (0708)", while Tanzania had "Vegetables, leguminous dried, shelled (0713)" as its best exportable horticultural commodity.

Notably, at the HS-4 digit level the high RCA index associated with Uganda's and Kenya's products may be attributable to a tariff line aggregation effect. On the other hand, Uganda's general outstanding export competitiveness may be explained by the convenient climatic and soil factors which favour production of these crops. However, the poor export competitiveness of exotic commodities such as apples, pears and quinces; stone fruit, fresh (apricot, cherry, plum, peach, etc.); and preserved fruits and vegetables may be on one hand attributed to the tropical climatic conditions that do not favour production of these commodities, and the limited technological advancements in adding value to such products.

Subsequently, analysis at HS-6 digit level focused on only sensitive tariff lines as categorized under the EU-GSP scheme, and only the top two tariff lines which presented the highest RCA values per country (at HS-4 digit level) were considered. At country level, the selected HS-4 digit level tariff lines for further assessment in the case of Kenya included "Leguminous vegetables (0708)" and "Other vegetables, fresh or chilled (0709)". For Tanzania, "Leguminous vegetables (0708)" and "Vegetables, leguminous dried, shelled (0713)" were chosen, while Uganda registered "Bananas, including plantains, fresh or dried (0803)", as well as "Other vegetables, fresh or chilled (0709)". Further disaggregation of the selected tariff lines led to a total of twenty-one (21) horticultural commodities (see Table 5.2 below) that were evaluated at HS-6 digit level.

**Table 5.2: Mean revealed comparative advantage index at HS-6 Digit level**

| CODE (HS-4) | CODE (HS-6) | Product description | RCA index (Mean 2008- 2011) | | |
|---|---|---|---|---|---|
| | | | Kenya | Tanzania | Uganda |
| 0708 | 070810 | Peas (Pisum sativum) | 17.88** | 0.56 | 0.00 |
| | 070820 | Beans (Vigna spp., Phaseolus spp.) | 3.70** | 2.23** | 1.23** |
| | 070890 | Other leguminous vegetables (excl. of 070810, 070810) | 0.55 | 0.01 | 0.26 |
| 0709 | 070920 | Asparagus, fresh/chilled | 8,504.32** | 0.00 | 0.00 |
| | 070930 | Aubergines (eggplants) | 409.99** | 0.00 | 47.08** |
| | 070940 | Celery other than celeriac | 0.12 | 0.00 | 0.00 |
| | 070951 | Mushrooms of the genus Agaricus | 0.09 | 0.00 | 0.00 |
| | 070959 | Mushrooms & truffles (excl. of 070951), fresh/chilled | 750.34** | 0.00 | 0.73 |
| | 070960 | Fruits of the genus Capsicum or of the genus Pimen | 164.28** | 0.00 | 27,668.87** |
| | 070970 | Spinach, New Zealand spinach and garden spinach | 509.19** | 0.00 | 0.00 |
| | 070990 | Vegetables, n.e.s. in 07.01-07.09, fresh/chilled | 0.15 | 24.60** | 1.67** |
| 0713 | 071310 | Peas dried, shelled | 0.02 | 0.00 | 0.00 |
| | 071320 | Chickpeas, dried, shelled | 0.00 | 0.06 | 0.00 |
| | 071331 | Urd, mung, black/green gram beans | 1.33** | 1.06** | 0.00 |
| | 071332 | Beans, small red (Adzuki) dried | 0.00 | 0.00 | 0.00 |
| | 071333 | Kidney beans & white pea beans | 1.73** | 13.51** | 0.00 |
| | 071339 | Beans dried, shelled | 0.02 | 0.03 | 0.00 |
| | 071340 | Lentils dried, shelled | 0.09 | 0.00 | 1.18** |
| | 071350 | Broad beans &horse beans dried | 0.00 | 0.00 | 0.00 |
| | 071390 | Leguminous vegetables dried | 0.00 | 0.00 | 0.08 |
| 0803 | 080300 | Bananas, including plantains | 31.09** | 2.40** | 25.98** |
| **Mean RCA index across all commodities** | | | **494.99*****| **2.12***** | **1,321.29***** |

** Denotes export competiveness at country level.

*** Mean RCA Index across all commodities was computed as the average of four years (2008–2011). Owing to limited data for 2011, Kenya's mean RCA index was based on the 2007–2010 period.

***Source***: Author’s own calculations

At HS-6 digit level of disaggregation, empirical results still show that Uganda out-performs the other East African states. Uganda's mean export competitiveness across all commodities is estimated at 1,321; followed by Kenya (495) and then Tanzania (2). However, the results show that Kenya exhibits export competitiveness in more commodities (10) than Uganda and Tanzania, which are only competitive in six (6) and five (5) commodities, respectively. Uganda's high mean RCA index (1,321) across all commodities is attributable to the "Fruits of the genus Capsicum or of the genus Pimen, fresh/chilled (070960)".

According to Kleih (2007), fruits of the genus Capsicum or of the genus Pimen, most especially scotch bonnet, dominate Uganda's horticultural exports and Uganda is one of the top suppliers of hot pepper to Europe. The performance of this commodity may also be attributed to the fact that it is less bulky to airlift and has a high monetary value. This greatly reduces the associated transaction costs. In addition, Uganda is endowed with an abundance of natural resources, such as fertile soils, a bi-modal rainfall pattern, and the tropical climatic conditions which are very conducive to a wide spectrum of horticultural crops. All these factors enhance organic production of the horticultural commodities which are in high demand in the developed economies, hence the competitiveness. This argument is supported by the fact that Uganda has the most developed sector of certified organic producers (IFOAM and FiBL, 2006). Further, ACODE (2006) postulates that Uganda has the lowest agro-chemical usage in Africa.

For Kenya, "Asparagus, fresh/chilled (070920)" was noted to be the most competitive horticultural commodity within the EU market, followed by "Mushrooms & truffles, fresh/chilled (070959)" and "Spinach, New Zealand spinach and garden spinach, fresh/chilled (070959)", in that order. Conversely, some commodities, like Adzuki beans (071332), exhibited a competitive disadvantage. Kenya's strong export competitiveness in the 10 horticultural commodities may be associated with the country's close proximity to the sea, thus greatly reducing the burden of transport costs. In addition, Kenya's success story may be attributable to the efforts of both the government and the private sector in developing the industry.

For instance, private institutions, such as the Fresh Produce Exporters Association of Kenya (FPEAK), have been in the lead to ensure that most farmers within the horticulture sector are duly certified under trade enhancing international standards like GLOBALG.A.P. To this effect, Kenya is rated to have the highest number of certified farmers of horticultural commodities within the EA region (Government of Kenya, 2012). This precedent inevitably serves as the impetus from which Kenya’s exportable horticultural products have become very competitive within the EU market.

In the case of Tanzania, “Vegetables, n.e.s, fresh/chilled (070990)” were the most competitive within the EU market, with an estimated RCA index of about 24.5. Other commodities that exhibited export competitiveness include: Kidney beans & white pea beans dried shelled, whether or not skinned or split (071333); Bananas, including plantains, fresh or dried (080300); Beans (Vigna spp., Phaseolus spp.) (070820); and Urd, mung, black/green gram beans dried shelled, whether/not skinned/split (071331), in that order.

The research findings imply that the respective countries would be better off if they invested more resources in the production and exports of horticultural commodities over which they have export competitiveness. Uganda's study findings relate with the results of Kleih *et al.* (2007) who reported that pepper (particularly, Scotch Bonnet), the East African Highland banana and apple banana are among the chief fruit and vegetable exports into the EU market. Results concerning Kenya concur with those of Nyangweso and Odhiambo (2004) who note that asparagus, among other vegetables, is one of the major horticultural commodities in the country. In the case of Tanzania, study findings are in tandem with results of MMA (2008) who note that vegetables, especially baby vegetables, destined for the EU market present a strong pillar for the horticulture sector in the country.

For the subsequent analysis, a few selected commodities from each country were considered. Detailed discussions are in the following sub-sections.

### 5.3 The influence of climate change on East Africa's horticultural trade flows

The relationship between climate change and imports of horticultural commodities into the EU market was examined using the gravity flow model framework. However, as a rule of thumb while using time series data, a number of diagnostic tests were undertaken to ascertain whether the variables were appropriate for the subsequent econometric analysis.

### 5.3.1 Diagnostic test results

Multi-collinearity test results presented in Appendix B reveal that serial correlation among the variables was not a serious problem for the various datasets used to assess the nexus between climate change and trade flows of horticultural commodities from EA states. That is, in the case of the Tolerance (TOL) test, values were more than 0.1, while for the mean Variance Inflation Factor (VIF) test all values were less than the threshold value of 10. Results of the correlation matrix test also divulge that there was no correlation problem, since correlation values were not greater than the threshold value of 0.7.

Over-dispersion test results presented in Table 5.3 show that there exists adequate supporting evidence for the existence of over-dispersion within the data series since the conditional variance deviates by far from the conditional mean. Similarly, normality test results (Appendix C) reveal that the disaggregated data series does not comply with the normal distribution assumption. This implies that Ordinary Least Squares (OLS) could not be used for this scenario.

**Table 5.3: Over-dispersion test results of horticulture exports by country**

| Variable | Kenya (N=195) | | Tanzania (N=195) | | Uganda (N=195) | |
|---|---|---|---|---|---|---|
| | Mean ('000 US$) | Variance | Mean ('000 US$) | Variance | Mean ('000 US$) | Variance |
| Horticulture imports into EU from EA ($X_{ijt}$) | 4,164.16 | 1.59e+08 | 323.094 | 1,041,719 | 84.15 | 138,017 |

***Source***: Author's own calculations

The unit root test results grounded on the Levin–Lin–Chu test (**LLC-test**) presented in Table 5.4 below signify that the variables are integrated of various orders. With the exception of the data series for horticultural exports (**X**$_{ijt}$) to the EU market, Linder's income similarity index (***In*****com**$_{ijt}$) and the level of infrastructure in the exporting country (***ln*****infra**$_{it}$), Kenya's time series were inherently stationary. Consequently, data series for horticultural exports ($X_{ijt}$) were found to be integrated of order 2, while Linder's income similarity index (***In*****com**$_{ijt}$) and the level of infrastructure in the exporting country (***ln*****infra**$_{it}$) were integrated of order 4.

**Table 5.4: LLC Panel Unit Root test results by country**

| | Kenya | Tanzania | | Uganda | |
|---|---|---|---|---|---|
| **Variable** | **LLC-test** | **LLC-test** | | **LLC-test** | |
| | **Levels** | **Levels** | ***I*(*1*)** | **Levels** | ***I*(*1*)** |
| Horticultural imports into *j*th state within EU from EA state *i* ('000 US$) (**$X_{ijt}$**) | -0.72 | 1.75 | | 7.52 | |
| Exporter's temperature anomalies **($DT_{it}$)** ($^0$C) | -13.7*** | -2.84*** | | -2.70*** | |
| Importer's temperature anomalies **($DT_{jt}$)** ($^0$C) | -3.59*** | -3.59*** | | -3.59*** | |
| Exporter's precipitation anomalies **($DPre_{it}$)** (mm) | -15.49*** | -0.88 | -3.19*** | 0.36 | -7.06*** |
| Importer's precipitation anomalies **($DPre_{jt}$)** (mm) | -3.47*** | -3.47*** | | -3.47*** | |
| Exporter's GDP in current US$ **($lnY1_{it}$)** | -1.75** | 2.21 | | -4.76*** | |
| Importer's GDP in current US$ **($lnY2_{jt}$)** | -8.92*** | -8.92*** | | -8.92*** | |
| Exporter's Crop production **($ln$Agri$_{it}$)** (tonnes) | -4.03*** | -3.00*** | | 2.23 | |
| Importer's Crop production index **($ln$Agri$_{jt}$)** | -3.24*** | -3.24*** | | -3.24*** | |
| Linder's income similarity index **($In$com$_{ijt}$)** | 6.08 | - | | 6.07 | |
| Exporter's infrastructure level **($ln$infra$_{it}$)** (aircraft departures) | 14.01 | - | | -4.76*** | |
| Exporter's inflation level **($lninflat_{it}$)** | -5.11*** | 10.52 | | -5.50*** | |

*******, ******, ***** denote significance at 1%, 5% and 10% level respectively. ***I*(*1*)** denotes integration of first order.

Similarly, Tanzania's data series for horticultural exports ($X_{ijt}$) and Gross Domestic Product (**$lnY1_{it}$**) became stationary after the seventh lag, hence are said to be integrated of order seven (7). On the other hand, the series for Tanzania's inflation and precipitation anomalies were integrated of order four (4) and two (2), respectively. In the case of Uganda, data series for horticultural exports ($X_{ijt}$) were integrated of order six (6) while Linder's income similarity index (**$In$com$_{ijt}$**) became stationary after the fourth lag (Integrated of order 4). Uganda's data series for precipitation anomalies and crop production (**$ln$Agri$_{it}$**) were integrated of order one (1) and two (2), respectively. Otherwise, Uganda's other data series were also inherently stationary. Given the evidence that the series were stationary, appropriate econometric estimations were made to establish the nexus between climate change and horticultural trade flows into the EU market.

### 5.3.2 The influence of climate change on East Africa's horticultural trade flows into the EU market

The influence of climate change on trade flows was examined using anomalies in temperature and precipitation in both the exporting and importing countries within the gravity flow model framework. The study employed count data estimation techniques to overcome the challenges of over-dispersion and excessive zero trade flows, which are usually encountered with disaggregated data. In the case of Kenya and Tanzania, the Zero Inflated Poisson (ZIP) estimator was used, while for Uganda the Negative Binomial Regression (NBR) was employed. The choice of an appropriate estimator was based on the properties exhibited by each country's dataset. For instance, datasets comprised of a high proportion of zero trade flows were estimated at 31.9 % and 75.5 % for Kenya and Tanzania, respectively.

Moreover, the statistically significant Vuong test results 2.85 ($p<0.01$) for Kenya and 1.51 ($p<0.10$) for Tanzania imply that the ZIP was a more apt estimator for this analysis, rather than using the standard Poisson estimator. In the case of Uganda, the highly significant Likelihood-ratio test results 323.29 ($p<0.01$) imply that the Negative Binomial Regression (NBR) estimator was the most suitable estimator, as compared to the Binomial regression. Regression results at country level are presented in Table 5.58 below.

**Table 5.5: Empirical effects of climate change on East Africa's horticultural imports into the EU market**

| Variable | Kenya | | Tanzania | | Uganda | |
|---|---|---|---|---|---|---|
| **Dependent variable ($X_{ijt}$)** = Net imports of horticultural commodities to a specific country *j* within the EU from EA states (denoted as *i* if it is either Uganda, Kenya or Tanzania) in year t in (000) US$ | | | | | | |
| | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Constant | -11.51*** (2.871) | 0.000 | 193.48** (78.54) | 0.014 | 1335.34* (759.452) | 0.079 |
| Precipitation anomalies in the importing country at a given time **($DPre_{jt}$)** (mm) | 0.01*** (0.003) | 0.000 | 0.07* (0.041) | 0.075 | 2.46*** (0.698) | 0.000 |
| Temperature anomalies in the importing country at a given time **($DT_{jt}$)** ($^0$C) | -0.03*** (0.003) | 0.000 | -0.76*** (0.065) | 0.000 | -2.13** (1.002) | 0.033 |
| Temperature anomalies in the exporting country at a given time **($DT_{it}$)** ($^0$C) | -0.18*** (0.013) | 0.000 | 0.34*** (0.087) | 0.000 | -3.48* (1.929) | 0.071 |
| Precipitation anomalies in the exporting country at a given time **($DPre_{it}$)** (mm) | 0.05*** (0.004) | 0.000 | -1.28*** (0.162) | 0.000 | -16.39* (8.786) | 0.062 |
| Exporter's Gross Domestic Product (GDP) in current US$ **($lnY1_{it}$)** | 0.42*** (0.025) | 0.000 | -18.27*** (2.484) | 0.000 | -36.63* (21.274) | 0.085 |
| Importer's Gross Domestic Product (GDP) in current US$ **($lnY2_{jt}$)** | 0.73*** (0.025) | 0.000 | 0.38* (0.229) | 0.098 | 1.80*** (0.672) | 0.007 |
| Distance between trading partners **($lnD_{ij}$)** (miles) | -2.05*** (0.248) | 0.000 | -8.73** (3.956) | 0.027 | -14.06** (6.509) | 0.031 |
| Crop production in the exporting country **($lnAgri_{it}$)** (tonnes) | 0.30*** (0.041) | 0.000 | 16.92*** (0.638) | 0.000 | -36.98 (22.942) | 0.107 |
| Crop production index in the importing country**($lnAgri_{jt}$)** | 0.48*** (0.055) | 0.000 | -5.22*** (1.184) | 0.000 | 0.06 (1.195) | 0.959 |
| Linder's income similarity index **($Incom_{ijt}$)** | 1.61*** (0.099) | 0.000 | 1.66 (1.489) | 0.265 | 2.96 (3.148) | 0.347 |
| Level of infrastructure in the exporting country *i* in year *t* **($lninfra_{it}$)** (aircraft departures) | - | - | - | - | 15.05* (8.359) | 0.072 |
| Inflation level in the exporting country *i* in year *t* **($lninflat_{it}$)** | -0.06*** (0.006) | 0.000 | -13.45*** (0.972) | 0.000 | 1.99** (0.834) | 0.017 |
| Dummy variable for common language (**$Dlang_{ij}$**) | 4.34*** | | 2.23*** | | 1.12 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| (=1, if share official language; =0, otherwise) | (0.070) | 0.000 | (0.769) | 0.004 | (1.412) | 0.426 |
| Vuong test (Z-value) | 2.85*** | 0.002 | 1.51* | 0.066 | - | - |
| Likelihood-ratio test of alpha=0 | | | | | 323.39*** | 0.000 |
| Fixed effects | Yes | | Yes | | Yes | |
| Number of observations (N) | 135 | | 90 | | 105 | |
| Nonzero observations ($N_1$) | 92 | | 22 | | | |
| Zero observations ($N_0$) | 43 | | 68 | | | |
| Log likelihood | -4376.76 | | -138.68 | | -101.551 | |
| Count data estimation technique used | ZIP | | ZIP | | NBR | |

***, **, * denote significance at 1%, 5% and 10% level respectively.

These show that precipitation anomalies in the EU market have a significant positive influence on horticultural trade flows from all three East African states, namely Uganda, Tanzania and Kenya, in that order. Notably, a unit percentage change in precipitation anomalies within the EU leads to US$ 2 500 ($p<0.01$) increase in Uganda's value of exports. In the case of Tanzania and Kenya, a similar unit change translates into an estimated US$ 70 ($p<0.10$) and US$ 10 ($p<0.01$) increase in the value of horticultural trade flows, respectively. In general terms, this positive trend may be associated with the unique and advantageous endowment of a tropical climate that favours production of exportable tropical fruits and vegetables through the year, relative to other countries which also export to the EU market. In addition, East African states specialize in high value, annual tropical horticultural commodities, such as asparagus, pepper and other specialty/exotic vegetables. These horticultural commodities have a short growing period and can be delivered to the EU market at any time of the year. These results are in concurrence with Nelson *et al.* (2010) who note that climate change variability will enhance trade flows of certain agricultural commodities from regions that are less affected to areas adversely limited in the production of given commodities.

