IMPACT OF HUMAN CAPITAL DEVELOPMENT AND FIXED CAPITAL FORMATION ON AGRICULTURE PRODUCTIVITY IN UGANDA

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DECLARATION

I Charles Owuor, declare that this thesis is my original work and has not been presented for the award of a degree in any other university or any other award.

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Supervisors' Approval

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DEDICATION

I dedicate this thesis to my lovely wife Dr Monica Kansiime Owuor who was the inspirational force behind this work. To my kids, Jenny, Zion and Nolan for withstanding my lack of attention during the course of this work and lastly, to my mum Christine.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

This study was inspired by the fact that Uganda's economic development prospect is intertwined with agriculture sector growth. The country has 80% of arable land, but only 35% is under production majorly using subsistence suboptimal methods. This thesis sought to deepen the understanding of agriculture and education nexus and the low transformation of the agriculture sector in Uganda. This work comes from a background that Uganda's education sector has been criticised for churning out half-baked graduants at all levels without the necessary skills and capacity to innovate, unlock and exploit critical value chains to spur economic growth. Therefore, this dissertation examines the multiple dimensions of the impact of public spending on education, school enrolment, physical capital formation and labour on agricultural sector output. The study is underpinned by the growing interest in empirical investigations on the effects of public education expenditure and education sector outputs on economic growth in developing countries to inform the education sector policy environment. The study utilised the ARDL framework using annual macroeconomic data from 1982 to 2018. The year 1982 marked the beginning of implementing economic reforms and structural adjustment program after a near economic collapse during the the Idi Amin era in 1970's. Theoretically, at sector level, growth in the agriculture sector is positively correlated to a reduction in rural poverty that is still a characteristic of rural households. Results reveal that public expenditure on education has a net positive effect on agriculture sector output. The training of agriculture graduates had a negative long run effect while the short run effects were significant but positive. Similary, phyiscal capital formation and labour force accumulation had short run positive effect on agriculture sector output in a short run, while in the longrun, the effects were negative. This study strongly recommends that the public sector puts in place an incentive system to retain skilled and qualified human resource in the agriculture sector. Further this study puts to the fore the argument that investment in education is still a viable public investment choice that has a positive effect on sectoral output which translates into overall economic growth, and confirms that education expenditure plays a critical role at sectoral level growth.

CHAPTER ONE

INTRODUCTION

1.1 Study Overview and Rationale

Empirical investigations of human capital development through tracking public expenditure on education, school enrolment and the effects of a mass of specifically skilled individuals in developing countries are attracting a lot of attention from researchers, policymakers, and development economists alike (Angrist et al., 2019; Gebrehiwot, 2015; Kruss et al., 2015). Peercy & Svenson, (2016) notes that as emerging nations advance the fight against poverty in the wake of solid economic growth registered over the last two decades, understanding the role of human capital development is progressively becoming critical. The causal linkage between education, human capital development and economic growth is an issue that has both theoretical and practical significance. According to the World Bank blog "*why education matters for economic development*", the estimated value of human capital is 62% of the total global wealth (Patrinos et al., 2017). This value is four times the combined worth of produced physical capital and natural resources (Collin & Weil, 2020).

The New Palgrave Economics Dictionary defines Human Capital as "the stock of skills and knowledge that people have". Human capital formation is multidimensional and is dependent on purposive investment in education, health and acquisition of many non-cognitive skills and traits by individuals in their productive lifetime (Villa, 2017). Taking a national-level perspective, human capital development demands long-term policy and public investment

decisions in education. It is undeniable empirical fact that education is critical variable in human capital development as the country's stock of skills, technological advancement and economic growth are anchored on the quality of its education system (Hanushek & Wößmann, 2007; Peercy & Svenson, 2016). As such, human capital development has become one of the leading drivers in accumulation and creation of physical capital, efficient exploitation of natural resources, as well as stimulating social change (Biggs, 2007; Coulibaly *et al*., 2018). However, Ahsan & Haque, (2017), using a dynamic threshold model, revealed that human capital proxied by average years of schooling for estimating economic growth is counter-productive until the country's economy crosses a threshold level of development where the acquired skills are absorbed and put into productive use.

At the firm level, workers' knowledge and skills are the drivers that push the competitive edge and innovation envelope thus maximising returns on investment in knowledge and skills acquisition schemes (Antonelli & Colombelli, 2015; Pol & Rameshkoumar, 2016). No wonder, the recent economic downturn coupled with the saturation of the business markets with same-level skills in a globalised economy has pushed firms to realise the importance of investing in new skill acquisition for their human resources (Lim *et al*., 2018). As Khadan (2018) observes, that firms that fail to do so will continuously face challenges of hiring employees with matching core and job-related skills and possessing the required experience at managerial and professional levels consquently curtailing their innovative capacities.

At the societal level, education is crucial in fortifying economic and social advancement as well as reducing inequality through improving income distribution (Kabir, 2019; Ma, 2019). Education is critical in the acquisition of new knowledge, enriches people's understanding, advance their quality of life, and bring a wide range of social benefits to individuals and society (Barbiero & Cournede, 2013; Kucharčíková, 2014). A decennial review of global literature on returns to education from 139 countries for the period 1954-2014 reveals that the global average private return to school for a year is 9% per annum, and even more striking, social returns to schooling equally remained higher (Psacharopoulos & Patrinos, 2018). These estimates of private returns to education compare favourably with earlier cross-country estimates of 10% per year (Patrinos & Montenegro, 2014). Critically, women achieve higher returns to schooling eased with expanding spaces and enabling environment promoting gender equality further proving that girl-child education is still a development priority (Orisadare et al., 2017). Education is a vital input in the development of a robust research and innovation ecosystem that translates into knowledge based economic outputs (Hanushek, 2013). In addition, education improves people's productivity and creativity, promotes human entrepreneurship, technological progress, thus, driving productivity and advancement of human kind. (Schutt, 2003; Alani, 2018).

At the economic sector level, Gillman (2019) hypothesises that with investment in human capital development, it is possible to have sectoral transformation along with a balanced growth path equilibrium with gradual shifts over time from less human capital-intensive sectors towards more

human capital-intensive ones. With this narrative, it can as well be hypothesised that investment in education can lead to higher agriculture sector output as a result of actors in the sector harnessing new knowledge and skills to stimulate the functioning of critical agri-food value chains hence creating more decent jobs. In this respect, specific observations were made by Mardalena et al. (2019) in Indonesia, and Hena et al., (2018) for the case of Pakistan in respect to the transition of labour within the agriculture sector. This transition and mobility of human capital within an economic ecosystem is vital as it leads to significant economic output because of increased productivity per worker and technological progress. See Tamura, (2002); Awad et al., (2010); Li et al., (2017); de Pleijt & Weisdorf, (2017); Bloom et al., (2020).

The World Economic Forum Human Capital Report of 2015 emphasises that the key to the future of any country and any institution lies in the talents, skills and capacities of its people. The same report further paints a gloomy forecasted future for both developed and emerging countries with a real possibility of facing severe talent shortages in the context of shifting population dynamics and limited resources (WEF, 2015). Therefore, the key pathway to accumulating human capital is via education. For instance, the latest assessment of Africa's innovation and intellectual capacity rates Uganda at a medium level of 54 points with Morocco standing out at the highest with 71 points. These ratings positively correlate with the current and projected economic growth of the countries the study considered (ACBF, 2017). Indeed, there is a wealth of empirical literature rooting for increased

investment in human capital development via education, especially in low and middle-income countries to facilitate their catch up on knowledge and technological frontiers (Liu & Jiang, 2001; Eberhardt et al., 2013; Affandi et al., 2018; Hong & Lee, 2016). There is no doubt that at a national level, it is the qualified and skilled individuals, rather than its physical capital and material resources that determine the character and speed of economic growth (Aremu, 2014).

There are also spill-over effects of human capital development on the national economies that stem from migration and free labour movement (Susanto & Udjianto, 2019). Fassio et al. (2019) conclude that despite the ongoing global debate on migrants and limitation of labour mobility, they established that highly educated migrants are critical for the growth and productivity of exceedingly specialised knowledge-based sectors. The latter is a particularly critical point of reflection for Uganda given the ongoing double debate of East African Community (EAC) economic integration and at a broad scale, the Africa Union Agenda 2063 that roots for free mobility of labour within the economic block. It is because of these realities that the World Bank launched the Human Capital Project (HCP) in 2018, which called on countries to accelerate the progress of human capital development for their populations (Gatti & Mohpal, 2019). The above has led to the grounding of Human Capital Theory (HCT) in contemporary development economics.

While neoclassical growth theory assumes that physical capital and labour are important pathways through which economic growth can be achieved, HCT considers human capital accumulation to be fundamental as

this determines the economic growth of a country due to increased productivity and technological innovation (Duan, 2019; McDonald & Roberts, 2002; Nnyanzi & Kilimani, 2018). Refocussing the attention to the agriculture sector, the paradigm of innovation system approach that is multi-directional, complex and process-based requires new a rationale and thinking that must come from a well-grounded training and skills development programme (Spielman, 2005).