Temperature anomalies in the importing country **($DT_{jt}$)** were found to have a significant negative influence on fruits and vegetable imports from EA states into the EU market. Results show that a unit change in temperature anomalies in the destination markets leads to a loss of US$ 2,130 ($p<0.05$), US$ 760 ($p<0.01$) and US$ 30 ($p<0.01$) in the value of fruits and vegetable imports from Uganda, Tanzania and Kenya, respectively. Among other factors, the results may be explained by the European Union's tendency to protect its domestic producers by subjecting horticultural imports to a series of tariffs, as well as by limiting the importation of specific horticultural commodities in favour of the EU production calendar (Petriccione *et al.*, 2011). Such requirements are stipulated under the EU-GSP preferential treatment granted to all developing countries. Within the production calendar, the EU furthermore alters tariff levels of some products, particularly fruits and vegetables, and this usually occurs during harvesting periods which coincide with the northern hemisphere winter season (UIA, 2001; Lubinga *et al.* 2013).

Given the high perishability of most unprocessed horticultural commodities, coupled with changes in EU market demand based on their production calendar, East African states tend to be discouraged from trading to their full potential within the EU market. As an example, UIA (2001) shows that much of Uganda's harvesting occurs between November and February, which coincides with the winter season in Europe when there is a high demand for fresh fruits and vegetables. According to the EU-GSP scheme, however, some horticultural commodities cannot be exported to the EU market. That is, the EU only allows imports of, for example cucumber (fresh or chilled), between 16 May and 31 December. Other commodities with limited access to the EU market in specific months include Mandarins (080520), Plums (080940) and fresh Peaches (080930) (UNCTAD, 2008).

The negative influence of temperature anomalies on East Africa's horticultural imports in the EU market may also be attributable to the relatively longer summer periods that were generally experienced in Europe in the late 2000s. Odongo (2007) asserts that during this period horticultural sales declined. The relatively small impact of temperature on Kenya's imports may be attributed to the fact that it exports a wide spectrum of fruits and vegetables of high demand and limited supply within the EU market, for example asparagus. In addition, given that Kenya's horticulture industry is highly developed given that it is reliant on irrigation and green houses. Thus, the harvesting periods for these crops can easily be controlled to avoid coinciding with the production cycle of the EU producers. These technological advancements render Kenyan traders capable of supplying the EU market only during periods of high demand for the fruits and vegetables, hence minimizing the negative effects of fluctuations in temperature in the destination markets. For example, Kenya is the second-leading exporter of horticultural commodities after South Africa in Sub-Saharan Africa (English *et al*,, 2004).

With regard to temperature **($DT_{it}$)** and precipitation **($DPre_{it}$)** anomalies in the exporting countries, a mixture of both negative and positive results was obtained. However, all coefficients were statistically significant at various levels. A unit percentage change in temperature anomalies in Tanzania was noted to enhance an increase in value of horticultural exports to the EU by US$ 340 ($p<0.01$), while a similar change led to a loss worth US$ 3,480 ($p<0.10$) and US$ 180 ($p<0.01$) in Uganda's and Kenya's exports, respectively.

The positive trend for Tanzania may be associated with the agronomic attributes of cashew nuts, which assume a large proportion the country's horticulture exports. Cashew nut production is strongly influenced by weather conditions and can withstand water-constrained conditions for a long period, unlike most annual fruits and vegetables. For instance, ARC (2013) opines that high temperatures stimulate early flowering. In essence, high temperatures during the production phase serve as an incentive to include this major crop within Tanzania's horticultural exports. In addition, it is a perennial crop, with a well-developed root system and renowned for high tolerance to drought conditions. Thus, such agronomic attributes of cashew nuts explain the positive trends in trade, despite fluctuations in Tanzania's temperature pattern over the years.

On the other hand, the decline in Uganda's and Kenya's exports may be attributed to the fact that these countries specialize more in annual horticultural crops, which according to researchers (UNDP and BCPR, 2013; McCandless *et al*., 2012) are very sensitive to higher temperatures. The vulnerability of annual horticultural crops is associated with the fact that high temperatures can quickly destroy the crop, unlike for perennial crops which might survive, but with lower yields or reduced quality (Lubinga *et al.,* 2013). According to GRID (2002), a 2 °C increase in annual temperature results in a reduction in the arable land suitable for a wide spectrum of crops within the East African region.

Furthermore, research shows that a unit change in Kenya's precipitation anomalies would lead to an increase in the monetary value of horticultural exports by US$ 50 ($p<0.01$). This positive observation may be attributable to the fact that Kenya has agriculture- and environment-related policies, strategies, and programmes which focus on adaptation to climate change (Odera *et al.,* 2013). Kenya drafted a "National Irrigation Policy" in a bid to promote advanced irrigation technology. Accordingly, recent data from the World Bank Development Indicators (WBDI) database (2012) shows that only Kenya, of the three EA states, has embraced irrigation technology at commercial levels. Within a period of three years (2001–2003), Kenya's proportion of irrigated land increased by close to threefold, from 0.04 % in 2001 to 0.11 % of agricultural land. In addition, it is worthwhile to mention that Kenya has a National Climate Change Response Strategy (NCCRS) with interventions designed for the various sectors of the economy.

In an effort to buffer crop production failures, probably due to climate change related factors, Kenyan farmers use more fertilizers than their Tanzanian and Ugandan counterparts. For instance, in 2002 and 2003, Kenya used on average 30.2 kilograms per hectare of fertilizers, compared with 3.8 and 1.5 kilograms per hectare of fertilizers in the case of Tanzania and Uganda, respectively (WBDI database, 2012). The use of such technological advancements acts as a buffer against the devastating effects of climate change, which would greatly lead to low productivity and reduced trade flows.

On the contrary, fluctuations in precipitation were observed to significantly influence declines in the value of Uganda's and Tanzania's trade flows by an estimated US$ 16,390 ($p<0.10$) and US$

1,280 ($p<0.01$), respectively. The large coefficient associated with Uganda's trade flows may be explained by Timmers' (2012) argument that rainy seasons have become increasingly erratic over the years, most especially within the Lake Victoria basin, and this curtails production. As an example, he argues that the increasingly erratic precipitation has led to an estimated 2.3 m decline in the water level within the lake over a six-year period (2000–2005). It is known that Uganda's subsistence agriculture sector depends largely on natural rainfall, hence lower rainfall.

Furthermore, the negative effects of precipitation anomalies for Tanzania and Uganda may be attributed to the extreme climatic catastrophes, such as floods and droughts, that were experienced during the period (1988–2000) considered for this analysis. According to Timmers (2012), floods, for instance, cause damage to agricultural infrastructure such as roads, bridges, storage facilities and processing lines; aggravate land mass movements; and a number of people lose their lives. All these problems associated with floods operate to increase trade barriers, given that they impede easy and quick access to goods and services, thus increasing the cost of doing business.

As an example, between 1988 and 2000, Tanzania experienced three severe floods. EM-DAT (2013) notes that the April 1989 floods affected slightly more than 140,000 people, while the 1990 and 1993 floods caused an estimated US$ 0.28 million and US$ 3.51 million worth of economic damage, respectively. In the case of Uganda, it is also noted that in 1997 the country experienced floods which affected about 0.15 million people, coupled with massive infrastructure damages estimated at US$ 1 million. Furthermore, Uganda witnessed a prolonged drought in 1998 which led to an estimated cost of US$ 1.6 million, affecting 0.13 million people. Other episodes of severe drought in Uganda were observed in 1987 and 1999, during which 0.6 million and 0.7 million people were affected (EM-DAT, 2013). Similarly, Tanzania also suffered long intense spells of drought in 1984, 1991 and 1996, during which 1.9 million, 0.8 million and 3 million people were adversely affected.

Extreme climate events like floods and droughts disrupt international trade, largely at the production stage, through their effect in reducing productivity of agricultural farms. Furthermore, the low agricultural productivity attributable to erratic climatic change may inhibit innovation and imitation, given that farmers are uncertain of what the near future has to offer. Coupled with the pervasive risky environmental effects on farming practices and farm performance, the increasing uncertainty probably discouraged farmers from upgrading production technology, thus further affecting productivity.

Notably, the negative effects of precipitation anomalies on Uganda's and Tanzania's trade may also be attributable to the migration of people from the rural areas to urban centres in a bid to adapt to harsh climatic changes (Marchiori *et al*., 2010). Accordingly, this migration could have culminated in the reallocation of the scarce labour force from the agricultural sector in rural areas to the non-agricultural sectors in urban areas, hence disrupting the production cycle, as well as agricultural trade in the long-run. For instance, within the 1996-2000 period during which severe drought was experienced (particularly 1997–1999), Uganda registered over 0.45million emigrants in net terms (WDI, 2012). A similar scenario was observed in Tanzania during the early 1980s drought, when over 22,000 people emigrated from the country. This is an enormously plausible amount and quality of labour lost from the agricultural sector.

Furthermore, the deterrent effects of precipitation anomalies in the case of Uganda and Tanzania's trade may be associated with the growth characteristics of a majority of their horticultural crops, particularly, the vegetables. These are annual crops with short growth periods during which they need much water. Thus, severe variations in precipitation patterns are capable of causing 100 % crop failure (Bashasha *et al.*, 2013; Kilembe *et al.*, 2013) and long-run production declines, which indeed curtail trade flows. Moreover, in Tanzania and Uganda large proportions of the populations are still surviving below the poverty line, which Kilembe *et al*. (2013) and Bashasha *et al*. (2013) note as being an enormous stumbling block in adapting to climate change within the horticulture sector. Under such high levels of poverty, farmers cannot ably have access to basic agro-inputs and credit through which they could create a buffer against the hastening climate change. Nelson *et al*. (2010) succinctly reckon that only smallholder farmers with fairly high disposable incomes can dare to experiment with new technologies and management systems, which might be expensive to invest in initially but enhance farmers' resilience to climate change effects through higher productivity. This guarantees sustainable trade flows in horticultural commodities.

Uganda's and Tanzania's negative findings in relation to precipitation anomalies are in accordance with those of other scholars (McCandless *et al*., 2012; Marchiori *et al*., 2010; Schlenker and Lobell, 2010; Nelson *et al*., 2009; Tao *et al*., 2008; Xiong *et al*., 2007; Sivakumar *et al*., 2005; Kumar *et al.*, 2004; Parry *et al*., 2004; FAO, 2001; Timmers, 2012; MWE, 2007) who argue that climatic factors that perturb agricultural productivity inevitably limit the economy's available tradable produce. Ludi *et al*. (2007) argue that climate change affects the volume of agricultural commodities produced within an economy, as well as the price of tradable agricultural produce from which foreign exchange is generated.

Generally, findings concerning the other variables used in the country models conform to the theoretical expectations of the gravity flow model. For instance, distance was found to have a significant negative influence on trade flows across all the three East African states. Uganda's large drop in trade by US$ 14,060 ($p<0.05$) may be attributed to the fact that it is a landlocked country, unlike Tanzania and Kenya, which registered a decline in their trade by US$ 8,730 ($p<0.05$) and US$ 2,050 ($p<0.01$), respectively. An increase in an importer’s Gross Domestic Product (GDP) ($lnY2_{jt}$) was also found to significantly enhance horticultural trade. Results reveal that a unit increase in an importer's GDP leads to about US$ 1,800 ($p<0.01$), US$ 730 ($p<0.01$) and US$ 380 ($p<0.10$) rises in the monetary worth of horticultural exports from Uganda, Kenya and Tanzania, respectively.

With the exception of Kenya, an increase in an exporter's (GDP) (**$lnY1_{it}$**) was found to significantly influence a drop in the value of horticultural exports from Uganda (US$ 36,630, $p<0.10$) and Tanzania (US$ 18,270, $p<0.01$). The declining trends may be attributable to the fact that these states have not duly recognized these horticultural commodities as foreign exchange earners (UNBS, 2013). Thus, an increase in GDP would probably foster promotion of the traditional cash crops like Coffee, cotton, tea and tobacco, rather than the fruit and vegetable sub-sector. Inevitably, an increase in Kenya's GDP was noted to enhance the exportation of horticultural exports by approximately 0.42 times. This observation may be associated with the fact that horticulture is the leading industry within the agricultural sector in Kenya, accounting for approximately 36 % of the Agricultural GDP (Government of Kenya, 2012).

Other variables, such as Linder’s income similarity index (**$In\mathbf{com}_{ijt}$**), Level of infrastructure in the exporting country *i* in year *t* (**$ln\mathbf{infra}_{it}$**) and Dummy variable for common language (**$\mathbf{Dlang}_{ij}$**), were also found to enhance exports of fruits and vegetables from EA states. However, for Uganda, the positive coefficient (1.12, $p>0.10$) for common language (**$\mathbf{Dlang}_{ij}$**) was an insignificant coefficient. Unlike for Tanzania, a unit percentage change in crop production in the importing country (**$ln\mathbf{Agri}_{jt}$**) was observed to promote Kenya's and Uganda's horticultural trade flows into the EU by US$ 480 ($p<0.01$) and US$ 60 ($p>0.10$), respectively. However, the result relating to Uganda was insignificant. This observation may be associated with the fact that Kenya has comparative advantage in the production of many high-value tropical fruits and vegetables which cannot easily be produced within the temperate EU.

## 5.4 The effect of the EU-GSP scheme on East Africa's fruits and vegetable imports into the EU market

Assessment of the impact of the EU-GSP scheme was carried out based on the results of objective one, under which an evaluation of the export competitiveness of the fruits and vegetable commodities from East African states in the EU market was conducted. The focus was on a few selected commodities (*see* Table 5.6 below) that exhibited export competitiveness within the EU market. From each EA State, two commodities were chosen following two basic procedures: (*i*) if the commodity exhibited an average export competitiveness index (RCA) of greater than one across all the three EA states, and (*ii*) if the commodity revealed the highest RCA amongst all commodities exported from a given country. In the case of Uganda, three commodities were considered, given that fruits of the genus Capsicum (070960) exhibited high RCA value (>27,600), in addition to the top two commodities that had been selected. Thus, seven (7) commodities in total were subsequently considered for evaluating the effect of the EU-GSP Scheme on horticultural commodities from the East African region.

**Table 5.6: East Africa's selected fruit and vegetable commodities with high export competitiveness in the EU market**

| Country | HS 6-Digit code | Commodity description | Mean RCA (2007-10) | Mean preference margin |
|---|---|---|---|---|
| Kenya | 070920 | Asparagus, fresh/chilled | 8,504.32 | 9.35 |
| | 070820 | Beans (Vigna spp., Phaseolus spp.) | 3.70 | 10.86 |
| Tanzania | 070990 | Vegetables, n.e.s. in 07.01-07.09, fresh/chilled | 24.60 | 13.69 |
| | 070820 | Beans (Vigna spp., Phaseolus spp.) | 2.23 | 10.86 |
| Uganda | 070960 | Fruits of the genus Capsicum/ Pimen | 27,668.87 | 3.56 |
| | 080300 | Bananas, including plantains, fresh/dried. | 25.98 | 23.15 |
| | 070820 | Beans (Vigna spp., Phaseolus spp.) | 1.23 | 10.86 |

***Source***: Author's calculations

Descriptive statistics of the selected commodities depict that bananas (080300) enjoyed the largest preferential margin, estimated at 23, followed by vegetables (13.7), beans (10.9), asparagus (9.6), and lastly, fruits of the genus Capsicum or of the genus Pimen (3.6). Prior to the econometric estimation of the effect of the EU-GSP scheme on the selected commodities, a number of diagnostic tests were conducted.

### 5.4.1 Diagnostic test results

According to the multi-collinearity test results presented in Appendices D to J, no serial correlation was found among the variables. *Viz,* in all commodities and across all the three EA states, the Tolerance (TOL) test values were in accord with the expected value (*more than 0.1*). On the other hand, the mean Variance Inflation Factor (VIF) test results shown in Table 5.7 below were also less than the threshold value of 10. Furthermore, the correlation matrix test results (see Appendices D – J ) depict that there exists no serial correlation problem across all commodities, since the correlation values were not greater than the threshold value of 0.7.

**Table 5.7: VIF test- and over-dispersion test- results for the horticultural commodities**

| Country | HS 6- Digit code | Mean VIF value | Mean ('000 US$) (n=105) | Variance |
|---|---|---|---|---|
| Kenya | 070820 | 2.06 | 9,488.14 | 4.68e+08 |
| | 070920 | 1.96 | 22.10 | 8,017.33 |
| Tanzania | 070820 | 2.17 | 210.14 | 353,270.4 |
| | 070990 | 2.74 | 13.88 | 8,393.40 |
| Uganda | 070820 | 3.97 | 2.67 | 64.85 |
| | 070960 | 2.11 | 257.82 | 422,124 |
| | 080300 | 7.33 | 200.11 | 373,606 |

***Source*:** Author's calculations

The over-dispersion test results presented in Table 5.7 above indicate that the import data series for the three EA states were highly over-dispersed, given that the conditional variance of each series deviated by far from the conditional mean. Moreover, the normality test results presented in Appendices K to M also show that the highly disaggregated data series were not normally distributed. Inevitably, the existence of over-dispersion, coupled with distribution asymmetry problems, imply that ordinary econometric estimation procedures cannot be used to obtain reliable results.

The unit root test results presented in Table 5.8 are based on both the Levin–Lin–Chu test (**LLC-test**) and the Harris-Tzavalis test (HT-test). All commodity series were found to be integrated of order one while using the LLC-test, except for Beans (070820) from Uganda, Asparagus (070920) from Kenya, and Vegetables (070990) from Tanzania. However, in instances where the stationarity could not be established, even after first order difference with the LLC-test, the HT-test was used. Interestingly, all data series upon which the HT-test was used were also found to be significantly stationary at all levels. Thus far, since the test statistics in both the

LLC- and HT-tests are significant at all levels ($p<0.01$), it is prudent to reject the null hypothesis of a unit root in the series in favour of the alternative hypothesis that all the series are stationary.

**Table 5.8: Panel Unit Root test results by commodity and country**

| Variable | Kenya | Tanzania | | Uganda | |
|---|---|---|---|---|---|
| | **Levels** | **Levels** | ***I(1)*** | **Levels** | ***I(1)*** |
| 070820 Beans ($M_{ijlt}$) ('000 US$) | -11.20*** | 2.95 | -6.41*** | 0.22*** (*ht*) | |
| 070920 Asparagus ($M_{ijlt}$) ('000 US$) | 0.25*** (*ht*) | - | - | - | - |
| 070990 Vegetables ($M_{ijlt}$) ('000 US$) | - | 0.24*** (*ht*) | | - | - |
| 070960 Peppers ($M_{ijlt}$) ('000 US$) | - | - | - | | -2.99*** |
| 080300 Bananas ($M_{ijlt}$) ('000 US$) | - | - | - | | -5.0743*** |
| **Other covariates** | **Levels** | **Levels** | | **Levels** | |
| Exporter's GDP (***ln*Y1$_{it}$**) (US$) | -14.65*** | -13.38*** | | -20.91*** | |
| Importer's GDP (***lnY2$_{jt}$***) (US$) | -17.73*** | -17.73*** | | -17.73*** | |
| Exporter's mean annual inflation rate (***lninflat$_{it}$***) | -7.05*** | - | | -6.25*** | |
| Cost of establishing a business (***ln*COSTBIZ$_{it}$**) (% of GNI per capita) | -6.84*** | - | | - | |
| Cost to exporting a 20-foot container (***ln*COSTEXP$_{it}$**) (% of GNI per capita) | - | 12.45 | | -84.83*** | |
| Public sector and government institutions role (***ln*GOV$_{it}$**) (*an index from 1=low to 6= high*) | - | 0.46*** (*ht*) | | -1.19 | |
| Net inflow of foreign direct investment (***ln*FDI$_{it}$**) (US$) | - | - | | -12.05*** | |

***, **, * denote significance at 1%, 5% and 10% level respectively. **(*ht*)** denotes that the Harris-Tzavalis unit-root test was used, otherwise other results are based on the LLC-test.
***Source***: Author's own calculations.

### 5.4.2 Empirical findings of the effect of the EU-GSP scheme on East Africa's fruits and vegetable imports into the EU market

Analytical results regarding the effect of the EU-GSP scheme on East Africa's horticultural imports into the EU are presented at country level. Owing to the varying data properties, the estimation techniques used are also highlighted.

#### 5.4.2.1 Kenya

Econometric estimation results presented in Table 5.9 below were estimated using the Zero Inflated Poisson (ZIP) technique, given that commodity datasets had excessive zeros, *that is*, 71 % of the Asparagus export dataset were zeros, while 27 % of the beans export dataset were also zeros. Moreover, Kenya's export data were also highly over-dispersed. In both cases, the statistically significant Vuong test results show that the ZIP estimator is preferable to the standard Poisson estimator.

With regard to the key variable of interest, the preference margin, findings show that the EU-GSP scheme hampers imports of Kenya's asparagus and beans into the EU market. At a one per cent level of significance, a unit rise in the preference margin granted under the EU-GSP scheme leads to a decline of US$ 2,460 ($p<0.01$) and US$ 280 ($p<0.01$) in Kenya's asparagus and bean exports to the EU market. This may be attributed to stiff competition from other exporters, such as Colombia, Ecuador, Ethiopia, Morocco, Israel and Egypt, partly as a result of preferential treatment.

**Table 5.9: Effect of the EU-GSP scheme on Kenya's Asparagus and Bean exports**

| **Dependent variable ($M_{ijlt}$) = Total value of commodity *l* from Kenya *i* to *j*th EU member state in year *t* in '000 US Dollars** | | | | |
|---|---|---|---|---|
| **Variable** | **Asparagus (070920)** | | **Beans (070820)** | |
| | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Constant | 65.71 (116.36) | 0.572 | 280.51*** (2.416) | 0.000 |
| Preference margin of a specific commodity, expressed as a share of the product value (***ln*PM**$_{ijlt}$) | -2.46*** (0.186) | 0.000 | -0.28*** (0.019) | 0.000 |
| Exporter's Gross Domestic Product (GDP) in current US$ (***ln*Y1**$_{it}$) | 6.15*** (0.312) | 0.000 | -0.07*** (0.010) | 0.000 |
| Importer's Gross Domestic Product (GDP) in current US$ (***ln*Y2**$_{jt}$) | 1.56*** (0.267) | 0.000 | 1.85*** (0.005) | 0.000 |
| Distance in miles between trading partners (***ln*D**$_{ij}$) | -27.71* (15.194) | 0.068 | -39.95*** (0.305) | 0.000 |
| Exporting country's mean annual inflation rate (**ln*inflat***$_{it}$) | -0.17** (0.068) | 0.015 | -0.05*** (0.003) | 0.000 |
| The cost of establishing a business, expressed as percentage of GNI per capita (***ln*COSTBIZ**$_{it}$) | -5.93*** (0.646) | 0.000 | -0.36*** (0.035) | 0.000 |
| Dummy variable for common language (=1, if share common language; = 0 otherwise) (**Dlang**$_{ij}$) | 6.73*** (1.863) | 0.000 | 15.51*** (0.078) | 0.000 |
| Vuong test (Z-value) | 4.64*** | 0.000 | 3.25*** | 0.001 |
| Fixed effects | Yes | | Yes | |
| Number of observations (N) | 105 | | 105 | |
| Nonzero observations ($N_1$) | 30 | | 77 | |
| Zero observations ($N_0$) | 75 | | 28 | |
| Log likelihood | -207.283 | | -22938.15 | |
| Count data estimation technique used | ZIP | | ZIP | |

***, **, * denote significance at 1 %, 5 % and 10 % levels, respectively.

The deterrent effect of the EU-GSP scheme on Kenya's asparagus and bean exports to the EU may also be the result of stringent standard requirements, to which horticultural commodities entering Europe are subject (e.g. GLOBALG.A.P and the British Retail Consortium (BRC) standard). Compliance with these continually changing standards comes with investment costs, which discriminates against smallholder farmers. Despite the fact that Kenya is regarded as a success story in the implementation of the private and voluntary GlobalG.A.P standard, researchers (Kuwornu and Mustapha, 2013; Asfaw *et al.*,2010; Aloui and Kenny, 2005; Augier *et al.*, 2005) argue that sustaining compliance with the standard poses both technical and financial constraints for smallholder farmers and exporters.

Under Option 2, where smallholder farmers are certified as a group, Kuwornu and Mustapha (2013) show that each group member contributes over 36,000 KSh (US$ 1 = 86.12 KSh), the equivalent of about 30 per cent of an individual smallholder farmer's annual income realized from crop enterprises. As a pre-condition to implement the standard, it is also mandatory for farmers to invest in infrastructure and equipment, such as stores, waste disposal pits and product handling facilities (grading shed and cooler).

Furthermore, the negative finding may result from Kenya's graduation from a Least Developed Country (LDC) to a lower-middle income country in December 2007. This change in status comes with lower benefits under the Lomé Convention between African Caribbean Pacific (ACP) countries (of which Kenya is a member) and the EU. The United States Agency for International Development (USAID) (2007) has argued this would have reduced its competitiveness within the EU market.

The inconsistency and unpredictability of small-scale exporters of the horticultural commodities may also be associated with the negative effects of the EU-GSP scheme on Kenya's commodities. Dolan *et al*. (2000) mention that the regular and consistent supply of specialty products, such as asparagus, is paramount within the EU market. However, probably owing to the dwindling production volumes by Kenyan farmers, such market conditions could not be realized, hence other competitors in the asparagus market (e.g. Lesotho) have increased their market shares. Dolan *et al*. (2000) show that there are many licensed exporters in Kenya, but only a handful are consistently in operation. Most of the exporters only take advantage of favourable short-term market conditions, especially during the peak season (October–April). This jeopardizes the benefits that might be realized through the EU-GSP scheme.

In addition, the non-beneficial nexus between the EU-GSP scheme and Kenya's commodities (asparagus and beans) may be attributed to the existence of other trade enhancing policies that probably present barriers to trade than the GSP scheme. Such policies include the Economic Partnership Agreements (EPAs) between the EU and African, Caribbean and Pacific (ACP) countries, as well as the African Growth and Opportunity Act (AGOA) initiative granted by the USA. According to FreshPlaza (2014), the AGOA initiative offers more duty-free benefits than what is granted under the GSP scheme and as a result, Kenya's horticultural exports to the USA have significantly increased and totalled more than US$ 38 million in 2011. Notably, under the AGOA initiative, the USA recently granted Kenya for fresh green beans, runner beans, baby carrots, baby corn and shelled beans. This implies that Kenya is experiencing a drift into other markets because of the existence of more attractive policies.

All in all, the results imply that the EU-GSP scheme is of less importance in boosting Kenya's asparagus and bean exports into the EU market. The results for Kenya closely relate with results of other researchers (Philippidis *et al*,, 2011; Asfaw *et al.*, 2010). Asfaw *et al*. (2010) argue that smallholder farmers who cannot cope with the frequently changing and stringent EU market standards are bound to search for alternative markets. Philippidis *et al*. (2011) also note that increasing import tariff rates deter exports of fruits and vegetables from developing countries to the European market.

Estimated coefficients of all the other covariates are in concurrence with the theoretical expectations of the gravity model framework. In general terms, a one per cent increase in the country's inflation rate **($ln inflat_{it}$)**, the cost of doing business **($ln\mathrm{COSTBIZ}_{it}$)** and distance **($ln\mathrm{D}_{ij}$)** is associated with varying levels of decline in trade flows, depending on the commodity, *viz*, asparagus or beans. Such results mean that high inflation rates, distance and the high cost of doing business in Kenya are bottlenecks to trading in these commodities.

On the other hand, a unit positive change in the importing country's GDP **($ln\mathrm{Y2}_{jt}$)** was noted to cause an estimated US$ 1,560 ($p<0.01$) and US$ 1,850 ($p<0.01$) rise in the monetary value of asparagus and bean trade flows, respectively. This implies that an increase in GDPs of EU-member states leads to higher demand for these commodities from Kenya. A unit change in Kenya's GDP **($ln\mathrm{Y1}_{jt}$)** was found to have mixed but significant effects on trade flows. For instance, a one per cent (1 %) rise in Kenya's GDP was noted to cause an increase in asparagus trade flows by US$ 6,200 ($p<0.01$), while a similar change in the country's economy would lead to a fall in bean exports by approximately US$ 70 ($p<0.01$) in monetary terms. This suggests that Kenya may not have adequate capacity or competitive advantage in the production of beans, as compared with the production of asparagus.

The results for the dummy variable for common language **($\mathrm{Dlang}_{ij}$)** also show that sharing similar cultural ties presents more trading opportunities. Sharing a common language was found to boost trade in beans and asparagus by US$15,500 ($p<0.01$) and US$ 6,700, respectively, relative to trade partners that do not have a common official language. Notably, much of Kenya's asparagus goes to the Netherlands (where Dutch is the official language), unlike beans which are taken to the United Kingdom, a former colonial master and where English is the official language.

#### 5.4.2.2 Tanzania

The assessment of the effect of the EU-GSP scheme on Tanzania's bean and vegetable imports to the EU-market was also based on the ZIP estimation technique for the same reasons (excess zeros trade flows and over-dispersion of the dependent variable) as in the case of Kenya. Specifically, the findings in Table 5.10 below show that Tanzania's bean export data contained more than 70 zero trade flows (approximately 68 % of the data), with vegetable exports registering 87.6 % zeros. The statistically significant Vuong test results (6.51, $p<0.01$ for beans; 3.11, $p<0.01$ for vegetables) used to compare the appropriateness of the ZIP model relative to the standard Poisson model also show that the ZIP estimator was an apt technique for this analysis.

**Table 5.10: Effect of the EU-GSP scheme on Tanzania's Vegetables and Bean exports**

| **Dependent variable ($M_{ijlt}$) = Total value of commodity *l* from Tanzania *i* to *j*th EU member state in year *t* in '000 US Dollars** | | | | |
|---|---|---|---|---|
| **Variable** | **Beans (070820)** | | **Vegetables (070990)** | |
| | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Constant | 65.77*** (4.590) | 0.000 | 141.73*** (46.579) | 0.002 |
| Preference margin of a specific commodity, expressed as a share of the product value (***ln*PM$_{ijlt}$**) | 1.01*** (0.086) | 0.000 | -0.09 (0.275) | 0.739 |
| Exporter's Gross Domestic Product (GDP) in current US$ (***ln*Y1$_{it}$**) | 0.52*** (0.078) | 0.000 | -7.29*** (0.609) | 0.000 |
| Importer's Gross Domestic Product (GDP) in current US$ (***ln*Y2$_{jt}$**) | -0.23*** (0 .019) | 0.000 | -2.43*** (0.434) | 0.000 |
| Distance in miles between trading partners (***ln*D$_{ij}$**) | -7.92*** (0.491) | 0.000 | 29.63*** (5.267) | 0.000 |
| Cost to exporting a 20-foot container in US$ per container (***ln*COSTEXP$_{it}$**) | -0.79*** (0.126) | 0.000 | -22.69*** (2.172) | 0.000 |
| The role of the public sector and government institutions, expressed as an index (***ln*GOV$_{it}$**) | 2.76*** (0.132) | 0.000 | 8.05*** (0.823) | 0.000 |
| Dummy variable for common language (**Dlang$_{ij}$**) | 3.01*** (0.041) | 0.000 | 5.53*** (0.910) | 0.000 |
| Vuong test (Z-value) | 6.51*** | 0.000 | 3.11*** | 0.001 |
| Fixed effects | Yes | | Yes | |
| Number of observations (N) | 105 | | 105 | |
| Nonzero observations ($N_1$) | 34 | | 13 | |
| Zero observations ($N_0$) | 71 | | 92 | |
| Log likelihood | -4604.642 | | -86.123 | |
| Count data estimation technique used | ZIP | | ZIP | |

***, **, * denote significance at 1%, 5% and 10% level respectively.

Estimated coefficients of all other covariates considered for the bean commodity were found to be in tandem with the theoretical expectations of the gravity model framework. With the exception of distance, all variables also exhibit significant effects on Tanzania's vegetable exports to the EU and the variables were found to have the theoretically expected signs. The positive results (US$ 29630, $p<0.01$) associated with the distance variable **($ln$D$_{ij}$)** imply that distance does not necessarily impede exports of Tanzania's vegetables to the EU. André and Joel (2012) and Marimoutou *et al*. (2009) opine that the deterring effect of distance ceases to be an issue if the trading partner's economic size (GDP) is by far larger than that of the exporting country. According to data provided by the WBDI database (2012), the economy of the United Kingdom (Tanzania's key destination market for vegetables in the EU) is more than 130 times larger than Tanzania's economy. Furthermore, Tanzania capitalizes more on high-value vegetables (USAID, 2007), such as snow peas, sugar snap peas, French green beans, and baby vegetables (carrots, maize, leeks, zucchini, pattypan squashes, and eggplants, among others), which are in high demand in the EU.

#### 5.4.2.3 Uganda

The analysis of the effect of the EU-GSP scheme on Uganda's banana, beans and pepper exports to the EU market was also grounded on the ZIP estimator, given that export data series of each of the commodities exhibited excess zeros, coupled with over-dispersion. The empirical results in Table 5.11 below reveal that, of the 105 observations for each of Uganda's banana, beans and pepper export datasets, there were 47, 86 and 30 zero trade flow values, respectively. 44.8, 81.9 and 28.6 percent for banana, beans and pepper export data. The statistically significant Vuong test results (2.38, $p<0.01$ for bananas; 9.65, $p<0.01$ for beans; 3.99, $p<0.01$ for pepper) also imply that the ZIP estimator was the most appropriate model for this analysis, relative to the standard Poisson model.

The preference margin ($\ln PM_{ijlt}$), a count variable used to proxy the role of the EU-GSP scheme, was found to have a statistically significant positive influence on Uganda's banana, bean and pepper exports to the EU market. A one per cent increase in the preferential margin granted under the EU-GSP scheme was observed to lead to an increase in the monetary value of Uganda's banana, bean and pepper imports into the EU market by US$ 770 ($p<0.01$), US$ 3050 ($p<0.05$) and US$ 280 ($p<0.01$), respectively. This observation implies that the scheme has had a contributory role in boosting Uganda's exports to the EU.