The sector faces significant transformation hindrances due to knowledge and skills deficit. Already there evidence that many modern technologies that could potentially transform the sector have encountered partial success in adoption and scaling out as revealed from the evaluations of the adoption rates within the agri-food value chains and systems (Stamoulis & Zezza, 2003; Dulani et al., 2013). The conventional wisdom to this lack of rapid adoption of innovations has been attributed to the usual suspects, namely; lack of credit, limited access to information, risks in the sector, and land fragmentation, while conveniently forgetting the insufficient critical mass of qualified individuals to service the sector to support the implementation of the new innovative rural outreach models (Signh & Sharma, 2004; Tsai et al., 2010).

There are proven processes through which the adoption of productive innovation takes place. This includes detection of innovation opportunity, testing, evaluating, refining and adoption. But for this to happen within an agri-food system, it requires four innovation-related competencies which are preparedness to harness innovative opportunities, the ability to generate new

concepts and solutions, the willingness to interrogate own and others' ideas, and the ability to coalesce diverse capacities for a common purpose (Vila, 2019). It is also critical to note that agriculture plays a critical role not only in the survival of people but also in the well-being and economic prosperity of nations. It is for this very reason, that sector occupies a conspicuous space among the United Nations (UN) Sustainable Development Goals (SDGs).

1.2 Education and Human Capital Development

Theodore Schultz followed by a publication in 1962 first advanced the Human Capital Theory in the 1960s (Schultz, 1961). Since then, the theory has become one of the most compelling in modern and development economics, with a theoretical focus on endogenous growth, stating that the rate of return on investment in human capital through education spending is remarkably similar to other forms of investment. (Dahlin, 2002; Pelinescu, 2015). Earlier, Bassanini & Scarpetta, (2001), proved that human capital accumulation leads to significant growth of research and development activity, with a warning that there should be a supportive macroeconomic environment, trade openness and functioning financial markets. The Human Capital Theory considers education as an investment with both long-run and short-run effects on economic growth rather than a consumptive policy decision. See, Clarke & Gholamshahi, (2018); Gillies, (2016); Li & Wang, (2016); Sefa et al. (2015). Individuals acquire knowledge and develop their potential to lead economically productive lives through the education process.

The primary route for human capital development is education and training that allows learners to acquire knowledge and productive skills which

increase labour productivity by supporting transient growth towards a higher equilibrium level of output, as augmented in neoclassical growth theories (Edwards, 2004). There is compelling evidence with conceptual clarity that links investment in education and the endogenous growth theory with a conclusion that human capital is one of the primary drivers of economic growth. See, Feyrer & Shekhar, (2002); Jorgenson et al. (1993); Teixeira & Queirós, (2016); Kiss, (2018).

There is substantial literature on human capital development as a function of public investment in education, school enrolment and effect of specifically skilled individuals on growth using aggregate production function (Pegkas, 2014; Bloom et al., 2014; Manda et al., 2006; Aremu, 2014). However, there very few empirical studies on these effects on sector level output. Further, most of the recent empirical studies are grounded on comparative cross-national datasets, see, Ahsan & Haque, (2017); Tsai et al., 2010). According to (Psacharopoulos & Patrinos, 2002), cross-national comparative approach is a less ideal estimation of the rate of return to investment in education as this should be based on a representative sample of the country's population rather than cross-country benchmarks.

For Uganda in particular, there is a deficit of knowledge relating to the country-specific understanding of economic returns to public investment in education. There is indeed little attention given to a country-specific examination of the causal relationship between the agriculture sector output and human capital development within a multivariate framework. In this regard, this is one of the pioneering empirical studies applying the

autoregressive distributive lag (ARDL) approach to estimate both the short and long-run effects on sectoral level economic output in Uganda. It is anticipated that this study will influence national fiscal policy and public expenditure on human capital development initiatives. The study will partly inform the on-going national debate on the expected reforms in the education sector that is continuously perceived as a mere public service good with less critical thoughts on its potential to transform the structure of the rural economy as well as fostering a policy reconsideration on the agriculture sector staffing that is now manned by the military under the "Operation Wealth Creation", a civil-military outfit that is promoting agriculture production.

1.3 The motivation of the study

Agriculture is the main driving force of Uganda's rural economy with great potential to strengthen livelihoods, provide nutritious foods for healthy wellbeing, revitalise rural and urban landscapes, and deliver inclusive and sustainable national growth (OECD, 2016). Therefore, there is no doubt that enhancing the knowledge and skills of the population through education is a wise public investment that can support the adoption of innovations and technologies to stimulate sector growth. This is critical bearing in mind that over 70% of Uganda's 40 million people live in rural areas and these depend on agriculture as a core employer and source of livelihood (UBOS, 2018).

Uganda is among the poorest nations in the world despite reducing its poverty rate. According to the 2016 Poverty Assessment, the country reduced monetary poverty at a very rapid rate. The poverty rate declined in the past two decades, but rebounded in 2016/17, reaching 21.4%, which means that 10

million people live below the national poverty line. From 2006 to 2013, agriculture accounted for 79% of the country's poverty reduction, which means that investment in the sector is critical to poverty reduction. This implies that any investment in the sector is critical for poverty reduction (The World Bank, 2018b). This sector contributes more than half of Uganda's export earnings and a quarter of the country's gross domestic product. (GDP), (UBOS, 2018).

At the household level, agriculture provides the main income stream and supports almost all rural livelihoods options. Therefore, skilling the population is vital to reduce poverty, boost prosperity and create meaningful and decent jobs. This aim is the centrepiece of Uganda's National Development Plan III, the Agriculture Sector Strategic Plan (ASSP) and Uganda's Vision 2040. These policy documents prioritise agriculture as a growth engine that will spur socio- economic transformation of Uganda into a middle-income country by 2040. Therefore, this study sought to estimate the impact of investment in education on agriculture sector growth and establish any predictive causal relationship. At the sector level, growth and prosperity are positively correlated to a reduction in rural poverty that is still a characteristic of an agriculture-dependent household (Arndt *et al*., 2016).

1.4 Problem statement

The importance of the education sector is unquestioned as it is a critical pathway in human capital formation, yet measures of its effect on agriculture sector output remain fairly least investigated. As a rule of the thumb, any country's human capital development success is dependent on

policy and public investment choices underpinned by the age structure of its population. Uganda's age structure is a paradox of its own. Census data indicates that close to 63% and 50% of the total population is below the age of 24 years and 15 years of age, respectively (UBOS, 2018). This young population demands purposive skilling and knowledge formation to enable them to find meaningful, inclusive and equitable engagement in the economy to circumvent potential unrest that is often a manifestation of exclusion of the young and ambitious segment of the population from economic activity (Shao & Wang, 2018; Mberu *et al.*, 2016).

Based on these demographic statistics, the country is characterised as "young". Conventional wisdom dictates that countries with young populations with a significant proportion of the population under the age of 15 years, as for the case of Uganda, need to invest more in human capital development. While those with older populations where the greater proportion of the population is 65 years and above need to invest more in the health sector as the consequence of ageing kicks in (Buesa et al., 2010). Uganda has less than 2% of the total population above 65 years of age and this fact underpins the need to invest in education. Secondly, the recent economic performance of Uganda's agriculture is even more worrying. Three-quarters of people aged 15 to 24 years remain in agriculture as their first job and the sector growth between 2014 and 2018 registered 2.2% annual growth against 3.3% population growth annually over the same period (The World Bank, 2018b). The gloomy picture of the sector holds despite Uganda being categorised as the "food basked" for the East African region due the conducive climate and with over 80% of the

total land arable (OPM, 2017). Sadly, at the global scene, Uganda is among the bunch of countries that failed to reap the dividends of the Green Revolution (Gashu & Stoecker, 2019).

Whereas there is an increase in agricultural output, this surge is attributed to growth in the share of arable land from 18.9% in 1996 to the current 34%, an annual increase of 1.25% (The World Bank, 2018a). However, this increase in agricultural economic output is outstripped by the double-pronged tragedy of a high unproductive and dependent population that is below the age of 15 years and the rapid population growth rate of 3.3% that impacts negatively on agricultural productivity at the household level (Josephson et al., 2014). Therefore, the re-examination of human capital development via public investment in education and output the education system is critical to further understand the constraints facing Uganda's agri-food system output and productivity.

1.5 The Study Objectives

This overall objective of this study was to examine and explain the relationship between human capital investment via public education spending and stock of qualified agriculture human resource on agriculture sector growth in Uganda. The study applied the Auto Regressive Distributed Lag (ARDL) regression models. The purpose was to test and estimate the long-run relationship between public investment on education, enrolement, stock of agri-skilled human capital, Physical Capital accumulation and labour force on the sector between 1982 to 2018. The Specific Objectives are to;

1) Estimate the effect of public education expenditure on agriculture sector output
2) Estimate the effects of school enrolment on Agriculture sector output
3) Estimate the effects of agriculture graduates on agriculture sector output

1.6 Research questions

The research attempts to answer the following pertinent questions'

1) What is the effect of public spending on education on the agriculture sector output between 1980 – 2018?
2) What is the effect of school enrolment on agriculture sector output 1980- 2018?
3) What is the effect of agriculture training on agriculture sector output between 2000-2018?

1.7 Significance of the Study

This study sought to contribute to a new paradigm of production analysis, which acknowledges the relevance of human capital that translates into new knowledge, technology and innovation consequently stimulating agriculture sector growth. This is underpinned by new growth theories which view human capital as the fundamental determinant of a country's economic growth due to the increase in productivity and technological innovation of its people. The proposed paradigm recognises the various roles of inputs in the production process and incorporates human capital into the production model, as well as other factors that lead to economic growth.