**Table 5.11: Effect of the EU-GSP scheme on Uganda's Banana, Bean and Pepper exports**

| **Dependent variable ($M_{ijlt}$) = Total value of commodity *l* from Uganda *i* to *j*th EU member state in year *t* in '000 US Dollars** | | | | | | |
|---|---|---|---|---|---|---|
| **Variable** | **Bananas (080300)** | | **Beans (070820)** | | **Pepper (070960)** | |
| | **Coefficient** | **p-value** | **Coefficient** | **p-value** | **Coefficient** | **p-value** |
| Constant | -7.77<br>(16.798) | 0.644 | 1442.33***<br>(211.209) | 0.000 | -81.74***<br>(2.116) | 0.000 |
| Preference margin of a specific commodity, expressed as a share of the product value (**$lnPM_{ijlt}$**) | 0.77***<br>(0.084) | 0.000 | 3.05**<br>(1.211) | 0.012 | 0.28***<br>(0.082) | 0.001 |
| Exporter's Gross Domestic Product (GDP) in current US$ (**$lnY1_{it}$**) | 3.076***<br>(0.203) | 0.000 | -0.02<br>(1.059) | 0.986 | 1.89***<br>(0.060) | 0.000 |
| Importer's Gross Domestic Product (GDP) in current US$ (**$lnY2_{jt}$**) | 1.63***<br>(0.042) | 0.000 | 6.64***<br>(1.035) | 0.000 | 0.99***<br>(0.010) | 0.000 |
| Distance in miles between trading partners (**$lnD_{ij}$**) | -17.67***<br>(1.857) | 0.000 | -196.07***<br>(27.662) | 0.000 | 1.99***<br>(0.194) | 0.000 |
| Exporting country's mean annual inflation rate (**$ln\,inflat_{it}$**) | -0.43***<br>(0.026) | 0.000 | 0.15<br>(0.129) | 0.256 | -0.08***<br>(0.017) | 0.000 |
| Cost to exporting a 20-foot container in US$ per container (**$lnCOSTEXP_{it}$**) | -0.75***<br>(0.070) | 0.000 | -0.09<br>(0.365) | 0.811 | - | - |
| The role of the public sector and government institutions, expressed as an index (*from 1=low to 6= high*) (**$lnGOV_{it}$**) | 1.57***<br>(0.182) | 0.000 | -5.05***<br>(1.707) | 0.003 | 1.80***<br>(0.182) | 0.000 |
| Net inflow of foreign direct investment in current US$ (**$lnFDI_{it}$**) | 2.08***<br>(0.086) | 0.000 | - | - | - | - |
| The cost of establishing a business, expressed as percentage of GNI per capita (**$lnCOSTBIZ_{it}$**) | - | - | - | - | -0.77***<br>(0.178) | 0.000 |
| Dummy variable for common language (=1, if share common language; = 0 otherwise) (**$Dlang_{ij}$**) | 4.46***<br>(0.110) | 0.000 | -3.14***<br>(1.017) | 0.002 | 1.98***<br>(0.022) | 0.000 |
| Vuong test (Z-value) | 2.38*** | 0.009 | 9.65*** | 0.000 | 3.99*** | 0.000 |
| Fixed effects | Yes | | Yes | | Yes | |
| Number of observations (N) | 105 | | 105 | | 105 | |
| Nonzero observations ($N_1$) | 58 | | 19 | | 75 | |
| Zero observations ($N_0$) | 47 | | 86 | | 30 | |
| Log likelihood | -803.596 | | -97.100 | | -8671.796 | |
| Count data estimation technique used | ZIP | | ZIP | | ZIP | |

***, **, * denote significance at 1%, 5% and 10% level respectively.

In general, the positive effect of the scheme on Uganda's commodities may be attributed to the fact that Uganda's agricultural commodities are produced organically. Generally, ACODE (2006) argues that Uganda has the lowest agro-chemical usage on the African continent. Furthermore, the International Federation of Organic Agriculture Movement (IFOAM) and Research Institute of Organic Agriculture (FiBL) (2006) also note that Uganda has the most established sector of certified organic smallholder producers. By the end of 2010, the country registered the highest number of certified organic farm households, that is more than 188,600, while many more uncertified smallholder farmers also manage their farms in compliance with internationally commended organic standards and guidelines (FiBL and IFOAM, 2013; 2005). Namuwoza and Tushemerirwe (2011) also contend that Uganda has the largest cultivated organic area, estimated at more than 0.22 million hectares.

Such organically produced agricultural commodities are in high demand in developed economies. For instance, according to FiBL and IFOAM (2013), Germany and France had the second- and third-largest organic market globally, after the United States in 2011. Germany's organic market size was estimated at US$ 9.2 billion, while France accounted for US$ 5.2 billion and the United Kingdom, US$ 2.6 billion. In terms of per capita consumption, 2013 statistics show that Switzerland (US$ 250.4), Denmark (US$ 225.7) and Luxemburg (US$ 187.3) are in the lead.

The positive influence of the EU-GSP scheme may further be linked to the successful negotiations between the EU and the USA regarding the mutual recognition of their organic standards and control systems (FiBL and IFOAM, 2013). Organic products, certified by a control body recognized for operations in the exporting country, can be sold in both regions without further inspection or certification. This has relieved some of the producers from implementing more than one organic standard, thus reducing the certification costs and boosting trade flows.

The generally positive trend of Uganda's horticultural exports under the EU-GSP scheme may be attributable to the fact that more than 90 % of these commodities are sold in niche markets. That is, sold in wholesale markets and through the food service sector which are less stringent with a number of standard requirements. According to Kleih *et al*. (2007), the strict demand for standards and other requirements for trade is largely a construct of the supermarkets, which Ugandan exporters are able to circumvent.

Furthermore, this may be associated with the external support accorded to the sector. For instance, by 2004, the Export Promotion of Organic Products from Africa (EPOPA) programme financed by the Swedish International Development Co-operation Agency (SIDA) trained and linked many smallholder farmers/exporters (19,000) to international markets where they are able to sell their produce (Forss and Lundström, 2004). According to FAO (2005), there are many other local and foreign associations and Non-Government Organizations (NGOs) promoting organic agriculture by building the capacity of smallholder farmers. Mentioned institutions include National Organic Agriculture Movement of Uganda (NOGAMU), Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA), Network for Ecofarming in Africa (NECOFA), and Women of Uganda Network (WOUGNET).

Given that most exported fruits and vegetables come from certified organic producers (Namuwoza and Tushemerirwe, 2011), these commodities tend to meet the minimum EU market safety standards with regard to Maximum Residue Levels (MRLs). This implies that the interception of Uganda's horticultural consignments within the EU may not, in most cases, be grounded in a failure to comply with safety standards. Furthermore, organically produced products are known to have a smaller carbon footprint, which commands a ready market for the produce within the EU.

These findings may also be attributed to Uganda's comparative advantage in producing horticulture commodities, such as bananas, beans, and peppers. The country's bi-modal rainfall pattern, fertile soils, cheap labour and ambient climatic conditions favour the production and export of horticultural produce to the EU market (Dolan *et al.,* 2000). Although the preference margin granted under the GSP scheme may not be so large, most exporters' success is based on trading in high-value commodities and in relatively large quantities to take advantage of economies of scale. The EU-GSP scheme is therefore a vital policy instrument in promoting Uganda's banana, beans and pepper exports to the EU market. (Also see Cipollina *et al*. 2013, Cirera *et al*. 2011, Aiello and Demaria, 2009, and Cipollina and Salvatici, 2009).

The coefficients of all the other covariates used for modelling the effect of the EU-GSP scheme on Uganda's banana imports into the EU market were found to be statistically significant and exhibit the expected signs according to the gravity flow model framework. With the exception of Uganda's mean annual inflation rate **($lninflat_{it}$),** the role of the public sector and government institutions **($ln\mathrm{GOV}_{it}$)**, and the dummy variable for common language **($\mathrm{Dlang}_{ij}$)**, the other variables were found to accord with theoretical expectations. Contrary to theory, fluctuations in the mean annual inflation rate do not influence bean exports to the EU market. This observation may be associated with high demand and the high price paid for organically produced foodstuffs. Thus, although high inflation could deter bean exports, the high returns realized upon exporting beans to the EU are probably responsible for offsetting the negative influence of high inflation. This, therefore, ends up having no influence on Uganda's bean exports to the EU market.

According to the analytical results (-3.14, p<0.01), having a common official language (**Dlang**$_{ij}$) significantly deters imports of Uganda's beans into the EU market by US$ 3140, as compared with other exporting countries within the market that do not share a common official language. This peculiar observation is attributable to the fact that, among Uganda's bean export destinations within the EU (the United Kingdom, Belgium, the Netherlands and Denmark, in that order), it is only the United Kingdom with whom Uganda shares a common official language (English). The other countries which use English are Ireland and Luxembourg, but existing data indicates that none of those countries ever imported beans from Uganda during the period (2005–2011) considered under this particular analysis.

Contrary to the expected results, Uganda's public sector and government institutions **(*ln*GOV**$_{it}$**)** were found not to play a contributory role in enhancing bean imports into the EU market. At 5 % significance level, results (-5.05, p<0.05) indicate that a unit change in the Country Policy and Institutional Assessment (CPIA) index for transparency, accountability, and corruption leads to a decline worth US$ 5,050 in the importation of Uganda's beans into the EU. This finding may be explained by the fact that most government interventions in boosting horticultural trade have been accorded to prioritized enterprises, such as flowers, bananas, citrus, pineapples and passion fruits. However, no single policy or government intervention has been found promoting either bean production or value addition, in particular.

In the case of Uganda's pepper imports into the EU, all covariates were found to be statistically significant at all levels, although the coefficient on the variable for distance between trading partners **(*ln*D**$_{ij}$**)** had a positive sign (1.99, p<0.01), instead of a negative sign. This result may be explained by the argument postulated by scholars (Marimoutou *et al*., 2009; André and Joel, 2012) that the influence of distance ceases to be an issue if the trading partner's economic size (GDP) is very large in comparison to that of the exporting country. Indeed, on average, Europe's GDP is 75 times more than that of Uganda, with Germany (highest) and Luxembourg (lowest) being about 250 and 4 times larger than Uganda, respectively (WDI, 2012). Furthermore, the positive sign may also be explained by the view of Kuwornu and Mustapha (2013) that the variety of the crop produced has a great influence on smallholder farmers' accessibility into the export market. In this regard, Uganda is known for producing highly-favoured pepper (Scotch bonnet). This variety of pepper is characterized by an aromatic flavour and high pungency, which are great attributes for peppers. According to Abdulla *et al*. (2008), the high pungency and aromatic flavour of the Scotch Bonnet are desirable in the pharmaceutical, as well the foods and beverages, industries.

## 5.5 East Africa's unilateral Trade Potential and performance in exporting fruits and vegetable into the EU market

The assessment of East Africa's trade potential and performance was carried out at country level for the different horticultural commodities considered under the third objective. Notably, the third objective examined the impact of the EU-GSP scheme on selected horticultural commodity imports from East African states into the EU market. The results are presented in Table 5.12 below and in the subsequent figures at country level.

**Table 5.12: Mean Absolute Difference ($AD_{ijlt}$) for East Africa's selected horticultural commodities at country level with the EU-15 states**

| EU-15 states | Kenya ('000 US$) | | Tanzania ('000 US$) | | Uganda ('000 US$) | | |
|---|---|---|---|---|---|---|---|
| | Beans | Asparagus | Beans | Vegetables | Beans | Bananas | Pepper |
| Austria | 127.5 | -467.4 | -5.7 | 0.9 | 15.9 | 7.8 | 1.1 |
| Belgium | 8,043.7 | -466.9 | 423.6 | 1.4 | 15.6 | 514.9 | 425.7 |
| Denmark | 3.4 | -474.6 | -5.2 | -3.1 | 6.3 | 28.0 | 1.9 |
| Finland | 66.8 | -469.6 | 10.2 | -4.5 | 16.2 | 1.3 | -0.6 |
| France | 17,981 | -459.5 | 64.4 | 2.9 | -14.9 | 5.6 | 169.4 |
| Germany | 9172.0 | -455.6 | -2.2 | 3.8 | -19.3 | 114.4 | 178.5 |
| Greece | -7.9 | -458.5 | -7.9 | 6.9 | -72.5 | -7.0 | -2.4 |
| Ireland | 363.9 | -473.2 | -7.7 | -11.6 | 25.5 | 2.4 | 15.2 |
| Italy | 121.6 | -466.2 | -6.3 | 7.3 | -53.5 | -7.3 | 0.3 |
| Luxembourg | 857.1 | -469.6 | -9.0 | -11.8 | 9.8 | -2.4 | -3.5 |
| Netherlands | 20,331 | -463.2 | 550.2 | -0.1 | -0.3 | 29.7 | 731.3 |
| Portugal | 6.4 | -468.2 | -5.6 | -2.8 | -4.2 | -0.5 | -3.1 |
| Spain | 11.4 | -469.4 | -5.4 | 2.7 | -24.7 | 6.2 | 8.8 |
| Sweden | 8.4 | -470.8 | -4.9 | -3.1 | 21.7 | 30 | -1.2 |
| UK | 85,164 | -184.2 | 2,071 | 199.5 | 16.8 | 2,233.2 | 2,284.6 |
| **Mean EU-15** | **9,483.4** | **-447.8** | **204.0** | **12.5** | **-4.1** | **197.1** | **253.7** |

***Source***: Author's own calculation

With the exception of asparagus (US$ -0.45 million) from Kenya and beans (US$ -4,100) from Uganda, the results based on the mean Absolute Difference (AD) measure generally show that there exists no un-exhausted trade between EA states and the EU market for these selected horticultural commodities. In the case of Kenya, the results mean that the current exports of asparagus to the EU market have not reached their full potential by approximately US$ 0.45 million, while for Uganda bean exports fall short by US$ 4,100. Kenya's asparagus and Uganda's beans have a high trade potential within the EU market and there exists room for further trade expansion. This may be attributed to the fact that asparagus is a speciality vegetable in the EU, while Uganda's beans are renowned for being organically produced.

On the other hand, the results show that the other commodities exceeded their trade potential with the EU. Kenya's beans registered the highest level of trade flows (US$ 9.5 million) that surpassed the optimum level, followed by Uganda's pepper (US$ 0.25 million), while vegetables from Tanzania ranked last (US$ 12,500). This implies that there is hardly any potential for further trade expansion in these commodities with the EU. The observation for Kenya's beans may be attributed to the fact that Kenya trades with virtually all EU member states, unlike Uganda and Tanzania. In the case of Uganda, the upper bound levels of trade in pepper with the EU may be associated with the commodity's attributes (pungency and aroma), hence making it very desirable in a number of industries. For Tanzania, the results may be associated with the fact that it consistently trades with very few EU member states, particularly Belgium and the United Kingdom (COMTRADE data, 2013).

At country level, the findings indicate that Kenya has un-exhausted trade potential in bean exports to Greece (US$ 7,900). This suggests that there is supportive evidence for Kenya's trade expansion with Greece for bean imports. For Tanzania, room for trade expansion in bean exports exists with Luxembourg, Greece, Ireland, Italy, Austria, Portugal, Spain, Denmark, Sweden and Germany. Similarly, provision for more trade in vegetables from Tanzania still exists with Luxembourg (US$ 118,000), Ireland (US$ 116,000), Finland (US$ 4,500), Portugal (US$ 2,800), and the Netherlands (US$ 100), as well as an estimated trade worth of US$ 3,100 for Denmark and Sweden. This also implies that Tanzania has room for trade expansion with the above-mentioned EU member states in bean and vegetable commodities.

Uganda has un-exhausted trade potential with Greece and Portugal for all three commodities. Thus, trade in these commodities has the capacity to grow further. With the exception of pepper imports into Greece in 2006 and 2008 (COMTRADE data, 2013), these results may be attributable to the fact that Uganda registered no exports to any of these countries for the period 2005–2011. For beans, other EU states with un-exploited trade potential include Italy (US$ 53,500), Spain (US$ 24,700), Germany (US$ 19,300), France (US$ 14,900) and the Netherlands (US$ 300). In the case of bananas, Italy and Luxembourg presented un-exhausted trade potential at an estimated value of US$ 7,300 and US$ 2,400, respectively. Other than Greece and Portugal, Luxembourg (US$ 3,500), Sweden (US$ 1,200) and Finland (US$ 600) also present Uganda with un-exploited trade potential in peppers. Thus, these states provide a basis for more trade expansion in pepper.

In light of the Relative Difference (RD) Index measure, the results provided in Figure 5.1 below show that Kenya has a very poor trade performance in asparagus with the EU market, given that the estimated index lies below zero across all the EU 15 member states. Conversely, Kenya generally exhibits good trade performance (38 %) in its bean imports into the EU. The results imply that Kenya has not established adequate trade cooperation with the EU in general in asparagus trade. On the other hand, the results also mean that Kenya has a good trade relationship in beans with the EU.

At EU state level, Kenya has very poor trade performance with Portugal (100 %), Denmark (48 %) and Sweden (11 %) in bean imports. This poor performance may be associated with language barriers, among other factors. With the exception of Spain (3 %), Kenya has very good trade relationships with all the other EU-15. The low, but positive, trade performance with Spain may be linked to divergence in cultural ties with Spain.

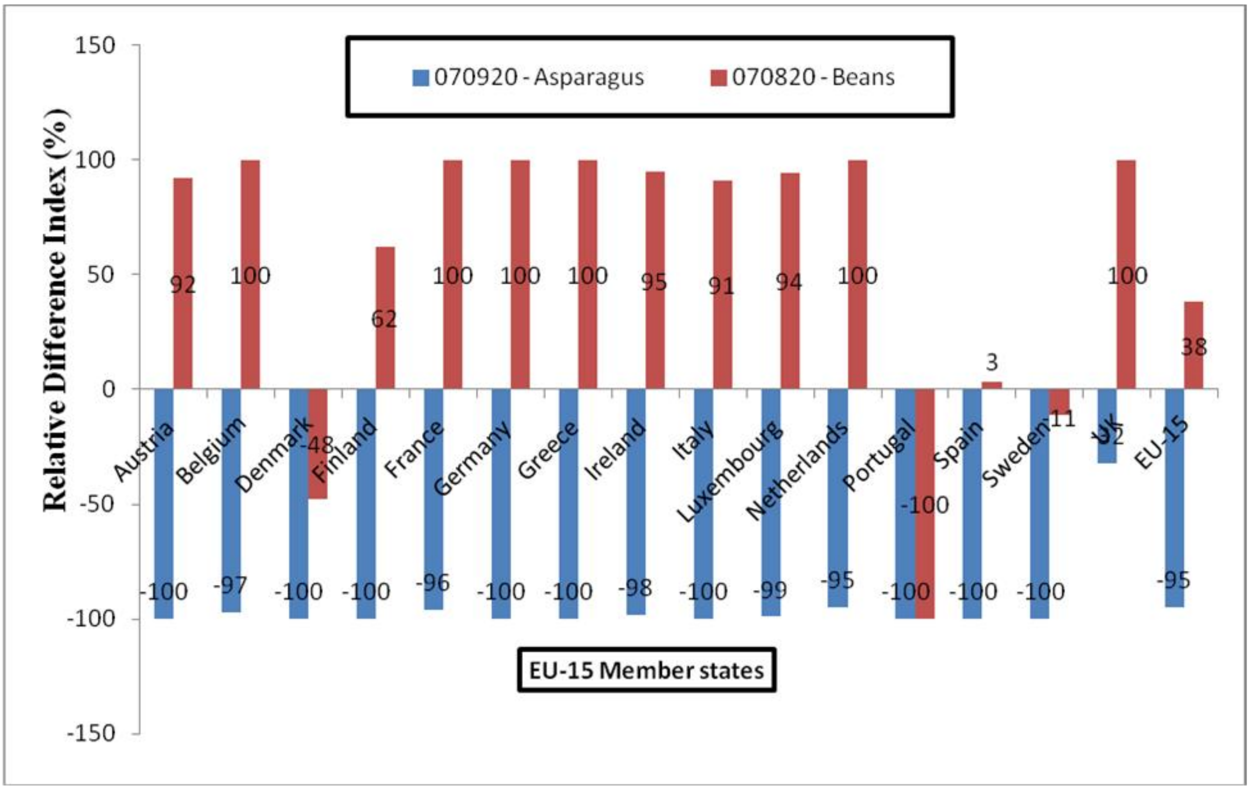


**Figure 5.1: The Relative Difference Index for Kenya's beans and asparagus exports with the EU-15 member states**
***Source***: Author's own calculation

For Tanzania, there is a general poor trade performance with the EU-15 market for both vegetables (83 %) and beans (45 %). This may be because there are few countries with which Tanzania trades within the European Union. According to Figure 5.2 below, Tanzania has a good trade performance in beans with Belgium (96 %), the Netherlands (97 %), the UK (99 %) and Finland (14 %), while the UK is the only EU-15 member state with which Tanzania has a good trade performance for both commodities. This may be associated with the fact that Tanzania was once a British colony, thus there exists long-term trade relations between the two countries. This observation is supported by the Absolute Difference measure, which shows that Tanzania has room for trade expansion in beans and vegetables with a number of EU-15 states.

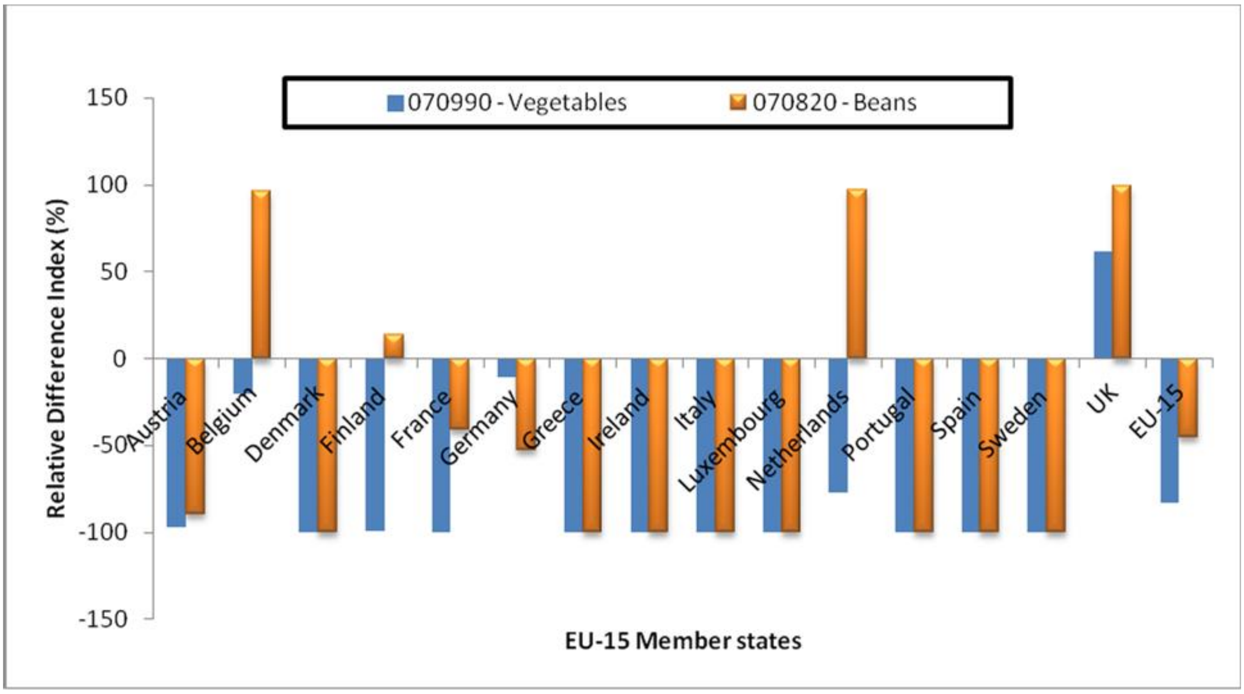


**Figure 5.2: The Relative Difference Index for Tanzania's beans and vegetable exports with the EU-15 member states**
***Source***: Author's own calculation

Uganda's trade performance, as measured by the Relative Difference Index, shows a poor trade performance in all three commodities with the EU in general. Beans have the weakest trade performance (74 %), followed by pepper (11 %) and then bananas at 6 %. At the commodity level, Uganda exhibited a strong trade performance in all three horticultural commodities with Belgium and the UK, only. This may be attributable to the long-term colonial ties with Britain and similarity in language. Although English is not one of the three official languages in Belgium (Wikipedia, 2014), it is widely spoken country wide as a second native language by Belgians. Figure 5.3 below also shows that Uganda has a poor trade performance with Finland, Greece, Italy, Portugal and Spain, in all three commodities. The results thus imply that Uganda has more room to trade with these EU states in all three commodities. Findings based on the Relative Difference (RD) index identify with the results based the Absolute Difference (AD) measure, which suggests that Uganda has a wide base for trade expansion in these horticultural commodities, most especially beans.

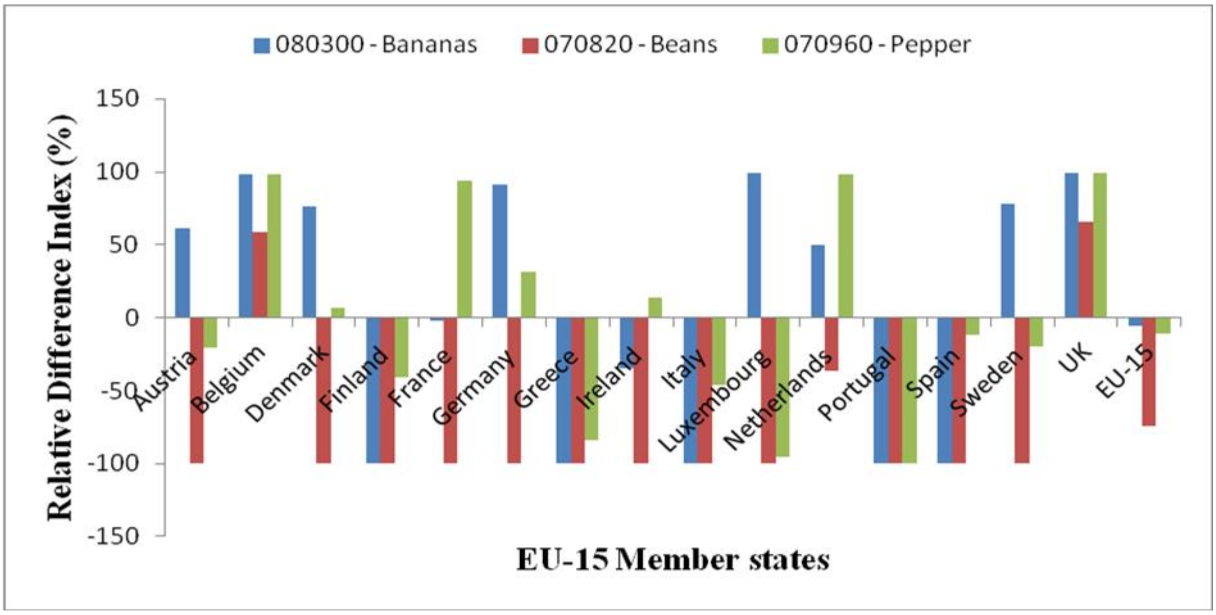


**Figure 5.3: The Relative Difference Index for Uganda's beans, bananas and pepper exports with the EU-15 member states**
***Source***: Author's own calculation

### 5.6 Summary of results and discussions

Purposively, this chapter aimed to analytically determine the export competitiveness of various fruit and vegetable products from three East African states in the EU market, to develop a set of climate change proxies and then use the proxies to ascertain the influence of climate change on East Africa's horticultural trade flows, and to examine the impact of the EU-GSP scheme on the various fruits and vegetable commodities imported into the EU from the East African region. Furthermore, this chapter aimed at predicting the trade potential and performance of East Africa's selected horticultural commodities imported into the EU market.

The mean export competitiveness results show that Uganda (1,321) by far out-competes Kenya (495) and Tanzania (2) within the EU-market. Detailed analysis shows that Kenya exhibits export competitiveness in more commodities (10) as compared with Uganda and Tanzania, which are only competitive in six (6) and five (5) commodities, respectively. For Kenya, "Asparagus (070920)" is the most competitive commodity, followed by "Mushrooms & truffles (070959)" among others. Kenya's good export competitiveness in the 10 horticultural commodities may be attributable to the breath-taking efforts undertaken by both the government and the private sector in developing the horticulture industry. For Tanzania, "Vegetables (070990)" were the most competitive, while in the case of Uganda, fruits of the genus Capsicum or of the genus Pimen, (**070960**), bananas and eggplants exhibited the highest levels of export competitiveness within the EU market. Thus, East African countries should capitalize on exporting horticultural commodities over which they have export competitiveness, *viz*, Asparagus, Mushrooms and truffles (Kenya); Vegetables for Tanzania; while Uganda should dwell more on peppers, bananas and eggplants, among other horticultural commodities.

The statistically significant climate change results depict both positive and negative influences on East Africa's horticultural trade flows into the EU-market, depending on the climate change proxy being put into perspective. While precipitation anomalies in the importing countries (EU) are noted to enhance horticultural trade flows from all the three East African states, temperature anomalies seem to negatively influence trade. On the other hand, temperature anomalies in exporting countries seem to boost trade in horticultural commodities from Tanzania and Uganda, but they may limit trade flows from Kenya. Similarly, precipitation anomalies in exporting countries favour horticultural trade flows from Kenya, while they deter trade flows from Tanzania and Uganda. Thus, it is prudent to conclude that climate change has both trade-enhancing and trade-deterring effects, depending on the country and the proxy being put into consideration. Therefore, owing to the trans-boundary nature of the climate change phenomenon, East African states should collaborate in designing, coordinating and implementing pro-growth and pro-poor development policies and investment strategies that will enhance the sustainability of the horticulture sector, as well as adapt to climate change. Such ventures may include breeding improved horticultural cultivars that can tolerate extreme climatic conditions, and investment in physical infrastructure, such as irrigation dams.

To determine the effect of the EU-GSP scheme, the preference margins of each of the seven horticultural commodities that exhibited export competitiveness within the EU-market were used for analysis within the gravity flow model framework. For Kenya, results show that the scheme reduces the value of trade flows in asparagus and beans by an estimated US$ 2,460 ($p<0.01$) and US$ 280 ($p<0.01$), respectively. This implies that the EU-GSP scheme is of less importance in boosting the importation of Kenya's asparagus and bean commodities into the EU-market. For Tanzania, findings at one per cent level of significance indicate that the scheme significantly enhances importation of beans into the EU, thus implying that it is a relevant policy in this scenario. However, despite the fact that the EU-GSP scheme has negative effects on Tanzania's vegetable imports into the EU, it is inconclusive since the result was insignificant at all levels. For Uganda, the statistically significant results indicate that the scheme promotes the importation of bananas, beans and pepper into the EU market. It is thus insightful to conclude that the EU-GSP scheme is a very vital policy instrument in promoting importation of Uganda's horticultural produce. Hence, Kenya should explore other international markets, such as the Middle East and the USA, for its asparagus and bean exports. However, Tanzania and Uganda should continue to aggressively seize the market opportunity granted by the EU, particularly for bananas and peppers (Uganda), as well as beans (Uganda and Tanzania).

In light of East Africa's trade potential and performance with the EU market, seven commodities were analysed. Generally, Kenya and Uganda exhibit un-exhausted trade potential in asparagus and beans worth US$ 0.44 million and US$ 4,100, respectively. This implies that there is room for further trade expansion within the EU market for these particular commodities. At commodity level, there exists a very large possibility for trade expansion for Kenya's asparagus across all the EU-15 member states that were considered in this study. For beans, results show that Kenya has un-exhausted trade worth about US$ 8,000 with only Greece, among other EU-member states. This suggests that Kenya can still by far expand her trade in beans with Greece than many other EU states. With the exception of Belgium, Finland, France, the Netherlands and the United Kingdom, all the other EU member states have room for expansion with Tanzania's trade in beans. In the case of Uganda, key destination markets with further possibility of trade expansion for beans include France, Germany, Greece, Italy, Spain, Portugal and the Netherlands. Furthermore, results for Uganda's pepper show that Luxembourg, Portugal, Greece, Sweden and Finland still have un-tapped trade opportunities that could be exploited by Uganda.

In terms of trade performance, it is plausible to conclude generally that Kenya has a very poor trade performance in asparagus within the EU market, while its beans perform fairly well. Similarly, with the exception of the UK, Tanzania has a very poor trade performance within the EU market for both beans and vegetables. Likewise, Uganda registered a poor trade performance in all the three commodities (bananas, beans and pepper) imported into the EU. The poor trade performance for the EA states within the EU market implies that EA states have not yet established strong trade relationships within the market.

All in all, empirical findings reveal that by successfully using a heterogeneous set of climate change proxies (anomalies in temperature and precipitation in both the importing and exporting countries) to investigate the effect of climate change on international trade, I have been able affirm that climate change possesses both negative and positive impacts on international trade in horticultural commodities. The positive and negative effects depend on the type of commodity, the origin of the commodity and the type of proxy used to quantify climate change. Furthermore, the results indicate that, by using a preference margin based on the trade weighted applied Most Favoured Nation (MFN) rate and the Ad Valorem Equivalents (AVEs), I have ably ascertained that the EU-GSP scheme selectively promotes importation of horticultural commodities into the EU-market, depending on the country of origin of the commodity.

# CHAPTER SIX:
# SUMMARY, CONCLUSION AND RECOMMENDATIONS

In this chapter, a brief summary, conclusions and recommendations are presented with reference to each objective. In particular cases, conclusions and recommendations are specific to a particular country.

## 6.1 Summary and conclusions

As one of the objectives, the study aimed at investigating the effects of a developed set of meteorological data variables as climate change proxies on international trade by using panel estimation techniques. The objective was achieved by using generated anomalies in temperature and precipitation, both in the exporting and importing countries. The use of anomalies in temperature and precipitation as proxies for climate change, particularly for trade flows skewed towards agricultural commodities, was motivated by the fact that these two factors are direct inputs in the agricultural sector. Thus, their fluctuations will directly be reflected in the volumes of agricultural commodities traded.

Findings based on the developed set of climate change proxies, *viz,* temperature and precipitation anomalies, imply that climate change has both positive and negative influences on horticultural trade flows to the EU-Market. The influence, however, depends on the climate change proxy being put into consideration. Within the EU market, anomalies in precipitation enhance horticultural imports from East Africa, while temperature anomalies seem to hinder trade. Anomalies in temperature in exporting countries boost horticultural trade flows from Tanzania and Uganda, while the contrary is true for Kenya. Precipitation anomalies in exporting countries favour horticultural trade flows from Kenya, while they curtail trade flows from Tanzania and Uganda. These empirical results correlate with findings of other scholars. Thus, it is prudent to conclude that the proposed approach of assessing the effects of climate change based on meteorological anomalies in agrarian-based economies may be a more reliable measure than the use of proxies based on Kyoto Protocol policies.

Furthermore, the study endeavoured to determine the effect of the EU-GSP preferential trade agreement on East Africa's fruits and vegetable exports to the European Union market. This objective was successfully achieved using the preference margin variable based on the trade weighted applied Most Favoured Nation (MFN) rate and the Ad Valorem Equivalents (AVEs).

The trade weighted preference margin measure takes into account all the policy instruments embedded within the EU-GSP scheme and other competitors within the EU market.
Empirical results suggest that the EU-GSP scheme selectively favours exports of certain horticultural commodities to the EU-market, depending on the country of origin. Particularly, the scheme promotes importation of bananas, beans and peppers from Uganda and beans from Tanzania. On the contrary, this policy instrument does not enhance asparagus and bean imports from Kenya. In conclusion, the use of preference margin, based on all the policy instruments embedded within the EU-GSP scheme, provides appropriate commodity-specific inferences regarding the effect of the EU-GSP scheme on horticultural imports into the EU market.

The study also aimed at determining the export competitiveness of East Africa's fruit and vegetable exports to the European Union market. The objective was successfully attained by using Balassa's index. At country level, results show that Kenya has export competitiveness in more commodities (10) than Uganda (6) and Tanzania (5). For Kenya, “Asparagus (070920)” and "Mushrooms & truffles (070959)" are the most competitive commodities, while for Uganda, fruits of the genus Capsicum or of the genus Pimen, (070960), bananas and eggplants registered the highest levels of export competitiveness within the EU market. In the case of Tanzania, “Vegetables (070990)” were the most competitive. Conclusively, each of these countries exhibits comparative advantage in exporting those commodities over which it has export competitiveness. Thus, East African countries should capitalize on exporting those horticultural commodities over which they have export competitiveness, *viz*, Asparagus, Mushrooms and truffles (Kenya); Vegetables for Tanzania; while Uganda should dwell more on peppers, bananas and eggplants, among other horticultural commodities.