In addition, the research defines the factor demand for agricultural production from a technical point of view, and is premised on the fact that human capital is an enabling driver of production process that stimulate the expected growth of the sector. Finally, this research addresses all aspects of economic sustainability of agricultural production by analysing Uganda's productivity growth and the factors affecting productivity growth, focusing on human capital structure, investment in education and physical capital accumulation, and labour expansion. This was intended to unravel the contagion effect of education investments, labour force participation and capital input on agriculture sector output and by extension, productivity.

1.8 Organisation of this Thesis

This thesis is organised as follows; Chapter Two provides an overview of existing literature on relevant research and the emerging frontier in human capital development via education expenditures and economic growth studies. Chapter Three articulates the Analytical Framework, provides an overview and rationale of the Research Design, the ARDL model estimation, detailed explanation of the diagnostic tests, data collection approaches and the chosen macroeconomic variables for estimation and, lastly the limitations and delimitations of the study. Chapter Four presents the findings and discussion of the study. This includes descriptive statistics; test results of time Series properties and diagnostic tests and a discussion of model estimates under each objective. Chapter Five provides conclusions and policy recommendations based on the study findings.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter provides an overview of the theoretical literature on human capital and economic development in general terms, the recent education and agriculture policy environment, facts and figures on the education investment, trends and outputs, the on-going empirical controversies and raging debates regarding human capital development via public education expenditures and economic growth. The last section of this chapter provides a summary of the existing knowledge and literature gaps that this study seeks to address, and more specifically in respect to Uganda.

2.2 Human Capital theory

The Human Capital Theory was first advanced in the 1960s by Theodore Schultz followed by a publication in 1961, (Schultz, 1961). The theory has had a significant impact on a range of disciplines from economics, education to sociology. The theory is based on the foundational narrative that education drives the marginal productivity of labour by enhancing cognitive and productive capabilities of individuals, which in turn drives earnings (Gillies, 2016; Fitzsimons, 2015). The underlying supposition is that education leads to intellectual formation, which in turn constitutes a mode of economic capital. See Affandi et al. (2018) and Ogundari & Awokuse, (2018). Fundamentally, in the short-run, education addresses the short-term social and economic goals of the country, while in the long run, it is directly related to

human capital development, factor productivity, economic growth and socio-economic development of the nation (Chang & Shi, 2016; Nowak & Dahal, 2016; Lee & Lee, 2016). The theory has gained traction in labour economics because it has been proven that firms that invest in developing the skills of their employees tend to maximise profits as a result of improved technical efficiencies (Coff & Raffiee, 2015). At the firm level, human capital is instrumental in explaining the sustained competitive advantage and it emerges out of purposeful investment in learning, skills development, knowledge creation and innovation to raise individuals' productivity (Baier et al., 2006; Cebeci *et al*., 2015; Van et al., 2018).

In modern Human Capital Theory, it is hypothesised that human behaviour in a free and competitive market is driven by self seeking economic interests (Andrés, et al., 2015). It is on this account that investment in education was re-theorised as a fundamental input into human capital development and is the most influencing theory that has over a half a century continued to define the framework for government policies on education (Sianesi & Reenen, 2003; Abubakar, Kassim, & Yusoff, 2015). Public spending on education impacts positively on schooling outcomes (Dauda, 2011), with strong and robust evidence on economic growth especially in sub-Saharan Africa (Akinlo & Oyeleke, 2020). In precise terms, investment in education yields returns to the individual in form of earnings from work, social mobility and wellbeing while to the state, the returns are in form of productivity output, taxation and ultimately economic growth. Education increases worker's marginal physical product as a result of increased output

arising from additional knowledge and skills (Bloom et al., 2020). Increase in the marginal physical product of workers increases technical efficiency in the production process optimising output and innovation within the production ecosystem. With the increasing importance of a globalised knowledge economy, there is indication that human capital build-up is significantly and positively correlated to the country's research and development performance. See Siddiqui & Rehman, (2017), on cross-national studies of nine Asian countries; and Ogundari & Awokuse, (2018) in sub-Saharan Africa.

The Human Capital theory postulates that widespread investment in human capital developemt results in a labour force with critical skills base that is indispensable to a nation's economic growth (Grimaccia & Lima, 2013). Collin & Weil, (2020), observed a dynamic and positive correlation between income and poverty reduction with increased investment in the human capital development and argue that it is more cost-effective than investing in physical capital as a means achieving specific income or poverty reduction goals. Education as a function of human capital development impacts positively on economic growth with innovation, technology and knowledge as spill-over outcomes (Osiobe, 2019).

There is a substantial body of literature demonstrating causal links between education and a diversity of non-economic outcomes such as improved health, increased longevity, fewer teen pregnancies, and lower divorce rates. (Ambrosio-Albalá & Bastiaensen, 2010; Apata et al., 2010; Stenberg et al., 2014). The endogenous growth unto which the theoretical

assumptions for human capital theory are based assert that Total Factor Productivity (TFP) is the key determinant of growth (Abdih & Joutz, 2006; Thai et al., 2016).

Therefore, in the context of this theory, human capital is defined as knowledge or attributes possessed by a worker (whether innate or acquired) that contribute to his or her productivity. However, there is a caveat. To maximise returns from human capital development investments require the presence of a functioning economic system and policy framework to stimulate innovations at scale and promote technological revolution (Fritsch & Franke, 2004; Antonelli & Colombelli, 2015; Davin et al., 2015). It is on this account that literature emanating from extensive empirical research has led to the emergence of economic allegories such as "technological change," "knowledge economy," "innovation," "productivity," "education outcomes," and "competitiveness" to help definitively appraise education as a channel through which human capital is attained (Attanasio, 2015). The same narrative is often used to explain the resultant growth and returns to investment in the education sector.

2.3 Education and Human Capital

It, therefore, follows that investment in education translates to the accumulation of human capital that promotes innovation and technical progress (Alani, 2018). At a societal level, it is widely accepted that an educated society tends to lead a quality life. It is presumed that returns to investment in education leads to human capital development and technological advancement and should be given priority in the advancement of economic

growth and development (Landau, 1983). It is not discounted that the remarkably rapid economic growth and poverty reduction of China are attributed to rapid accumulation of human capital (Hua, 2005; Yang, & Wu, 2018; Li & Wang, 2016; Li et al., 2013). The same narrative of the impact of rapid human capital accumulation is also observed in the rapid growth of both China and the agriculture sector that has surprisingly defied Malthusian theory (Luh, 2017; Takeuchi, 2010; Tsai et al., 2010).

The above narrative has provided strong justification for nations to allocate a significant proportion of their public expenditure to the education sector. Indeed, the World Economic Forum articulates that the future of any country or firm lies in the talent, capabilities and skills of its people (WEF, 2015). AUC/OECD, (2019) in the Africa Development Dynamic Report paints a grim picture for sub-Saharan African countries where talent shortages are going to be severely felt and therefore advocates for strategic investment in human capital development. This imperative is even more critical in the context of shifting population dynamics, limited resources that demands new knowledge and fit-for-purpose skilled workforce to catalyse growth through efficient exploitation of natural resources to build a sustainable physical capital base via education spending. See (Collin & Weil, 2020; Musaba et al., 2013; Muyanga et al., 2011) For instance, Nnyanzi & Kilimani, (2018) while examining the impact of education expansion on economic growth in sub-Saharan Africa, established that the greatest contribution to growth came from secondary education followed by primary education and lastly, tertiary education which included vocational training.

Despite the placement of the Human Capital Theory as the most influential philosophy of western education, it is critical to note that most of the empirical studies on the impact of human development on economic growth and the wellbeing of society are cross-national comparisons (Angrist et al., 2019; Bloom et al., 2006; Bloom & Canning, 2005; Bloom et al., 2014; Psacharopoulos & Patrinos, 2018). Yet, there are underlying characteristics that are country-specific such as systems of governance, prevailing policy framework, labour market dynamics and brain drain, to mention but a few, that render cross-national comparisons inaccurate and misleading to inform country-specific policy recommendations (Hamilton et al., 2009; Lui, 2014). Von Brockdorff & Amaira, (2017) perhaps stresses it more appropriately that cross-national estimation of determinants of productivity fails to reflect on the existing heterogeneity and differential effects in countries. The state superstructure is quite diverse across countries and has implications on productivity operation context and performance. Secondly, at the sectoral level, there is a glaring deficit of studies that have evaluated the impact of public education investment on agriculture sector output.

2.4 Significance of Human Capital studies

Human capital research has many uses. It can be used to understand the drivers of economic growth, assess the long-term sustainability of the country's development trajectory, and most importantly, estimate the economic output and productivity of the education sector. (Liu, 2014; Nowak & Dahal, 2016). Such studies help to improve the fitness of growth models which have explanatory variables of capital and labour inputs in explaining the level of

economic development and growth difference (Sunde & Vischer, 2015). Teixeira & Queirós, (2016) established that human capital development and the countries' productive specialisation and transition to high knowledge-intensive industries are intertwined.

Therefore, for developing countries like Uganda, Singapore is one country that one can get inspiration. The country was at par in terms of economy size, demographic characteristics at independence with most African countries in the immediate post-independence era of the 1960s, with no known natural resource but the country is now one of the leading economies in Asia also known as "Asian Tigers" (Maitra, 2016). The country reached a Human Development Index (HDI) score of 0.932 in 2017 from 0.718 recorded in 1990 (Andrés et al., 2015) and well-shaped development policies and actions towards achieving direct goals of poverty eradication (Hulme, 2013).