Lastly, the study aimed at predicting East Africa’s unilateral trade potential and performance. Kenya and Uganda exhibit the existence of un-realized trade potential, thus implying that these countries still have room to expand their horticultural trade with the EU market. For Kenya, asparagus is a key commodity for further market expansion across all EU member states, while to expand Uganda's market for beans and pepper, trade partnerships should be considered with countries such as France, Germany, Luxembourg, Portugal and Greece. Other than Belgium, Finland, France, the Netherlands and the United Kingdom, all the other EU member states have room for trade expansion for beans from Tanzania. With regard to trade performance, results indicate that all the three East African states have poor trade performance with the EU market in the various commodities. This suggests that there exists an array of trade barriers curtailing East

Africa's horticultural imports into the EU. Conclusively, there is need for the East African states to foster trade cooperation in horticultural commodities with the EU member states.

## 6.2 Recommendations

The following recommendations are based on the empirical results of this study. Recommendations are categorized into four (4) types, *viz*, recommendations to exporters; policy recommendations; recommendations to researchers, and recommendations for further research.

### 6.2.1 Recommendations to exporters

- Based on empirical results from the analysis for export competitiveness, exporters should trade more in the following top five horticultural commodities at country level. For Kenya, the key commodities are: Asparagus (070920), Mushrooms & truffles (070959), Spinach and New Zealand spinach (070959), Aubergines (070930) and Peppers (070960). For Tanzania, Vegetables (070990), Kidney & white pea beans (071333), Bananas (080300), Beans (070820) and Urd, mung, gram beans (071331) are the most important. For Uganda, peppers (070960), Aubergines (070930), Bananas (080300), Vegetables (070990) and Beans (070820) are the major horticultural commodities that should be focused on.

- In light of results for trade potential and performance, it is commended that exporters, with support from government institutions responsible for promoting trade, should strengthen trade cooperation with the various EU member states, particularly with Greece, Portugal, Sweden Luxembourg and Italy, among others. This will greatly enhance the capacity of East African states to exploit the untapped trade potential within the EU market.

- Based on trade potential and performance results, it is prudent to recommend that East African states should consider exploring and strengthening trade linkages with alternative markets such as the USA and the Middle East. This will probably reduce greatly the non-tariff barriers to trade associated with the frequently changing strict "voluntary" standard (Global G.A.P) within the EU market.

### 6.2.2 Policy recommendations

- In light of the developed set of climate change proxies based on temperature and precipitation, it is recommended that representatives of agriculture-based economies, such as Kenya, Tanzania and Uganda, should lobby and advocate for putting into consideration other measures for quantifying the effects of climate change, rather than relying on measures based on Kyoto Protocol policies. The lobbying and advocating for such pertinent considerations should be brought forward at the international climate change negotiation forums, at which agriculture-based economies have representatives. Measures based on Kyoto Protocol policies are more appropriate and applicable for industrious countries. Putting into practice such new measures for quantifying climate change for agriculture-based economies will greatly protect such countries from being compelled to adopt the unaffordable or costly industrial technologies, which are noted to be one of the factors hindering the curbing of climate change effects. The use of anomalies will most likely stimulate development of technological innovations, like breeding crop varieties that are tolerant to extreme climatic conditions and which will match the changing climate within the agricultural sector.

- Based on the negative findings relating to climate change effects on trade, it is recommended that East African states should design and implement good overall development policies and programmes. Owing to the trans-boundary nature of the unprecedented climate change phenomenon, the East African states should collaborate to design, coordinate and implement pro-growth and pro-poor development policies that enhance the sustainability of the horticulture sector, as well as the adaptation to climate change.

- Kenya, Tanzania and Uganda should undertake more investments aimed at boosting productivity of the horticultural sector. Such investments may include:

  - Agricultural research and development. Through science- and technology-based innovations, like the breeding improved horticultural cultivars (biotechnology) that can withstand extreme climatic conditions and improved farm management practices, the productivity of this sector will become less vulnerable to climatic fluctuations. This in the long-run translates into high and sustainable production of horticultural commodities, thus implying the availability of horticultural commodities that can be traded globally.

  - East African states should also invest in physical infrastructure, such as irrigation dams so as to enhance efficiency in water use.

### 6.2.3 Recommendations to researchers

- Within the gravity flow model framework, it is recommended that anomalies in temperature and precipitation should be used to proxy for climate change when evaluating the impact of climate change on trade flows skewed towards agricultural commodities. That is, if a country's or a region's exports comprise mostly agricultural commodities, then anomalies in temperature and precipitation should be used. The other climate change proxies based on Kyoto Protocol policies should be used when dealing with manufactured goods from industry-based economies.

- Evaluation of the influence of non-reciprocal preferential trade agreement(s) granted to developing countries, based on preference margins, should always take into account the various instruments embedded within the EU-GSP scheme. The omission of any of the instruments may lead to over-estimation of the preference margin.

### 6.2.4 Recommendations for further research

- Because of the lack of comparable meteorological datasets, this study was at one hand based on historical meteorological data (1988–2000), which may not provide an adequate perspective of the three East African states' horticultural trade flows to the EU market. Therefore, further research based on temperature and precipitation anomalies is desirable to affirm the effects of climate change.

- The evaluation of the impact of the EU-GSP scheme, while employing the preference margin variable, focused on selected horticultural commodities. However, given that the EU-GSP takes into consideration other commodities, it is recommended that the preference margin approach used in this study should be employed on the other commodities as well.

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# APPENDICES

## Appendix A: The EU-15 member states considered under this study

| No. | Country | Year joined EU |
|---|---|---|
| 1 | Belgium | 1957 |
| 2 | France | 1957 |
| 3 | Germany | 1957 |
| 4 | Italy | 1957 |
| 5 | Luxembourg | 1957 |
| 6 | Netherlands | 1957 |
| 7 | Denmark | 1973 |
| 8 | Ireland | 1973 |
| 9 | United Kingdom | 1973 |
| 10 | Greece | 1981 |
| 11 | Portugal | 1986 |
| 12 | Spain | 1986 |
| 13 | Austria | 1995 |
| 14 | Finland | 1995 |
| 15 | Sweden | 1995 |

**Appendix B: Multi-collinearity test results for the three East African states**

**(Objective 2: *The influence of climate change on East Africa's horticultural trade flows*)**

## 1. KENYA

### i) VIF and TOL test results

| Variable | VIF | 1/VIF |
|---|---|---|
| $DT_{jt}$ | 27.60 | 0.036231 |
| $Incom_{ijt}$ | 19.01 | 0.052600 |
| $Dlang_{ij}$ | 12.45 | 0.080296 |
| $lnY2_{jt}$ | 11.89 | 0.084104 |
| $lnAgri_{jt}$ | 8.68 | 0.115233 |
| m9 | 8.18 | 0.122300 |
| m8 | 5.07 | 0.197310 |
| m5 | 4.62 | 0.216267 |
| $lnD_{ij}$ | 4.53 | 0.220892 |
| $DT_{it}$ | 4.28 | 0.233534 |
| m6 | 4.04 | 0.247460 |
| $lnY1_{it}$ | 3.92 | 0.255029 |
| $lninflat_{it}$ | 3.48 | 0.287631 |
| m4 | 3.11 | 0.321922 |
| $lnAgri_{it}$ | 2.79 | 0.359017 |
| m13 | 1.99 | 0.501604 |
| m3 | 1.98 | 0.505480 |
| m11 | 1.80 | 0.555235 |
| m1 | 1.69 | 0.591275 |
| $Pre_{jt}$ | 1.33 | 0.753568 |
| $Pre_{it}$ | 1.31 | 0.762127 |
| Mean VIF | 6.37 | |

**NB:** Variables m1-m13 within the annexure denote importer fixed effects

**ii) Pearson's correlation matrix**

| | X | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $DT_{it}$ | $Pre_{it}$ | $DT_{jt}$ |
|---|---|---|---|---|---|---|---|
| X | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.2588 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.3992 | 0.0826 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.1360 | -0.0000 | -0.0717 | 1.0000 | | | |
| $DT_{it}$ | 0.0664 | 0.3271 | 0.0404 | -0.0000 | 1.0000 | | |
| $Pre_{it}$ | -0.1034 | -0.3381 | -0.0760 | 0.0000 | -0.3461 | 1.0000 | |
| $DT_{jt}$ | 0.0448 | 0.0141 | 0.1398 | -0.6416 | -0.0312 | 0.0199 | 1.0000 |
| $Pre_{jt}$ | 0.1568 | 0.1726 | -0.0275 | 0.3564 | 0.0627 | -0.0955 | -0.2110 |
| $lnAgri_{it}$ | 0.1954 | 0.4803 | 0.1123 | 0.0000 | 0.0823 | -0.5084 | 0.0034 |
| $lnAgri_{jt}$ | -0.0797 | -0.0146 | -0.5532 | 0.0371 | 0.0134 | 0.0349 | -0.1041 |
| $Dlang_{ij}$ | 0.2769 | 0.0000 | -0.3475 | 0.2931 | -0.0000 | 0.0000 | 0.0802 |
| $lninflat_{it}$ | -0.1676 | -0.5891 | -0.0600 | -0.0000 | -0.5125 | 0.2270 | -0.0126 |
| $Incom_{ijt}$ | 0.1455 | 0.0899 | -0.0711 | 0.4382 | -0.0031 | -0.0552 | -0.6512 |
| m1 | -0.0853 | -0.0000 | -0.0621 | -0.1779 | -0.0000 | -0.0000 | -0.2121 |
| m3 | -0.0820 | -0.0000 | -0.1080 | 0.1578 | -0.0000 | -0.0000 | -0.2189 |
| m4 | -0.0861 | -0.0000 | -0.1582 | 0.2327 | -0.0000 | -0.0000 | -0.4477 |
| m5 | 0.1803 | -0.0000 | 0.3434 | -0.0961 | -0.0000 | -0.0000 | 0.0997 |
| m6 | 0.1030 | -0.0000 | 0.4241 | 0.0564 | -0.0000 | -0.0000 | -0.1389 |
| m8 | -0.0764 | -0.0000 | -0.2958 | 0.2327 | -0.0000 | -0.0000 | 0.1636 |
| m9 | -0.0834 | -0.0000 | 0.3078 | -0.3779 | -0.0000 | -0.0000 | 0.4469 |
| m11 | 0.0437 | -0.0000 | 0.0621 | 0.1442 | -0.0000 | -0.0000 | -0.0790 |
| m13 | -0.0870 | -0.0000 | 0.1565 | -0.0391 | -0.0000 | -0.0000 | 0.1730 |

| | $Pre_{jt}$ | $lnAgri_{it}$ | $lnAgri_{jt}$ | $Dlang_{ij}$ | $lninflat_{it}$ | $Incom_{ijt}$ | m1 |
|---|---|---|---|---|---|---|---|
| $Pre_{jt}$ | 1.0000 | | | | | | |
| $lnAgri_{it}$ | 0.2130 | 1.0000 | | | | | |
| $lnAgri_{jt}$ | -0.0398 | -0.0166 | 1.0000 | | | | |
| $Dlang_{ij}$ | 0.1786 | -0.0000 | 0.5144 | 1.0000 | | | |
| $lninflat_{it}$ | -0.1323 | -0.1415 | 0.0020 | -0.0000 | 1.0000 | | |
| $Incom_{ijt}$ | 0.1877 | 0.0653 | 0.4730 | 0.3023 | -0.0662 | 1.0000 | |
| m1 | -0.0394 | 0.0000 | -0.0722 | -0.1336 | 0.0000 | 0.0819 | 1.0000 |
| m3 | 0.0407 | -0.0000 | -0.0643 | -0.1336 | -0.0000 | 0.2669 | -0.0714 |
| m4 | 0.0835 | 0.0000 | -0.0701 | -0.1336 | -0.0000 | 0.0488 | -0.0714 |
| m5 | -0.0261 | 0.0000 | -0.0666 | -0.1336 | -0.0000 | 0.0500 | -0.0714 |
| m6 | -0.0414 | 0.0000 | -0.0714 | -0.1336 | -0.0000 | 0.0996 | -0.0714 |
| m8 | 0.1682 | 0.0000 | -0.0702 | 0.5345 | -0.0000 | -0.1352 | -0.0714 |
| m9 | -0.1425 | 0.0000 | -0.0688 | -0.1336 | -0.0000 | -0.0357 | -0.0714 |
| m11 | 0.0478 | 0.0000 | -0.0710 | -0.1336 | -0.0000 | 0.0684 | -0.0714 |
| m13 | -0.0921 | 0.0000 | -0.0752 | -0.1336 | -0.0000 | -0.3357 | -0.0714 |

| | m3 | m4 | m5 | m6 | m8 | m9 | m11 |
|---|---|---|---|---|---|---|---|
| m3 | 1.0000 | | | | | | |
| m4 | -0.0714 | 1.0000 | | | | | |
| m5 | -0.0714 | -0.0714 | 1.0000 | | | | |
| m6 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | | | |
| m8 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | | |
| m9 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | |
| m11 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | 1.0000 |
| m13 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 |

| | m13 |
|---|---|
| m13 | 1.0000 |

**2. TANZANIA**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lninflat_{it}$ | 50.19 | 0.019923 |
| $lnY1_{it}$ | 49.66 | 0.020135 |
| $Incom_{ijt}$ | 6.47 | 0.154591 |
| $lnAgri_{it}$ | 6.42 | 0.155884 |
| $Pre_{it}$ | 5.95 | 0.168102 |
| $lnAgri_{jt}$ | 4.05 | 0.247175 |
| $lnD_{ij}$ | 3.36 | 0.297366 |
| m12 | 3.34 | 0.298967 |
| $DT_{jt}$ | 2.97 | 0.336622 |
| $DT_{it}$ | 2.44 | 0.410151 |
| $Dlang_{ij}$ | 2.42 | 0.414011 |
| $lnY2_{jt}$ | 2.31 | 0.433775 |
| m13 | 1.96 | 0.510892 |
| m4 | 1.45 | 0.687730 |
| m6 | 1.41 | 0.707788 |
| $Pre_{jt}$ | 1.31 | 0.763305 |
| m11 | 1.18 | 0.850502 |
| Mean VIF | 8.64 | |

**ii) Pearson's correlation matrix**

| | X | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $DT_{it}$ | $DT_{jt}$ | $Pre_{it}$ |
|---|---|---|---|---|---|---|---|
| X | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.0100 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.3230 | -0.0229 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.0627 | 0.0000 | -0.0472 | 1.0000 | | | |
| $DT_{it}$ | -0.0359 | -0.4137 | 0.0615 | -0.0000 | 1.0000 | | |
| $DT_{jt}$ | 0.0586 | -0.2212 | 0.1144 | 0.0894 | -0.1205 | 1.0000 | |
| $Pre_{it}$ | 0.0105 | 0.4720 | 0.0084 | 0.0000 | 0.1220 | -0.0651 | 1.0000 |
| $Pre_{jt}$ | 0.0067 | -0.0494 | -0.0275 | 0.3594 | 0.1791 | 0.2186 | -0.0336 |
| $lnAgri_{it}$ | 0.1377 | -0.0502 | 0.0552 | -0.0000 | 0.3011 | 0.3034 | 0.1958 |
| $lnAgri_{jt}$ | -0.0698 | -0.0418 | -0.5509 | 0.0216 | -0.0000 | -0.0446 | -0.0011 |
| $Dlang_{ij}$ | -0.1326 | 0.0000 | -0.3475 | 0.3299 | 0.0000 | -0.0068 | 0.0000 |
| m4 | -0.0719 | 0.0000 | -0.1582 | 0.2014 | -0.0000 | -0.1040 | 0.0000 |
| m6 | 0.6885 | 0.0000 | 0.4241 | 0.0373 | -0.0000 | 0.0139 | 0.0000 |
| m11 | 0.2318 | 0.0000 | 0.0621 | 0.1240 | -0.0000 | -0.0134 | 0.0000 |
| m12 | -0.0608 | 0.0000 | -0.1999 | 0.0375 | -0.0000 | 0.1013 | 0.0000 |
| m13 | -0.0720 | 0.0000 | 0.1565 | -0.0625 | -0.0000 | 0.1360 | 0.0000 |
| $lninflat_{it}$ | 0.0195 | -0.8141 | -0.0174 | -0.0000 | -0.0270 | 0.1943 | -0.4400 |
| $Incom_{ijt}$ | 0.0994 | 0.0124 | -0.0724 | 0.4239 | 0.0231 | -0.0553 | 0.0305 |

| | $Pre_{jt}$ | $lnAgri_{it}$ | $lnAgri_{jt}$ | $Dlang_{ij}$ | m4 | m6 | m11 |
|---|---|---|---|---|---|---|---|
| $Pre_{jt}$ | 1.0000 | | | | | | |
| $lnAgri_{it}$ | 0.2573 | 1.0000 | | | | | |
| $lnAgri_{jt}$ | -0.0319 | -0.0069 | 1.0000 | | | | |
| $Dlang_{ij}$ | 0.1814 | -0.0000 | 0.5188 | 1.0000 | | | |
| m4 | 0.0850 | -0.0000 | -0.0741 | -0.1336 | 1.0000 | | |
| m6 | -0.0398 | -0.0000 | -0.0783 | -0.1336 | -0.0714 | 1.0000 | |
| m11 | 0.0493 | -0.0000 | -0.0768 | -0.1336 | -0.0714 | -0.0714 | 1.0000 |
| m12 | -0.0038 | -0.0000 | -0.0614 | -0.1336 | -0.0714 | -0.0714 | -0.0714 |
| m13 | -0.0904 | -0.0000 | -0.0910 | -0.1336 | -0.0714 | -0.0714 | -0.0714 |
| $lninflat_{it}$ | 0.0636 | -0.0626 | 0.0258 | 0.0000 | -0.0000 | -0.0000 | -0.0000 |
| $Incom_{ijt}$ | 0.1845 | 0.0861 | 0.4771 | 0.3028 | 0.0484 | 0.0994 | 0.0682 |

| | m12 | m13 | $lninflat_{it}$ | $Incom_{ijt}$ |
|---|---|---|---|---|
| m12 | 1.0000 | | | |
| m13 | -0.0714 | 1.0000 | | |
| $lninflat_{it}$ | -0.0000 | -0.0000 | 1.0000 | |
| $Incom_{ijt}$ | -0.5298 | -0.3358 | -0.0501 | 1.0000 |

## 3. UGANDA

### i) VIF and TOL test results

| Variable | VIF | 1/VIF |
|---|---|---|
| $lninfra_{it}$ | 58.19 | 0.017186 |
| $lnAgri_{it}$ | 42.17 | 0.023716 |
| $lnY1_{it}$ | 20.25 | 0.049392 |
| $Pre_{it}$ | 16.97 | 0.005077 |
| $DT_{it}$ | 6.34 | 0.157767 |
| $lninflat_{it}$ | 3.68 | 0.271697 |
| $lnAgri_{jt}$ | 3.09 | 0.324018 |
| $Incom_{ijt}$ | 2.64 | 0.379013 |
| $DT_{jt}$ | 2.43 | 0.412317 |
| $lnY2_{jt}$ | 2.29 | 0.436104 |
| $lnD_{ij}$ | 1.70 | 0.587806 |
| $Dlang_{ij}$ | 1.63 | 0.615223 |
| m6 | 1.34 | 0.746740 |
| m3 | 1.29 | 0.776777 |
| $Pre_{jt}$ | 1.28 | 0.778791 |
| Mean VIF | 11.01 | |

### ii) Pearson's correlation matrix

| | X | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lninflat_{it}$ | $lnAgri_{it}$ | $lnAgri_{jt}$ |
|---|---|---|---|---|---|---|---|
| X | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.0367 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.1986 | 0.0283 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.0821 | 0.0000 | -0.0524 | 1.0000 | | | |
| $lninflat_{it}$ | 0.0282 | -0.0628 | -0.0738 | 0.0000 | 1.0000 | | |
| $lnAgri_{it}$ | 0.1935 | 0.1711 | 0.0335 | 0.0000 | -0.3435 | 1.0000 | |
| $lnAgri_{jt}$ | -0.0264 | -0.0016 | -0.5502 | 0.0126 | -0.0006 | -0.0258 | 1.0000 |
| $DT_{it}$ | -0.0155 | 0.4857 | 0.0609 | -0.0000 | -0.0451 | 0.0230 | -0.0119 |
| $DT_{jt}$ | 0.0625 | 0.1610 | 0.1144 | 0.0647 | 0.1074 | 0.3884 | -0.0430 |
| $Pre_{it}$ | -0.0958 | -0.1540 | -0.0916 | 0.0000 | 0.6394 | -0.5908 | 0.0241 |
| $Pre_{jt}$ | 0.2219 | 0.2028 | -0.0275 | 0.3684 | -0.1680 | 0.2765 | -0.0302 |
| $lninfra_{it}$ | 0.0037 | 0.0140 | -0.0396 | -0.0000 | 0.0989 | -0.0830 | 0.0467 |
| $Dlang_{ij}$ | 0.2718 | -0.0000 | -0.3475 | 0.2836 | 0.0000 | 0.0000 | 0.5192 |
| m3 | -0.0379 | -0.0000 | -0.1080 | 0.1372 | 0.0000 | 0.0000 | -0.0528 |
| m6 | -0.0038 | -0.0000 | 0.4241 | 0.0267 | 0.0000 | 0.0000 | -0.0793 |
| $Incom_{ijt}$ | 0.0808 | 0.1014 | -0.0734 | 0.4614 | -0.0227 | 0.0794 | 0.4785 |

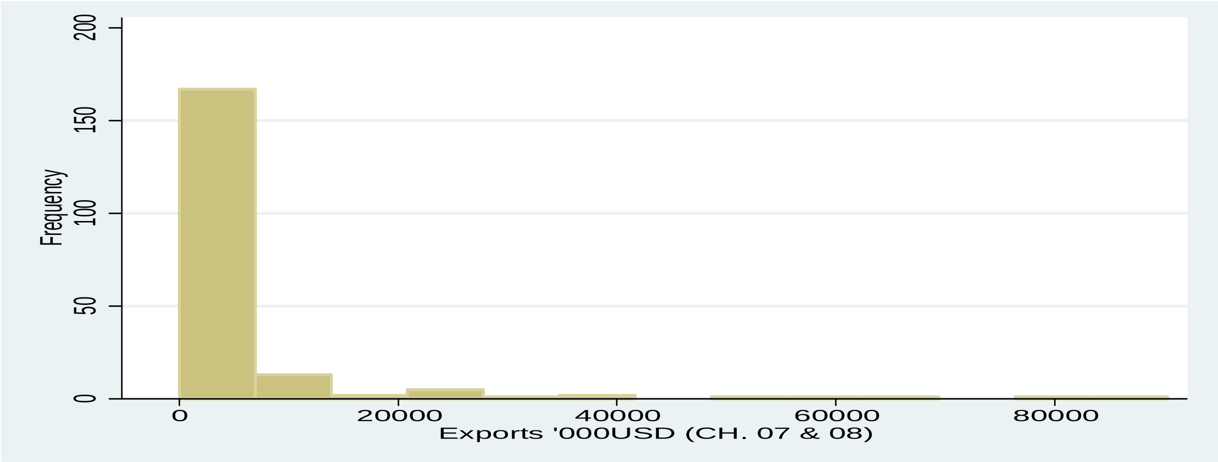
| | $DT_{it}$ | $DT_{jt}$ | $Pre_{it}$ | $Pre_{jt}$ | $lninfra_{it}$ | $Dlang_{ij}$ | m3 |
|---|---|---|---|---|---|---|---|
| $DT_{it}$ | 1.0000 | | | | | | |
| $DT_{jt}$ | 0.0283 | 1.0000 | | | | | |
| $Pre_{it}$ | -0.3924 | -0.1608 | 1.0000 | | | | |
| $Pre_{jt}$ | 0.1255 | 0.2186 | -0.1292 | 1.0000 | | | |
| $lninfra_{it}$ | -0.4029 | 0.0646 | 0.5162 | -0.0532 | 1.0000 | | |
| $Dlang_{ij}$ | -0.0000 | -0.0068 | 0.0000 | 0.1814 | 0.0000 | 1.0000 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| m3 | 0.0000 | -0.0435 | -0.0000 | 0.0422 | 0.0000 | -0.1336 | 1.0000 |
| m6 | 0.0000 | 0.0139 | -0.0000 | -0.0398 | 0.0000 | -0.1336 | -0.0714 |
| $Incom_{ijt}$ | 0.0520 | -0.0568 | -0.0775 | 0.1837 | -0.0051 | 0.3032 | 0.2675 |

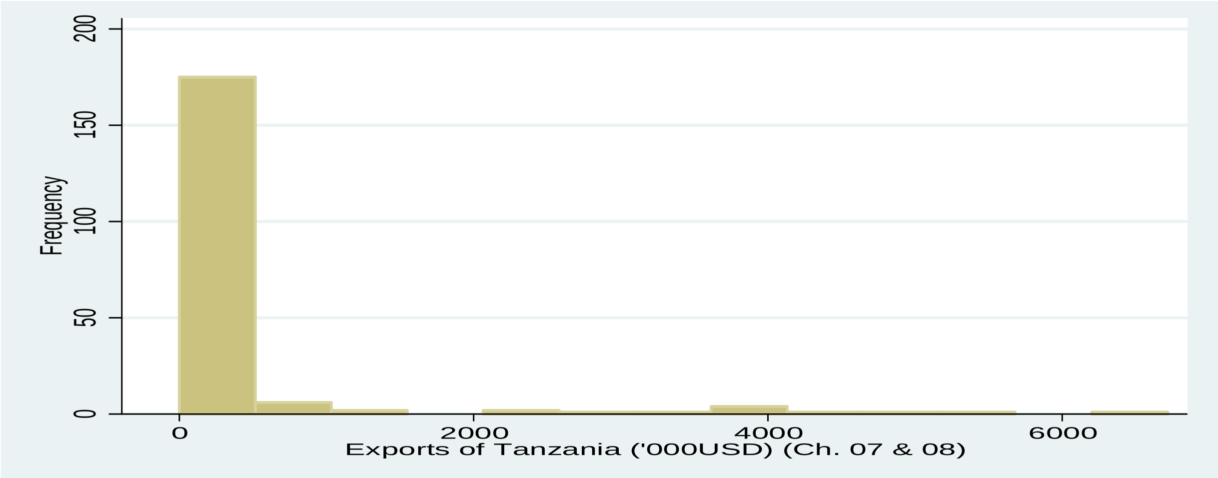
| | m6 | $Incom_{ijt}$ |
|---|---|---|
| m6 | 1.0000 | |
| $Incom_{ijt}$ | 0.0993 | 1.0000 |

**Appendix C: Normality test results for objective two (The influence of climate change on East Africa's horticultural trade flows)**

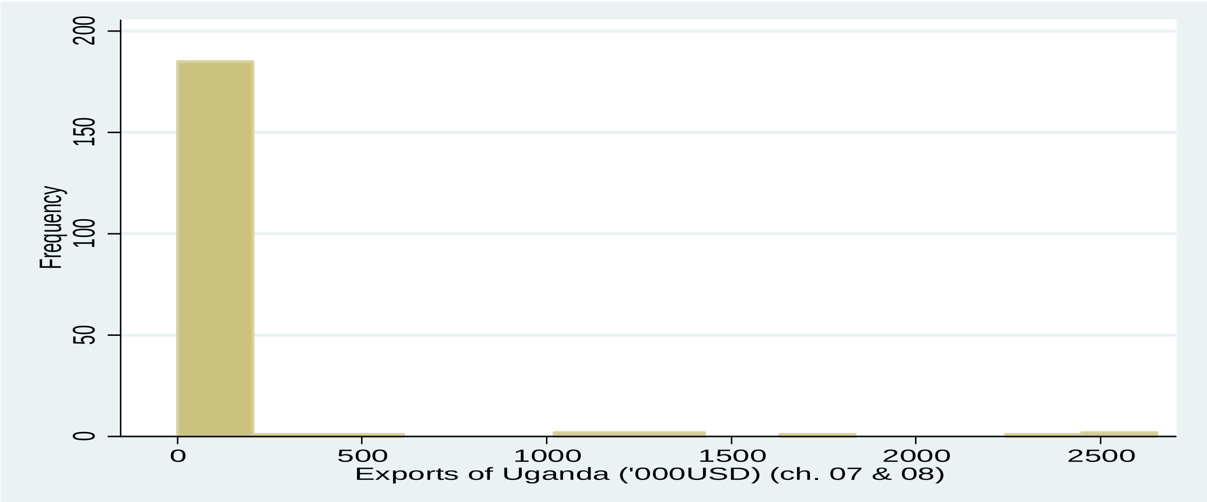
**i) KENYA**




**ii) TANZANIA**




**iii) UGANDA**



**Appendix D: Multi-collinearity test results for Kenya's Asparagus- 070920 (*Objective three*)**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnCOSTBIZ_{it}$ | 4.33 | 0.230803 |
| $lnY1_{it}$ | 3.70 | 0.270335 |
| $lninflat_{it}$ | 3.43 | 0.291686 |
| $lnPM_{ijlt}$ | 2.26 | 0.442550 |
| $Dlang_{ij}$ | 1.76 | 0.566968 |
| m8 | 1.43 | 0.701157 |
| $lnY1_{jt}$ | 1.38 | 0.724584 |
| $lnD_{ij}$ | 1.32 | 0.760379 |
| m6 | 1.27 | 0.788595 |
| m3 | 1.19 | 0.843215 |
| m11 | 1.14 | 0.874947 |
| m2 | 1.13 | 0.886589 |
| m1 | 1.10 | 0.910023 |
| Mean VIF | 1.96 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lninflat_{it}$ | $lnCOSTBIZ_{it}$ |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.1254 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.2921 | 0.0735 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.1723 | -0.0000 | -0.0823 | 1.0000 | | | |
| $lnPM_{ijlt}$ | 0.0527 | 0.7338 | 0.0263 | 0.0097 | 1.0000 | | |
| $lninflat_{it}$ | 0.0511 | -0.0959 | 0.0206 | -0.0000 | 0.0469 | 1.0000 | |
| $lnCOSTBIZ_{it}$ | -0.1185 | -0.4780 | -0.0595 | -0.0000 | -0.4232 | -0.6858 | 1.0000 |
| $Dlang_{ij}$ | 0.4404 | 0.0000 | -0.2699 | 0.2931 | -0.0192 | 0.0000 | 0.0000 |
| m1 | -0.0659 | -0.0000 | -0.1087 | -0.1779 | -0.0102 | 0.0000 | 0.0000 |
| m2 | -0.0455 | -0.0000 | -0.0480 | 0.1043 | -0.0102 | 0.0000 | 0.0000 |
| m3 | -0.0647 | -0.0000 | -0.1410 | 0.1578 | -0.0102 | 0.0000 | 0.0000 |
| m6 | -0.0663 | -0.0000 | 0.4101 | 0.0564 | -0.0102 | 0.0000 | 0.0000 |
| m8 | -0.0538 | -0.0000 | -0.2099 | 0.2327 | -0.0102 | 0.0000 | 0.0000 |
| m11 | -0.0303 | -0.0000 | 0.0731 | 0.1442 | -0.0102 | 0.0000 | 0.0000 |

| | $Dlang_{ij}$ | m1 | m2 | m3 | m6 | m8 | m11 |
|---|---|---|---|---|---|---|---|
| $Dlang_{ij}$ | 1.0000 | | | | | | |
| m1 | -0.1336 | 1.0000 | | | | | |
| m2 | -0.1336 | -0.0714 | 1.0000 | | | | |
| m3 | -0.1336 | -0.0714 | -0.0714 | 1.0000 | | | |
| m6 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | | |
| m8 | 0.5345 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | |

m11 | -0.1336 -0.0714 -0.0714 -0.0714 -0.0714 -0.0714 1.0000

**Appendix E: Multi-collinearity test results for Kenya's Beans- 070820 (*Objective three*)**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnCOSTBIZ_{it}$ | 4.34 | 0.230623 |
| $lnY1_{it}$ | 4.19 | 0.238787 |
| $lninflat_{it}$ | 3.45 | 0.289870 |
| $lnPM_{ijlt}$ | 2.70 | 0.369715 |
| $Dlang_{ij}$ | 1.81 | 0.552289 |
| $lnY2_{jt}$ | 1.71 | 0.583140 |
| $lnD_{ij}$ | 1.58 | 0.634555 |
| m4 | 1.44 | 0.692105 |
| m6 | 1.40 | 0.712746 |
| m3 | 1.33 | 0.754378 |
| m5 | 1.29 | 0.776327 |
| m11 | 1.26 | 0.791668 |
| m2 | 1.24 | 0.806038 |
| m1 | 1.14 | 0.873757 |
| Mean VIF | 2.06 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lninflat_{it}$ | $lnCOSTBIZ_{it}$ |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.0370 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.4665 | 0.0735 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.2274 | -0.0000 | -0.0823 | 1.0000 | | | |
| $lnPM_{ijlt}$ | -0.0415 | -0.7833 | -0.0602 | -0.0000 | 1.0000 | | |
| $lninflat_{it}$ | 0.0248 | -0.0959 | 0.0206 | -0.0000 | -0.0500 | 1.0000 | |
| $lnCOSTBIZ_{it}$ | -0.0412 | -0.4780 | -0.0595 | -0.0000 | 0.4517 | -0.6858 | 1.0000 |
| $Dlang_{ij}$ | 0.4488 | 0.0000 | -0.2699 | 0.2931 | 0.0000 | 0.0000 | 0.0000 |
| m1 | -0.1162 | -0.0000 | -0.1087 | -0.1779 | -0.0000 | 0.0000 | 0.0000 |
| m2 | -0.0178 | -0.0000 | -0.0480 | 0.1043 | -0.0000 | 0.0000 | 0.0000 |
| m3 | -0.1178 | -0.0000 | -0.1410 | 0.1578 | -0.0000 | 0.0000 | 0.0000 |
| m4 | -0.1169 | -0.0000 | -0.2012 | 0.2327 | -0.0000 | 0.0000 | 0.0000 |
| m5 | 0.1056 | -0.0000 | 0.3517 | -0.0961 | -0.0000 | 0.0000 | -0.0000 |
| m6 | -0.0038 | -0.0000 | 0.4101 | 0.0564 | -0.0000 | 0.0000 | 0.0000 |
| m11 | 0.1348 | -0.0000 | 0.0731 | 0.1442 | -0.0000 | 0.0000 | 0.0000 |

| | $Dlang_{ij}$ | m1 | m2 | m3 | m4 | m5 | m6 |
|---|---|---|---|---|---|---|---|
| $Dlang_{ij}$ | 1.0000 | | | | | | |
| m1 | -0.1336 | 1.0000 | | | | | |
| m2 | -0.1336 | -0.0714 | 1.0000 | | | | |
| m3 | -0.1336 | -0.0714 | -0.0714 | 1.0000 | | | |
| m4 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | | |
| m5 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | 1.0000 | |
| m6 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | 1.0000 |
| m11 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 | -0.0714 |

| | m11 |
|---|---|
| m11 | 1.0000 |

**Appendix F: Multi-collinearity test results for Tanzania's Beans- 070820 (*Objective three*)**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnY1_{it}$ | 4.82 | 0.207394 |
| $lnGOV_{it}$ | 4.07 | 0.245464 |
| $lnCOSTEXP_{it}$ | 2.15 | 0.466068 |
| $lnPM_{ijlt}$ | 1.74 | 0.573827 |
| $Dlang_{ij}$ | 1.25 | 0.801374 |
| $lnD_{ij}$ | 1.16 | 0.860909 |
| $lnY2_{jt}$ | 1.09 | 0.918319 |
| m11 | 1.05 | 0.949535 |
| Mean VIF | 2.17 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ X | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lnCOSTEXP_{it}$ | lnGOVit |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | -0.0682 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.3202 | 0.0653 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.2041 | 0.0000 | -0.0460 | 1.0000 | | | |
| $lnPM_{ijlt}$ | 0.0758 | -0.5705 | -0.0602 | -0.0000 | 1.0000 | | |
| $lnCOSTEXP_{it}$ | 0.0223 | -0.6174 | -0.0155 | -0.0000 | 0.1037 | 1.0000 | |
| $lnGOV_{it}$ | 0.0668 | -0.8445 | -0.0399 | 0.0000 | 0.4036 | 0.6805 | 1.0000 |
| $Dlang_{ij}$ | 0.4081 | -0.0000 | -0.2699 | 0.3299 | 0.0000 | 0.0000 | -0.0000 |
| m11 | 0.1565 | 0.0000 | 0.0731 | 0.1240 | -0.0000 | 0.0000 | 0.0000 |

| | $Dlang_{ij}$ | m11 |
|---|---|---|
| $Dlang_{ij}$ | 1.0000 | |
| m11 | -0.1336 | 1.0000 |