Other countries in Asia followed suit and have excelled economically and technologically through their conscious efforts to invest in human capital development via intentional skilling of their population through education (Li et al., 2013; Abrigo et al., 2018). Human Capital is an accelerator of scientific, technological progress and innovation. No wonder, various authors have attributed this phenomenal growth of most of the Asian countries to intensive investment in human capital development that led to the accumulation of a critical mass of skilled and employable labour force with innovative capacities and high productivity to cause a rise in economic growth (Azam & Ahmed, 2015; Pegkas, 2014; Reza & Valeecha, 2012).

In advanced and innovative economies, basic socio-economic functions of capital have shifted to knowledge capital and information capital, which have become the main productive force with a significant decline in direct physical labour demand (Teixeira & Queirós, 2016; Yakushev & Filin, 2020). There are many notable examples of countries that can attribute their phenomenal economic growth to focused public investment in human capital development. See, (Chang & Shi, 2016; Grant, 2017; IFAD, 2010). Faria et al. (2016) in particular, remarks that despite the fierce debates in the comparative economic literature about the role of educational institutions in the formation of human resources, these institutions have had a positive and statistically significant effect on growth. Fitzsimons, (2015) further notes that recently, western countries have re-theorised education under the Human Capital Theory as an economic derivative that continues to shape the framework of government education policies.

Therefore, there is a consensus that human capital development improves individuals' material well-being and spurs the overall growth in the economy. The primary source of human capital is education. Education through acquiring knowledge and skills raises labour force productivity, improves general welfare, fosters growth, and supports the development of knowledge systems for innovation. See, Affandi et al., (2018); Dissou, et al., (2016); Adil, & Khalil, (2018); Njenga & Kosimbei, (2013). Therefore, mass school enrolment at all levels of education is critical. Haldar & Mallik, (2010), using primary education enrolment data for India established that investment in physical capital has neither long run nor short-run effects, but human capital

via education attainment and investment has a significant long-run effect on per capita GNP. Therefore, school enrolment rates and investments are a key determinant parameter in human capital development investigations.

2.5 Gaps in Human Capital effect at Sector level

The comprehensive approach to estimating the effect of human capital on the overall economic growth offers a limited scope of sector-specific impacts. This approach also leaves grey areas on the effect of industry-specific skilled human capital and its effect on the current and future growth of a particular sector (Jiménez et al., 2014; Lucian, 2013; Wilson & Briscoe, 2004). Due to these omissions, some scholars have attempted to breakdown how different education disciplines affect specific sector output and growth. Tsai et al. (2010), analysed the effect of several conformations of human capital on economic growth using alternative measures of human capital conformations from five fields of higher education study and established the critical role of differentiated human capital on economic development. The sector-specific analysis becomes even more critical for the agriculture sector in Uganda with its myriad of growth challenges that are up to date are still thorny to the governments. Therefore, a critical relook on Uganda education and agriculture policy environments is necessary to have holistic reflection on human capital development and agriculture sector nexus.

2.6 Uganda National Development Policy Environment

Uganda's development ambition is guided by Vision 2040, "*A Transformed Ugandan Society from a Peasant to a Modern and Prosperous Country within 30 years*" truncated into five-year planning cycles commonly

referred to as the National Development Plan (NDP). This development ambition purposes to transition the country from a low-income country to an upper-middle-income through a private sector-led development strategy. This overarching development strategy explicitly recognises that due to lack of skills and the economy's slow ability to absorb labour, Uganda is facing a huge challenge of underemployed or unemployed for most of its labour force (NPA, 2007). Further, there is a mismatch between the current human capital and with what is needed in the economy. This fact was explicitly highlighted in Africa's Development Dynamics 2019: Achieving Productive Transformation Report (AUC/OECD, 2019). This has resulted in a huge number of unwaged youths who are increasingly becoming a political and social-economic existential threat to long-term stability (Tiongson, 2005).

Underpinning the achievement of this Vision is a raft of policies enacted by the government to guide different state and non-state actors on the much-needed sector actions and priority interventions. The national policy narratives and the accompanying implementation strategies are the critical levers through which the policy objectives are delivered. These set the framework through which the public sector can improve and integrate smallholders into value chains and ensuring that policies and the existing environment eases the costs of doing business with small farmers largely involved in subsistence agriculture.

The Government of Uganda developed and adopted a National Private Sector Development Strategy (2017/18-2021/22) that aims to improve the business enabling environment, accelerate industrialisation and support firm-

level productivity and modernisation. The strategy aims to strengthen the policy of a private-sector-led economy, improve coordination of policies and initiatives. Further, the strategy seeks to grow and develop businesses and facilitate performance measurement and management of national efforts aimed at improving private-sector competitiveness. It is hoped that this strategy will seek to address the current gap of the absence of a public institution/entity responsible for private sector engagement and coordination of efforts across and within sectors including space for engagement with development partners. What is less understood from the policy dimension is the absence of clear public-driven incentive mechanism that is supportive to the retention of prerequisite skills and knowledge to serve the agriculture sector. The current perception of enabling government interventions supporting private sector development are skewed towards the manufacturing and industry sectors with support mechanism for land acquisition in the recently developed industrial parks, tax relief on the importation of machinery, but fewer interventions towards enhancing those firms involved in the agricultural sector. Therefore, a detailed relook at the agriculture sector policy environment in critical.

2.7 Agriculture Policy Environment in Uganda

Over the last 33 years (since 1987), the Government of Uganda enacted policy framework and implemented several strategies and programs to support the agriculture sector in the country. These are divided into two categories: overarching national policies and specific agricultural and rural development initiatives. (MAFAP 2013). The economic recovery program (ERP) was the first phase of reforms with an impact on the agricultural sector and focused on

the liberalization of the trade including agricultural inputs and outputs. This was followed by Public Enterprise Reform and Divestiture Act of 1993 (privatization policy) that saw the denationalisation of public sector- owned enterprises such as the Coffee Marketing Board (CMB), Lint Marketing Board (LMB), and Produce Marketing Board (PMB) (MAFAP 2013). Due to ERP flaws, the Poverty Eradication Action Plan (PEAP) was created in 1997 as the country's 10-year (1997–2007) planning framework for accelerating growth, reducing poverty, and promoting sustainable development.

The primary goal of PEAP was to reduce Uganda's poverty rate from 35% in 2000 to less than 10% by 2017. (MFPED 2000). Following the expiration of the PEAP (2008), a National Development Plan (NDP) was developed with the goal of addressing the economy's structural bottlenecks and accelerating the socioeconomic transformation for prosperity. Three waves of the NDP have so far been implemented with the current NDP III (2020-2025) having an overarching goal of "Increased Household Incomes and Improved Quality of Life of Ugandans" (NPA 2020).

Agriculture-led growth plays a vital role in reducing food and nutrition insecurity, improve rural livelihoods and transform national economies. This has been the case for many Asian and Latin American countries that witnessed a high input and output green revolution era coupled with robust knowledge from the agricultre research and innovation systems. While for most of the african countries, they are yet to achieve this sector revolution despite the fact that most are signatories to continental conventions and treaties, that demand similar investments in the agriculture sector. In Uganda, the real growth in

agriculture output has been negative for the last two decades (World Bank 2018).

Food insecurity and poverty remain major challenges with increasing national food imports over the last decade (World Bank 2018). The importation of food is a paradox, over 80% of the land is arable and conducive for agriculture production. About 21% of the population live below the poverty line, and over 30% face some level of chronic food insecurity (UBOS 2019a). Geographical disparities in poverty levels remain, as rural areas lag behind urban centres, and the Eastern and Northern Uganda regions comprise 3/4 of the monetarily poor. As of 2016, the poverty headcount rate in the Eastern and Northern regions was 36% and 33% respectively (World Bank 2020). The cause of these high poverty rates has been attributed to the low physical and human capital endowment (Gillman, 2019).

Simultaneously, in 2001, the Plan for Modernization of Agriculture (PMA), a multi-sectoral policy framework for agriculture and rural development, was launched. The plan's goal was to modernize the sector by promoting a profitable, competitive, sustainable, and dynamic agro-industrial sector. Lessons learned in the implementation of the PMA led to the emergence of the Rural Development Strategy (RDS) with the overall objective of raising household incomes. In 2006, the Government formulated a much broader vision of Prosperity for All (PFA). Other related policies and strategies include; Ministry of Agriculture Animal Industry and Fisheries (MAAIF's) Agricultural Sector Development Strategy and Investment Plan (DSIP), Agricultural Sector Strategic Plan (ASSP), and the Agricultural

Zoning Strategy. Several statutory bodies were established under MAAIF to improve the efficiency of agricultural goods and services delivery.. The crop related bodies are; National Agricultural Research Systems (NARS), National Agricultural Advisory Services (NAADS), Uganda Coffee Development Authority (UCDA), Cotton Development Organization (CDO), and the Plan for Modernisation of Agriculture (PMA) Secretariat for multi-sectoral coordination.

The main thrust of these strategies was to contribute towards boosting rural incomes by raising farm productivity, improving quality of life, raising the proportion of agricultural products that is sold, expanding on-farm and off-farm employment prospects, and creating long-term wealth. One of the pillars for PEAP was modernization of agricultural sector that considered the country's comparative advantage at home, regionally and globally. This related directly to selection and promotion of enterprises where the country had the ability to carry out production and marketing more efficiently than another activity/enterprise.