**Appendix G: Multi-colinearity test results for Tanzania's Vegetables- 070990 (*Objective three)***

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnY1_{it}$ | 4.82 | 0.207394 |
| $lnGOV_{it}$ | 4.07 | 0.245464 |
| $lnCOSTEXP_{it}$ | 2.15 | 0.466068 |
| $lnPM_{ijlt}$ | 1.74 | 0.573827 |
| $Dlang_{ij}$ | 1.25 | 0.801374 |
| $lnD_{ij}$ | 1.16 | 0.860909 |
| $lnY2_{jt}$ | 1.09 | 0.918319 |
| m11 | 1.05 | 0.949535 |
| Mean VIF | 2.17 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lnCOSTEXP_{it}$ | lnGOVit |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | -0.1422 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.1868 | 0.0653 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.1008 | 0.0000 | -0.0460 | 1.0000 | | | |
| $lnPM_{ijlt}$ | -0.1070 | -0.2250 | 0.0185 | -0.0000 | 1.0000 | | |
| $lnCOSTEXP_{it}$ | 0.0126 | -0.6174 | -0.0155 | -0.0000 | 0.7801 | 1.0000 | |
| $lnGOV_{it}$ | 0.1064 | -0.8445 | -0.0399 | 0.0000 | 0.3651 | 0.6805 | 1.0000 |
| $Dlang_{ij}$ | 0.2961 | -0.0000 | -0.2699 | 0.3299 | 0.0000 | 0.0000 | -0.0000 |
| m11 | -0.0367 | 0.0000 | 0.0731 | 0.1240 | 0.0000 | 0.0000 | 0.0000 |

| | $Dlang_{ij}$ | m11 |
|---|---|---|
| $Dlang_{ij}$ | 1.0000 | |
| m11 | -0.1336 | 1.0000 |

**Appendix H: Multi-colinearity test results for Uganda's Beans- 070820 (*Objective three*)**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnY1_{it}$ | 16.21 | 0.061683 |
| $lnCOSTEXP_{it}$ | 6.32 | 0.158350 |
| $lnGOV_{it}$ | 5.64 | 0.177156 |
| $lnPM_{ijlt}$ | 1.98 | 0.505827 |
| $Dlang_{ij}$ | 1.19 | 0.841795 |
| $lnD_{ij}$ | 1.11 | 0.898619 |
| $lnY2_{jt}$ | 1.11 | 0.899153 |
| $lninflat_{it}$ | 1.07 | 0.931004 |
| m1 | 1.07 | 0.937790 |
| Mean VIF | 3.97 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lninflat_{it}$ | $lnCOSTEXP_{it}$ |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.0894 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.1985 | 0.0644 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.1399 | -0.0000 | -0.0617 | 1.0000 | | | |
| $lnPM_{ijlt}$ | -0.0392 | -0.6306 | -0.0602 | 0.0000 | 1.0000 | | |
| $lninflat_{it}$ | 0.0874 | 0.2201 | 0.0290 | 0.0000 | -0.0442 | 1.0000 | |
| $lnCOSTEXP_{it}$ | 0.0832 | 0.8593 | 0.0749 | 0.0000 | -0.6430 | 0.2091 | 1.0000 |
| $lnGOV_{it}$ | -0.0822 | -0.8253 | -0.0284 | -0.0000 | 0.3536 | -0.1904 | -0.5286 |
| $Dlang_{ij}$ | 0.2450 | 0.0000 | -0.2699 | 0.2836 | 0.0000 | 0.0000 | -0.0000 |
| m1 | -0.0889 | 0.0000 | -0.1087 | -0.1811 | -0.0000 | 0.0000 | 0.0000 |

| | $lnGOV_{it}$ | $Dlang_{ij}$ | m1 |
|---|---|---|---|
| $lnGOV_{it}$ | 1.0000 | | |
| $Dlang_{ij}$ | 0.0000 | 1.0000 | |
| m1 | 0.0000 | -0.1336 | 1.0000 |

**Appendix I: Multi-colinearity test results for Uganda's Peppers- 070960 (*Objective three*)**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnGOV_{it}$ | 6.06 | 0.165018 |
| $lnY1_{it}$ | 3.45 | 0.289870 |
| $lnCOSTBIZ_{it}$ | 3.34 | 0.299083 |
| $lnPM_{ijlt}$ | 2.14 | 0.466580 |
| $lninflat_{it}$ | 2.00 | 0.499633 |
| $Dlang_{ij}$ | 1.32 | 0.756695 |
| $lnY2_{jt}$ | 1.29 | 0.777170 |
| $lnD_{ij}$ | 1.20 | 0.834398 |
| m5 | 1.18 | 0.845410 |
| m3 | 1.13 | 0.886178 |
| m11 | 1.09 | 0.920564 |
| m1 | 1.09 | 0.921616 |
| Mean VIF | 2.11 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lninflat_{it}$ | $lnCOSTBIZ_{it}$ |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.1294 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.3735 | 0.0644 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.1854 | -0.0000 | -0.0617 | 1.0000 | | | |
| $lnPM_{ijlt}$ | 0.0594 | 0.4117 | 0.0287 | -0.0000 | 1.0000 | | |
| $lninflat_{it}$ | 0.0331 | 0.2201 | 0.0290 | 0.0000 | 0.6307 | 1.0000 | |
| $lnCOSTBIZ_{it}$ | -0.0593 | -0.5571 | -0.0286 | 0.0000 | -0.5822 | -0.4580 | 1.0000 |
| $lnGOV_{it}$ | -0.0819 | -0.8253 | -0.0284 | -0.0000 | -0.4714 | -0.1904 | 0.7550 |
| $Dlang_{ij}$ | 0.3968 | 0.0000 | -0.2699 | 0.2836 | 0.0000 | 0.0000 | -0.0000 |
| m3 | -0.1054 | 0.0000 | -0.1410 | 0.1372 | 0.0000 | 0.0000 | 0.0000 |
| m5 | -0.0345 | 0.0000 | 0.3517 | 0.0569 | 0.0000 | 0.0000 | -0.0000 |
| m11 | 0.1984 | 0.0000 | 0.0731 | 0.1090 | 0.0000 | 0.0000 | 0.0000 |
| m1 | -0.1063 | 0.0000 | -0.1087 | -0.1811 | 0.0000 | 0.0000 | -0.0000 |

| | $lnGOV_{it}$ | $Dlang_{ij}$ | m3 | m5 | m11 | m1 |
|---|---|---|---|---|---|---|
| $lnGOV_{it}$ | 1.0000 | | | | | |
| $Dlang_{ij}$ | 0.0000 | 1.0000 | | | | |
| m3 | 0.0000 | -0.1336 | 1.0000 | | | |
| m5 | 0.0000 | -0.1336 | -0.0714 | 1.0000 | | |
| m11 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | 1.0000 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| m1 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | 1.0000 |

**Appendix J: Multi-colinearity test results for Uganda's Bananas- 080300 (Objective three)**

**i) VIF and TOL test results**

| Variable | VIF | 1/VIF |
|---|---|---|
| $lnY1_{it}$ | 51.22 | 0.019523 |
| $lnCOSTEXP_{it}$ | 21.90 | 0.045666 |
| $lnPM_{ijlt}$ | 13.35 | 0.074911 |
| $lnFDI_{it}$ | 8.02 | 0.124642 |
| $lnGOV_{it}$ | 6.14 | 0.162844 |
| $lninflat_{it}$ | 2.96 | 0.338068 |
| $Dlang_{ij}$ | 1.79 | 0.557569 |
| $lnD_{ij}$ | 1.65 | 0.605607 |
| m14 | 1.52 | 0.659808 |
| $lnY2_{jt}$ | 1.37 | 0.732321 |
| m5 | 1.31 | 0.762590 |
| m3 | 1.30 | 0.766558 |
| m11 | 1.24 | 0.807625 |
| m2 | 1.22 | 0.822081 |
| m13 | 1.17 | 0.857442 |
| m1 | 1.14 | 0.875108 |
| Mean VIF | 7.33 | |

**ii) Pearson's correlation matrix**

| | $M_{ijkt}$ | $lnY1_{it}$ | $lnY2_{jt}$ | $lnD_{ij}$ | $lnPM_{ijlt}$ | $lninflat_{it}$ | $lnCOSTEXP_{it}$ |
|---|---|---|---|---|---|---|---|
| $M_{ijkt}$ | 1.0000 | | | | | | |
| $lnY1_{it}$ | 0.0812 | 1.0000 | | | | | |
| $lnY2_{jt}$ | 0.3285 | 0.0644 | 1.0000 | | | | |
| $lnD_{ij}$ | 0.1648 | -0.0000 | -0.0617 | 1.0000 | | | |
| $lnPM_{ijlt}$ | -0.0778 | -0.8409 | -0.0565 | -0.0000 | 1.0000 | | |
| $lninflat_{it}$ | 0.0293 | 0.2201 | 0.0290 | 0.0000 | -0.0309 | 1.0000 | |
| $lnCOSTEXP_{it}$ | 0.1034 | 0.8593 | 0.0749 | 0.0000 | -0.6538 | 0.2091 | 1.0000 |
| $lnGOV_{it}$ | -0.0359 | -0.8253 | -0.0284 | -0.0000 | 0.6863 | -0.1904 | -0.5286 |
| $lnFDI_{it}$ | 0.1060 | 0.5408 | 0.0638 | 0.0000 | -0.5986 | 0.4356 | 0.7038 |
| $Dlang_{ij}$ | 0.4508 | 0.0000 | -0.2699 | 0.2836 | -0.0000 | 0.0000 | -0.0000 |
| m1 | -0.0835 | 0.0000 | -0.1087 | -0.1811 | -0.0000 | 0.0000 | 0.0000 |
| m2 | 0.1410 | 0.0000 | -0.0480 | 0.0681 | -0.0000 | 0.0000 | 0.0000 |

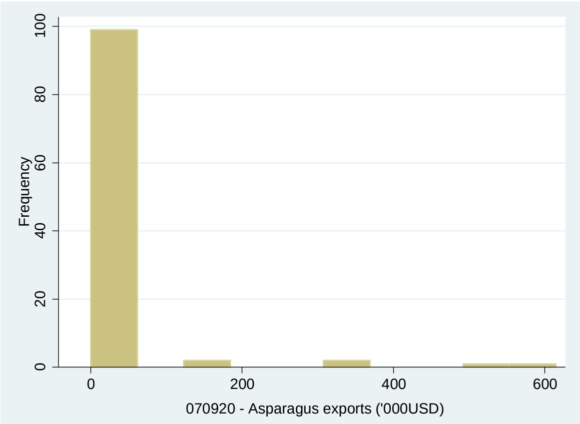
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| m3 | -0.0742 | 0.0000 | -0.1410 | 0.1372 | -0.0000 | 0.0000 | 0.0000 |
| m5 | -0.0844 | 0.0000 | 0.3517 | 0.0569 | -0.0000 | 0.0000 | 0.0000 |
| m11 | -0.0734 | 0.0000 | 0.0731 | 0.1090 | -0.0000 | 0.0000 | 0.0000 |
| m13 | -0.0879 | 0.0000 | 0.2109 | -0.0968 | -0.0000 | 0.0000 | 0.0000 |
| m14 | -0.0733 | -0.0000 | -0.0538 | 0.3376 | -0.0000 | 0.0000 | 0.0000 |

| | $lnGOV_{it}$ | $lnFDI_{it}$ | $Dlang_{ij}$ | m1 | m2 | m3 | m5 |
|---|---|---|---|---|---|---|---|
| $lnGOV_{it}$ | 1.0000 | | | | | | |
| $lnFDI_{it}$ | -0.2890 | 1.0000 | | | | | |
| $Dlang_{ij}$ | 0.0000 | 0.0000 | 1.0000 | | | | |
| m1 | 0.0000 | 0.0000 | -0.1336 | 1.0000 | | | |
| m2 | 0.0000 | 0.0000 | -0.1336 | -0.0714 | 1.0000 | | |
| m3 | 0.0000 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | 1.0000 | |
| m5 | 0.0000 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | 1.0000 |
| m11 | 0.0000 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | -0.0714 |
| m13 | 0.0000 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | -0.0714 |
| m14 | 0.0000 | 0.0000 | -0.1336 | -0.0714 | -0.0714 | -0.0714 | -0.0714 |

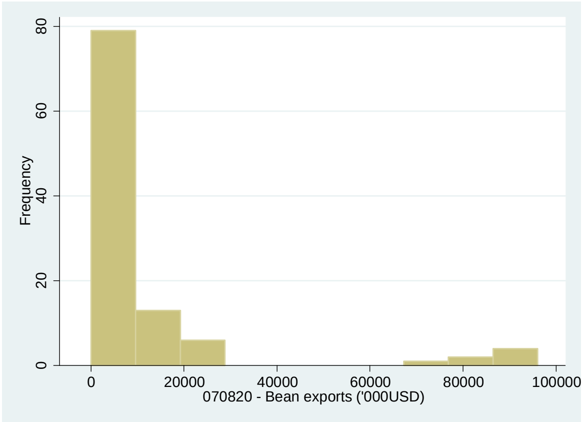
| | m11 | m13 | m14 |
|---|---|---|---|
| m11 | 1.0000 | | |
| m13 | -0.0714 | 1.0000 | |
| m14 | -0.0714 | -0.0714 | 1.0000 |

## Appendix K: Kenya's normality test results for Asparagus and Beans

**Asparagus**

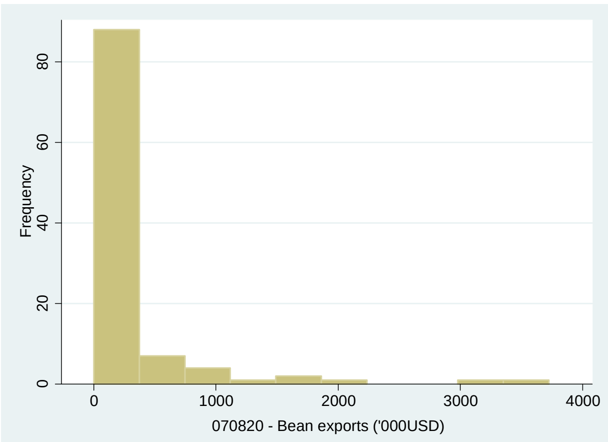



**Beans**

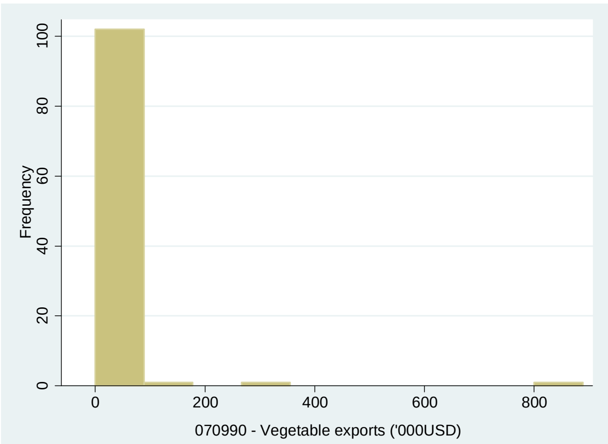



## Appendix L: Tanzania's normality test results for Beans and Vegetables

**Beans**

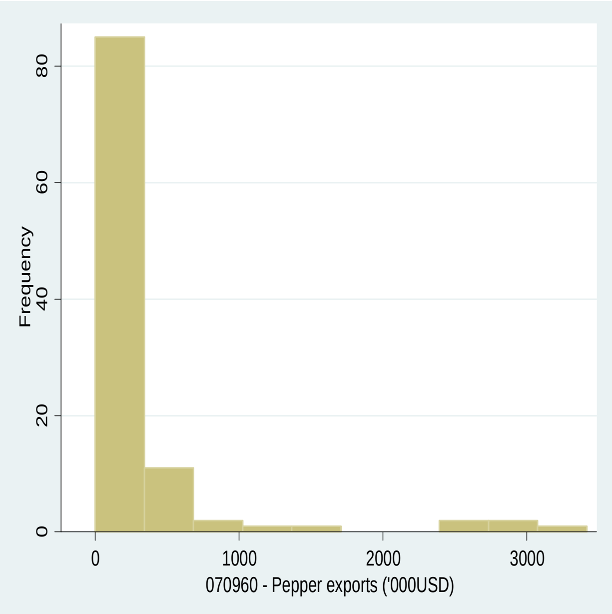



**Vegetables**

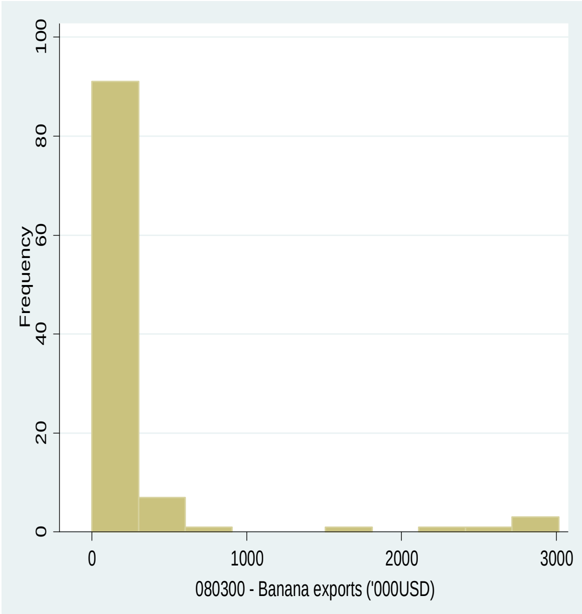


## Appendix M: Uganda's normality test results for Pepper, Bananas and Beans

**Pepper**




**Bananas**




**Beans**