For the agriculture sector, in particular, the Plan for Modernization of Agriculture (PMA), the Medium, and Term Competitiveness Strategy – MTCS (2000-2005) and the Competitiveness and Investment, Climate Strategy (CICS) I (2005/6-2009/10) and II (2011-2015/16) were strategic instruments that enlisted the help of the private sector in identifying business opportunities in the area. The Ugandan government, through the Ministry of Agriculture, Livestock and Fisheries (MAAIF), formulated a national agricultural extension policy to guide, coordinate and regulate the delivery of

agricultural extension services to farmers/groups, and other actor and users of agricultural extension knowledge in the respective value chains . National value chain. This 2016 policy places MAAIF as a nerve centre and a leader in the implementation of agricultural extension and related services to address deficits that caused past shortcomings, respond to current beneficiary demands and take up developing opportunities as well as the long-term support the transition of smallholder farmers from subsistence farming to market-oriented commercial farming that is much needed.

Further, according to the policy, agricultural services will be provided via a pluralistic, equal and fair, decentralised, system that connects all classifications of "users" along the value chain with suitable services and innovative technologies. The National Agriculture extension policy objectives are to; (i) create an agricultural extension delivery system that well coordinated, pluralistic and harmonised for greater efficiency and efficacy. (ii) strengthen the capacity of institutions to effectively deliver agricultural extension services. (iii) establish a long-term framework for packaging and sharing relevant agricultural technologies to all sorts of farmers and other recipients. (iv) support farmers and other value chain players (particularly youth, women, and other vulnerable groups) to successfully participate in agricultural extension activities and strengthen their power to demand services. From the above objectives and strategies and the eight (8), implementation guidelines, the role of private-sector actors in provision extension servces is the least well-defined.

Despite growing complaints about inadequate staffing, limited farmer reach and participation, and a lack of re-tooling of extension workers to handle developing concerns in the sector, the government has continued to offer extension and agriculture-related public goods and services. A novel program, NAADS that was designed to be customer centered and demand-driven agricultural consulting service delivery program, been criticized for only targeting "elite" farmers who are capable of becoming commercial farmers. Therefore, it is not surprising that the programme though had its successes, only managed to reach 22% of the target farmers, with mistrust among the majority of rural smallholder farmers that indeed the programme was a success. The findings from the study on the trust and effectiveness of the NAADs programme showed that trust is probably the starting point to explain farmers' behaviour towards the effectivenes and delivery of extension services in the country (Turyahikayo and Kamagara 2016).

The follow-on program, Operation Wealth Creation, one of the largest civil-military operations, is also confronted with a slew of issues, including weak farmer groups and institutions, untimely delivery of inputs to farmers, delivery of poor quality and quantity inputs, high mortality rates of breeding stock and planting materials due to drought, and mismanagement. Entrance standards into the programme are strict, emphasizing land as a primary prerequisite for participation in the program. This requirement does not benefit women and youth, as they either do not hold land or are unable to make key land-use decisions. Furthermore, the elite have seized control of the program, distributing inputs amongst themselves while claiming to represent farmers

(Tabaro and Katusiimeh, 2018). Amidst these implementation inconsistencies and gaps in agriculture service delivery, private sector companies have assumed a bigger role in delivering the public goods, though their contribution has not been fully documented. Besides, it's not clear who and what extension and agricultural-related services are being delivered.

2.8 Education Policy Environment in Uganda

Before the advent of full implementation of the World Bank's Structural Adjustment Programme (SAP), the education sector like any other form of public service was free. The SAP consisted of conditional loans provided by the International Monetary Fund (IMF) and the World Bank (WB) to countries that experienced economic crises on condition that they put in place policies and reforms towards a market-oriented economy (Makokha, 2001). These policy changes led the government to abolish tuition subsidies in all tertiary education institutions and equally introduced the private sponsorship scheme in all public institutions of higher learning to support the resource allocative policy to achieve universal primary education objectives (Bakkabulindi, 2006; Katunguka, 2015).

2.9 Economic Returns to investment in education

Economic returns to education investment are significant. Recent evidence suggests that education is a determinant of personal income and can generate public and private benefits, also known as social benefits, (Pegkas, 2014; Schündeln & Playforth, 2014; Shao & Wang, 2018). Bloom et al., (2014) using data from UNESCO, estimated that due to capacity shortages, it is projected that Sub-Saharan Africa's output level is around 23% below its

production potential frontier. It was also discovered that due to factor inputs, a one-year increase in the tertiary education stock would raise the long-run steady-state level of African GDP per capita by 12.2%. However, there is growing concern that returns to investment in education are diminishing in view of increased unemployment among the educated workforce, as a result of limited placements in public service and private sector to absorb the existing human capital. Unemployment rate and labour productivity growth rate are negatively correlated (Doppelt, 2018). This comes amidst fiscal difficulties facing national governments with the implication that education, as a factor of human capital will decrease returns.

2.10 Public Expenditure Rationale

Public expenditure is necessary to address the diverse social, economic, and regulatory requirements of an economy. It is characterised by the state producing goods and services which are generally offered to citizens free of charge (Patel & Annapoorna, 2019). Examples of public goods and services are education where the public sector provides infrastructure, waives of fees as witnessed in universal primary (UPE) and gradual piloting in secondary education (USE); health sector through the provision of human resource and medicines, and lastly, in the agriculture sector where the government is providing agriculture extension and input provision under the National Agriculture Advisory Services (NAADS) and more recently, the military-civil Operation Wealth Creation.

Public expenditure contributes to economic growth and social development through multiple channels that lead to employment opportunities

and economic output. Kumar & Joe, (2018), observes that despite the fact that government spending is predicted to have a strong growth multiplier effect, there are some restrictions in determining the magnitude of sectoral allocation. Similarly, the composition of spending allocation and the health of the fiscal environment have a significant impact on the efficacy of government expenditure.. (World Bank, 2018b). In developing economies like Uganda, can achieve a faster catch up process and more sustained income per capita level in the long-run if they activate and support synergies among their main growth engines (Castellacci, 2017).

2.11 Public education expenditure and student enrolment

The introduction of Universal Primary Education (UPE) and the Universal Secondary Education (USE) saw an escalation in student enrolment numbers (Bategeka & Okurut, 2006). While at tertiary education level the "universitisation" of once certificate and diploma awarding public institutions led to an increase in the number of degree-holding graduates. This public policy direction is perhaps anchored on empirical evidence from sub-Saharan Africa that expansion of higher education facilitates economic performance (Nnyanzi & Kilimani, 2018). However, with 70% of the population dependent on agriculture and close to 83% of the rural households engaged in agricultural self-employment as the main economic activity, poverty is still a thorny socio-economic issue in Uganda (Bahiigwa et al., 2005; Bategeka et al., 2013; Christiaensen et al., 2011).

The motive for increasing public expenditure on primary education was also probably underpinned by studies that indicated that the returns to

public investment were higher in primary than secondary and tertiary education (Psacharopoulos, 1984; Psacharopoulos & Patrinos, 2002). Thus, the Government of Uganda introduced the Universal Primary Education (UPE), which almost tripled the net primary school enrolment, but with a catastrophic change in the public investment landscape at both secondary and tertiary education levels whose effects are still being felt today. See Figure 2.1. In the 1990s, government education policy focused on improving access to primary education and expanding economic opportunities for the poor. (Fan & Zhang, 2008).

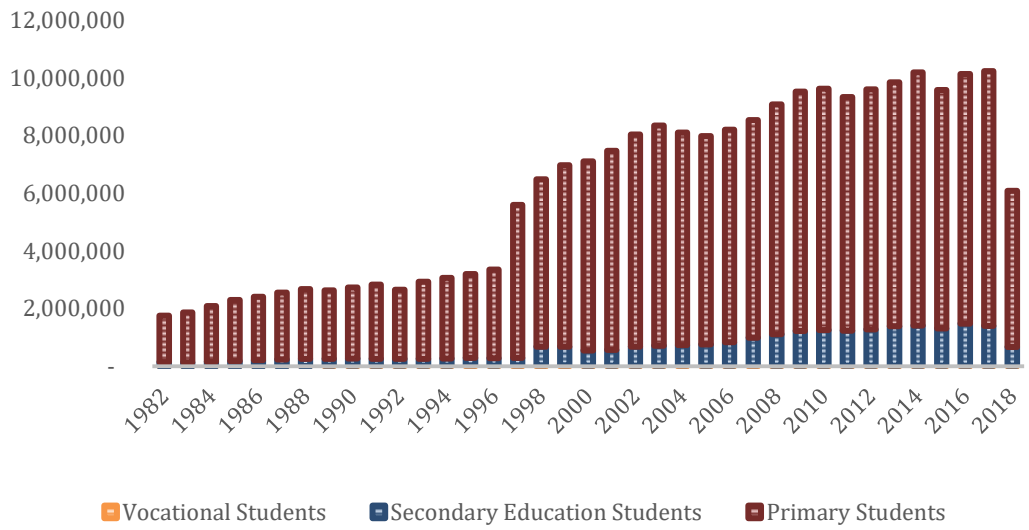


Figure 2.1 School enrolment between 1982-2018

Data source: World Bank Development Indicators, 2018

Despite the increased enrolment rates that were sustained beyond grade five with effects much larger among girls in poor households, the education system still faces challenges in terms of internal efficiency and inequality in the quality of education. (Huylebroeck & Titeca, 2015). The same policy led to increased investment in the education sector by the private sector.

According to the latest Annual School census of 2016, there are a total of 6,798 pre-primary schools of which 19,718 Primary schools of these, 12,109 (61%) are government-owned whereas the rest are privately owned (UBOS, 2018). The impact of these policy directives is clear from the longitudinal data (1982-2017) on public expenditure on the education sector spanning over 37 years. Figure 2.2 shows education public expenditure for primary, secondary and tertiary education levels, respectively.

2.12 Public education expenditures

Uganda, like all countries, uses the cash-based national budget as a planning tool for public expenditure showing projected overall resource envelope for the medium and overall priority interventions including investment in the education sector. However, the cash-based budgeting system undermines the efforts to improve macroeconomic performance and commitment to budget discipline amidst competing for short term political gains *versus* long-term development goals (Kuteesa et al., 2006) The protracted process of human capital development involves learning in a structured environment, which is only attainable in a formal education system.

The universalisation of primary education in the mid-nineties led to an irreversible increase in primary education expenditures and for the first-time surpassing allocations to secondary education level which trend has remained so to date. The spike in secondary education expenditure from 2007 onwards was due to the introduction of Universal Secondary Education (USE), a new policy that introduced free secondary education in selected secondary schools

whether private or public. The objective of USE was to support the poor but academically promising students to access secondary education.

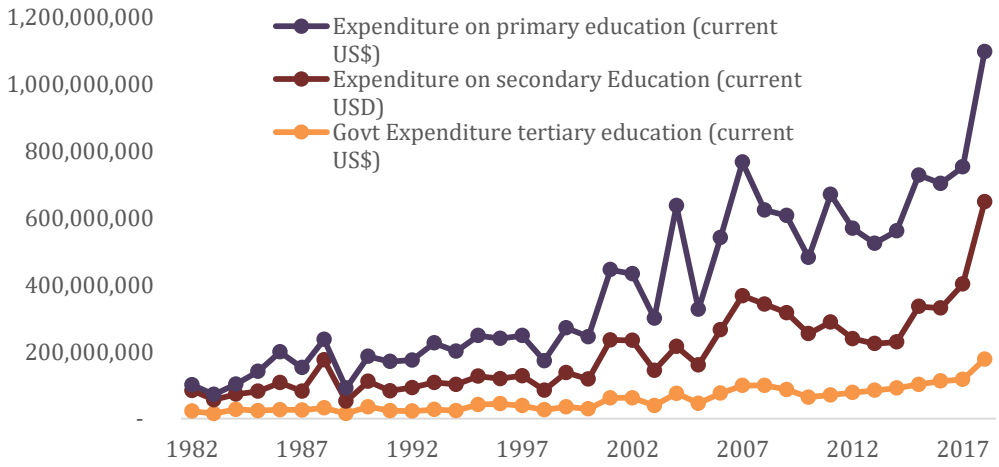


Figure 2.2 Public Expenditure in primary Secondary and tertiary Education. Period 1982-2018

Data source: World Bank Development Indicators, 2018

According to the 2016 Ministry of Education and Sports, Annual School Census (2016) Uganda has a total of 3,070 secondary schools of which 1592 (51.9%) are USE out of which 690 schools were private USE schools (UBOS, 2017). The increased resource allocations to tertiary education universities are largely attributed to an increase in the number of public tertiary institutions from four in one in 1982 to the current 12. The level of funding at the tertiary education level does not reflect the aspirations of the second National Development Plan (NDPII). The NDPII demands that higher education funding through the government should be at least 1% of GDP, but the current funding level has stagnated at 0.3%. Further, the then envisaged revenue from the privatisation of higher education did not improve the balance

sheet of most of the tertiary institutions and as such are unable to meet their capitation objectives. According to the Uganda budget monitoring and accountability unit under the Ministry of Finance, Planning and Economic Development, on average all public universities receive less than 50% of their budgeted capital development fund (BMAU, 2019).

2.13 Employment status in Uganda

The two recent Uganda National Household Surveys (UNHS) on labour market indicators of the working population aged between 14-64 years, revealed that unemployment statistics are higher in urban than rural areas (Table 1). For instance, between 2013 and 2017, the proportion of the population employed in urban areas grew marginally from 23% to 24.3% an increase of less than two percentage points for five years. Whereas over the same period, there was a drop in the working population in rural areas from 77% to 75% of which 47% are employed in the agriculture sector. Similarly, the proportion of the working population in the agriculture sector among males declined from 37% to 31% while the employment rate for women remained stable at 47% on average. Overall, there is a high unemployment rate in urban areas approximated at 75% that need a critical reflection on despite the consistent upward trajectory of economic and wellbeing indicators. This level of economic exclusion poses a dilemma and may even reverse the gains made towards achieving the objectives of the Sustainable Development Goals (SDGs). Uganda's unemployment status cannot be looked at in isolation without looking at the trends in the education sector policy environment and performance metrics.

Table 2.1 Key Labour Market Indicators of Working Population (14-64 years) by sex and residence

Selected Labour Market Indicators	Male	Female	Rural	Urban	Total
UNHS 2016/17					
Working age population (‘000)	8,965	10,139	13,803	5,301	19,104
Working population (‘000)	7,397	7,656	11,395	3,658	15,053
% of working population	49.1	50.9	75.7	24.3	100
Subsistence agriculture (‘000)	2,310	3,604	5,373	541	5,915
Percentage working in subsistence agriculture only	31.2	47.1	47.2	14.8	39.3
UNHS 2012/13					
Working age population (‘000)	7,850	8,652	12,289	4,213	16,502
Working population (‘000)	6,827	7,069	10,732	3,164	13,896
% of working population	49.1	50.9	77.2	22.8	100
Subsistence agriculture (‘000)	2,517	3,493	5,345	664	6,009
Percentage working in subsistence agriculture only	36.9	49.4	49.8	21	43.2

Source: UNHS 2012/13 & 2016/17, UBOS, 2018

2.14 Human Capital and Agriculture sector growth

The lack of skilled human capital in agriculture is very glaring. Between the period 2004 -2011, less than 2% of all graduates enrolled in tertiary institutions in the country pursued agriculture as a discipline. See Table 2, below. This percentage has remained the same despite an increase in tertiary education enrolment and the expansion of the post-secondary education system to cater for a large number of students that are annually qualifying to join tertiary institutions. This lack of adequate human capital makes all attempts by the public sector to implement policies supporting rural economic and institutional transformation processes led by local rural actors themselves to be ineffective as the key actors do not have the prerequisite knowledge and skills to harness the dividends of technology and innovation in the sector (Ambrosio-Albalá & Bastiaensen, 2010). Therefore, the future of

productivity growth in the agriculture sector is dependent on the ability to maximise productivity gains in existing sectors and develop new high-productivity sectors.

Table 2.2***Number of graduates disaggregated by discipline***

Institution	**2010 Arts/Hum**	**2010 Science/Tech**	**2005 Arts/Hum**	**2005 Science/Tech**
Universities & Univ Colleges	84,658	45,584	73,204	19,401
Technical Colleges	0	2,941	0	1,980
Teachers Colleges	5,542	2,375	7,757	3,240
Commerce/Business	14,060	8,617	11,347	6,834
Mgt/Social Development	5,173	106	3,841	315
Health	0	6,274	0	3,132
Agriculture/Fisheries/Forestry	0	1293	0	1,651
Theology	1,580	0	1,098	0
Art and Design	175	20	0	0%
Media	729	891	472	1,004
Hotel and Tourism	23	203	0	143
Study Centres	639	0	604	0
Survey and Land Management	0	30	0	
Law Development	800	0	800	0
Aviation	0	147	0	
Meteorology	0	39	0	39
Cooperatives	443	23	328	0
Total	**113,822**	**68,543**	**99,451**	**37,739**

Data source: *Uganda National Council of Higher Education (NCHE). Reconstructed by the author*

The emergence of knowledge-based competition in a globalizing economy has prompted a rethinking of higher education's role in development and and economic growth (Bloom et al., 2014). The current trend is debunking the previously held view that investing in education is expensive and inefficient public service that only benefits the privileged few (Patrinos & Montenegro, 2014; Psacharopoulos & Patrinos, 2018).

2.15 Education and Agriculture nexus

According to Dethier & Effenberger, (2012), agriculture is again in the headlines due to increasing food insecurity and poverty that requires finding viable solutions to several complex technical, institutional, and policy issues. Uganda's economic development and future growth potential are inseparable from the agriculture sector. The 80% arable land could feed 200 million people if sector is fully utilised (Lunyolo et al., 2021). The country has 80% of the land which is arable but only 35% is being cultivated majorly using subsistence suboptimal methods (Dietrich et al., 2014). According to Uganda's Agriculture Sector Strategic Plan, the growth in the sector has been slow compared to the annual GDP growth rate. For instance, in 2010 growth in the sector declined from 2.6% to -0.2% in 2012, before eventually recovering to 3.6% in 2013 and 2.9% in 2014 (Goobi et al., 2017).

The growth in the agriculture sector contrasts sharply with the annual GDP growth rate of 5.2% over the same period. The sector contributes to almost half of the total revenue of exports, and about 20% of the gross domestic product (GDP) but it is still undeveloped. However, with growing urbanisation, income and related lifestyle improvements and changes in dietary habits, the demand for processed agricultural products is increasing. (Naluwairo, 2011). According to estimates by the World Bank, Uganda's population will reach 102 million by 2050. This is a huge market that will provide huge opportunities for the country's agricultural sector and wider agri-food system. (Sebudde et al., 2011; World Bank, 2008). Recent estimates argue that the value-add of agriculture to GDP will increase if investments are

in made higher-end value chain activities that include manufacturing and food processing (OECD, 2016).

2.16 Employment in the agriculture sector

The 12th Edition of the Uganda Economic Outlook for 2018 reiterates that for Uganda to accelerate its poverty reduction trajectory, larger human capital investments, such as in the education and health sectors, as well as the expansion of social protection programs, are required. In terms of growth analysis, the agriculture sector is of particular interest. The reasons are relevant for both practical and theoretical reasons. The agriculture sector is of particular interest in growth analysis. The reasons are relevant both for practical relevance and theoretical arguments as permanent growth in agricultural production has macroeconomic relevance (Bahiigwa et al., 2005; Diao, 2010). In Uganda, the agriculture sector employs close to 70% of the population and growth in the sector is key to poverty reduction. The share of employment has consistently remained at close to 70% mark for the past two decades despite the doubling of the total force during the same period. This employment rate distribution across sectors has been stagnant for the entire period of post-independence Uganda that is coming close to 60 years. The remaining 30% of the employed population is split between the service and industry sectors at 25% and 5%, respectively. (Figure 2.3).

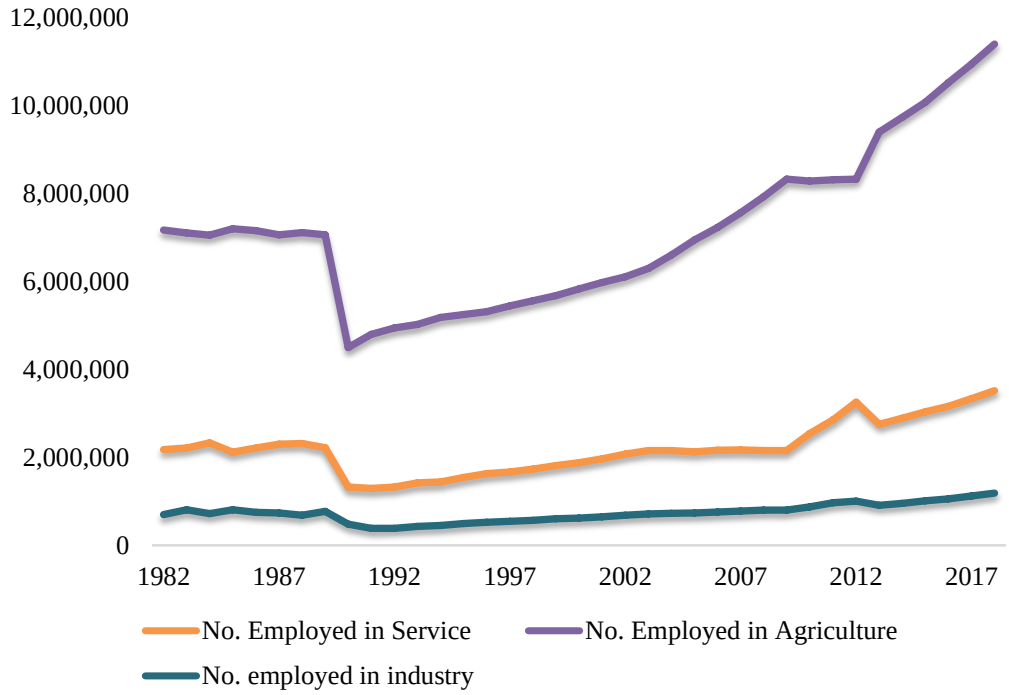


Figure 2.3 Number of employed by economic Sector 1982-2018

Therefore, growth in the sector is key to poverty reduction and there is no doubt this growth can be stimulated from innovations emanating from the country's agricultural training and research innovation system. Based on the above, it can as well be argued that under-investment by many governments in higher education has been constraining development through lack of innovation and technological advancement contributing to increased youth unemployment, inequality and limiting inclusive economic growth (Mogues *et al*., 2012).

2.17 The implication of education investment on agriculture sector growth Agriculture Sector

According to the Africa Development Dynamics report of 2019, in the EAC region in which Uganda is situated, the services sector has solidified its position as the largest contributor to economic output or value add. The report emphatically calls for countries in the region to do more to increase labour productivity across all sectors of the economy. The three economic sectors namely; agriculture, industry and services are in tandem with the overall performance and growth trajectory of the economy. However, the growth in agriculture could be much higher because of high productivity emanating from improved knowledge and skills for innovation.

Indeed, (Rodrik, 2018; Rodrik & Hirschman, 2013) posit that for countries like Uganda, they need to pursue an alternative development pathway that may be agriculture-led or services-led growth that will be driven by a critical mass of human capital. The recently released African Development Dynamics Report of 2019, recognises that the country is struggling with low productivity concerns of agriculture jobs coupled with the effect of rapid urbanisation that is eroding the gains made in human capital development for the sector (AUC/OECD, 2019). Agriculture occupies conspicuous space in Uganda's development agenda due to increasing food insecurity and poverty that requires finding viable solutions to several complex technical, institutional, and policy issues (NPA, 2007). Growth emanating from the sector increases income distribution of the bottom third of

the population and therefore playing a critical role in rural poverty reduction and ending hunger (Sebudde et al., 2011).

On the other side, education increases people's productivity and creativity, fosters entrepreneurship, and advances humankind's technical advancement, resulting in increased output. (Hanushek & Wößmann, 2007; Yakushev & Filin, 2020). Africa's Development Dynamic report, 2019 Edition, highlights that indeed Africa in general and Uganda in particular, is experiencing a conducive economic environment underpinned by a favourable micro-economic trend that is likely to contribute to the much-needed transformation (AUC/OECD, 2019). However, the lack of clarity on the interconnection between investment in education and agriculture sector growth is compelling.

Fundamentally, there is a plethora of evidence that alludes to the fact investment in education enhances factor productivity, stimulates economic growth and promotes socio-economic development (Baldos et al., 2015; Barro & Lee, 2013; Patrinos & Montenegro, 2014; Ono & Uchida, 2018; Lim et al., 2018). Indeed, the registered improved economic performance in sub-Saharan Africa has been to some extent attributed to the rapid expansion of the tertiary education sub-sector (Darvas, et al., 2017). More specific to the agriculture sector, investing in education through training and research generates new technologies and innovations that potentially increase agricultural productivity and help solve some of the world food crisis and mitigate natural resources degradation (Luh, 2017; Darvas et al., 2017; Ndour, 2017; Blackie, 2016; Singh & Sharma, 2004). According to Mogues, et al., (2015) , sustained and

substantial public investment in technologies, infrastructure, and services that support the growth of the agricultural sector has resulted in impressive and sustained agricultural productivity, which we now call Asia's "Green Revolution". Sadly, Africa has yet to witness this transformation of its agri-food system.

2.18 Education and Agriculture Sector growth pathways

There is a firm consensus among academicians and development actors that education drives economic growth as well as foster intellectual, cultural and trade links in an increasingly developing knowledge ecosystem and multi-lateral thinking. Burgess, (2016) three policy areas have been identified, through which education is essential as a means of building human capital. First, in a highly competitive international environment, a country's skill base is critical to its economic growth potential. Second, economic inequality is influenced by the distribution of human capital which becomes more and more important with the high premium of skill wages. Third, the relationship between a person's human capital and his upbringing is the most important factor in determining social mobility and the permanence of disadvantage.. For agriculture, in particular, education contributes to the generation of skilled labour who provide the prerequisite knowledge for production and activation of critical value chains that have the potential to advance the vibrancy of the entire national agricultural innovation system and spur growth.

Chen & Dahlman, (2004), postulates four pillars through which education can be exploited in a productive way to achieve a fully functioning knowledge economy ecosystem. These are; (a) an institutional and economic

system that provides incentives for the effective use of novel and existing knowledge and the thriving of entrepreneurship; (b) an educated and trained population is able use the aquired knowledge to innovate; (c) a dynamic information infrastructure that enables effective information communication, distribution, and processing; (d) Companies, research institutes, universities, consultants, and other organizations that form an efficient and inventive system to take advantage of the developing global Knowledge system, absorb and adapt it to local needs, and develop new technologies.. Therefore, both human capital and knowledge systems are critical in improving the productivity of agri-food systems while ensuring environmental sustainability (Li et al., 2013).

Ironically, despite the expansion of tertiary education with over 48 universities and college degree-awarding institutions as of 2019, only 12 offered agriculture as a discipline (Epeju, 2020). See table 2.3 overleaf. On the lighter note, there are approved syllabuses at primary, secondary, tertiary institutions and universities that offer agriculture as a subject. However, the impact of these low-level training on agriculture output remains largely unknown. This uncertainty anchored the rationale of using school enrolment data to estimate its effect on the sector output.

Table 2.3 Number of agriculture graduates from Makerere university disaggregated by discipline

	Academic Program							
Academic Year	Agribusiness Management	Agricultural and Rural Development	Agricultural Engineering	Agricultural Land Use and Management	Agriculture	Animal Product Technology	Development Studies	Total
2018	74	86	17	37	54	28	377	673
2017	47	47	23	22	50	21	399	609
2016	52	39	25	15	35	17	410	593
2015	68	56	18	19	57	6	340	564
2014	70	51	27	30	61	13	272	524
2013	57	41	19	34	47	21	183	402
2012	64	40	16	39	47	27	211	444
2011	71	0	25	49	95	12	205	457
2010	72	0	15	44	64	16	263	474
2009	85	0	21	58	99	10	310	583

Data compiled by the author

Through the emerging multidisciplinary teaching and research methods in universities and related higher education systems, the agricultural innovation system greatly benefits from other scientific, economic and social science disciplines, helping to fully understand the challenges of rural development in low-income and middle-income countries. agriculture. Advances in mental, neurology, brain, and cognitive research, for example, have tremendously aided in a better understanding and positioning of the teaching process, as well as a more efficient structuring of educational activities. Economists, sociologists, and political scientists, for example, have made substantial contributions to challenges such as prioritizing investment and maximizing system results (Varghese, 2009).

There are three major pathways to which higher education impacts development namely that of teaching, research and innovation. The notion of teaching empowers individual learners to gain capabilities to be more innovative and productive and directly earn more. Despite the growing massification and differentiation of agriculture higher education as a factor human capital development, Uganda's agricultural sector has dismally grown at a rate of 2% which is comparable to 1.8% growth rate across the sub-Sahara Africa and yet the sector accounts for over 70% of the labour force in agriculture (Diao et al., 2010).

It is argued that improvements in the stock of human capital will result in the generation of new technologies, innovations and new knowledge to unlock the current bottlenecks in value chains significantly increasing agricultural productivity. Despite the concerted effort by the public to invest in

education as part of human capital development, the education pipeline is visually a very tightly funnelled pyramid with less than 2% of the annual total multi-level school enrolment accessing tertiary education (see Figure 2). Of these on average, less than 20% complete secondary with over 75% not going beyond the primary level. According to the World Bank gross school enrolment at secondary level was reported at 23.24 % in 2015. See figure below).

Further, Bloom, et al., (2014b) argues that due to the relatively poor endowment to supplement human capital and factor accumulation, physical capital cannot flow into poor countries. The long-term, increase in agricultural productivity in the developed countries has been attributed to advances in knowledge and technology derivatives of human capital (Li *et al*., 2013; Kassie *et al*., 2011). Therefore, the extent to which the existing agricultural knowledge systems and human capital contribute to agricultural development need to be extensively studied. This has been advanced by various authors. For instance, in China (H. Liu & Jiang, 2001); European regions (Sterlacchini, 2008) and Latin America (Torres & Schugurensky, 2002). For Africa's case, the literature is scanty. See (Alani, 2018; Minten & Barrett, 2008; Spielman et al., 2008). Therefore, to estimate the effect of human capital on sector-specific growth, there is a need to investigate whether there is an impact on the overall investment in human capital development.

2.19 Human Capital Estimates and Empirical Controversies

Many empirical studies have explored the impact of public investment on human capital development on economic growth, although the conclusions reached are contradictory. Romer, (1990), found a positive effect of human capital and concluded that the bottom line is that growth is driven by technological changes brought about by the deliberate investment decisions in profit-maximizing agents. Benhabib & Spiegel, (1994) also found a significant effect of Human Capital on economic growth. Earlier estimation of growth based on the Solow Model predicted far large magnitudes of saving and population on income growth with the omission of the Human capital variable (Weil, 1992). The augmented Solow Model potentially attempted to explain the estimated influences of saving and population growth that appeared too large by breaking economic growth into constituent components of education and year of schooling (Hoff & Stiglitz, 1999).

In respect to the rapid population growth as the case of current demographics of Uganda, there are concerns of the dilution effect of population growth and the effect of unemployment rate on returns to human capital development especially as being experienced in the most of sub-Saharan Africa (Bucci et al., 2018; Hadia & Bachtiar, 2019). Further, long-run growth as a result of human capital accumulation is dependent on the efficiency with which resources available are deployed and utilised within the various sectors of the economy (Opeyemi et al., 2017; Han & Lee, 2016). Marginson, (2015), perhaps provides the most controversial narrative that human capital theory failed the test for realism due to methodological flaws,

the use of a single theoretical perspective and closed systems modelling, the inappropriate application of mathematical tools, and single linear Multivariate analysis of variables, that ignores the complex channel between heterogeneous education and work.

The key concerns for this mixed observation are attributed to poorly measuring human capital (Stroombergen & Nana, 2002; Angrist et al., 2019; Son, 2012). The advanced motivation for these observations is either that the proxies utilized do not reflect crucial aspects of human capital, or that the data on the proxies is inaccurate. (Lee & Lee, 2016). Besides, there could be misspecification errors in the measurement of capital, data quality and the existence of outlier observations (Gemmell, 1996). The limited empirical effect of human capital on growth in existing cross-country research is partly due to an incorrect specification that ignores the various channels via which human capital influences growth (Sunde & Vischer, 2015). The same authors further debunked the suggestion of earlier studies that observed weak empirical effects of human capital on economic growth based on the endogenous growth theory. Romer, (1990); also argues that human capital accelerates long-run continuous economic growth.

These contradicting findings have sparked a lengthy debate about the role of human capital in economic growth. Bucci et al., (2018), alludes to the fact that the debate is on and no compromise has been reached in respect to the effect of human capital on economic growth. Nevertheless, there is an increasing focus on the specification of empirical growth equation and the market value of human capital (Barro & Lee, 2013; Edwards, 2004; Feyrer &

Shekhar, 2002; Tang, 2011). The market value of human capital falls short of highlighting the impact of intangible assets such as R&D, patents, intellectual capital, etc. in the market value and development of the company, which ultimately leads to economic growth. (Pelinescu, 2015). Furthermore, most estimation methodologies emphasize supply-side drivers while neglecting demand-side elements, particularly the importance of structural change processes, which include the interaction of human capital with diverse sectors of the economy (Teixeira & Queirós, 2016).

Uganda's education sector has been overly criticised for compounding the problem of unemployment, with the use of antiquated curricular that churns out not fit-for market graduates. Because of this realisation, there is emerging interest and attention in Vocational training. This education subsector is witnessing increasing public allocation of resources ostensibly to avert the current youth unemployment, which burden is afflicting the majority of countries in sub-Saharan Africa with potentially catastrophic outcomes for sitting regimes. As a result, the government developed the Business, Technical and Vocational Education and Training (BTVET) Strategic Plan 2011 – 2020 with a paradigm shift for skills development in Uganda. The strategy is embedded in the overall education policy framework and underpinned by the Government white paper (GWE 1992) on education as well as the insufficient skills to propel the informal sector especially the non-farm informal sector.

The informal non-agricultural sector, which mainly includes micro-enterprises, self-employed and unpaid family workers, has declined in recent years, but still accounts for 18% of total employment and 58% of non-

agricultural employment. Hanushek & Woessmann, (2016), observes that there are significant gains that accrue from providing universal basic skills. Returns to such investment projected to be six times those of just providing universal access to schools. Datzberger, (2018), in his quest for why education is not helping the poor in Uganda, observed that assimilative approaches as outlined in the policy implementation strategies of (a) increase education and retention opportunities; (b) improve the quality of education; (c) create employment through education, which has little impact on the political, economic and social structure that is the root cause of poverty. The Human Capital Theory (HCT) advances the concept that investment in education is a key determinant of human capital accumulation. The theory also set an influential framework through which public financing and reforms of the education sector are anchored (Fitzsimons, 2015; Tiongson, 2005).

The increasing importance of the concept of "knowledge economy" over the last two decades has further placed credence on this theory due to the strong connections between education and training, and economic growth. There are both short and long-run positive effects of investing in education at a macroeconomic level (Psacharopoulos & Patrinos, 2018). The concept in itself is complex and multidimensional with interactions between physical capital, R&D, innovation and population dynamics leading to co-evolutionary growth of the economic system (Castellacci, 2017). As a result, empirical investigations of human capital and its impacts on economic growth continue to attract a large number of studies worldwide in an attempt to gain a comprehensive understanding of the key elements influencing growth. The

HCT is used to account for the wealth of nations and is more comprehensively finding its way in the national and international policy conversations (Liu & Jiang, 2018).

As such, there is growing emphasis to invest in human capital development through training and research to generate technologies and innovations that will increase agricultural productivity to help solve some of the world food crisis and natural resources degradation (World Economic Forum 2015). There are indications that this is indeed a viable public investment option. See, Mogues et al., (2012) and Olowa & Olowa, (2014) The underpinning factor is the vital role agricultural graduates play as innovators to stimulate improvements and unlock the untapped potential to cause improvements in agricultural productivity and growth and sustainable development (Asadullah & Ullah, 2018; OECD, 2016). This is the human capital stock that should be harnessed to cause desirable changes in the agricultural sector (Ragasa, 2016; Fox, 2015). Thus, if human capital development is to be considered an investment option, the spill over should be felt in Uganda's agriculture sector, which still relies on low technology, limited diversification, employing low-quality labour.

2.20 Conceptual Framework

The conceptual framework is shown in Figure 1, below starts with the current national context of the national Agricultural Innovation System. The key considerations in this study the level of public expenditure and output from the higher education sector; the status of the extension service and delivery mechanism and the complementary role training institutions are

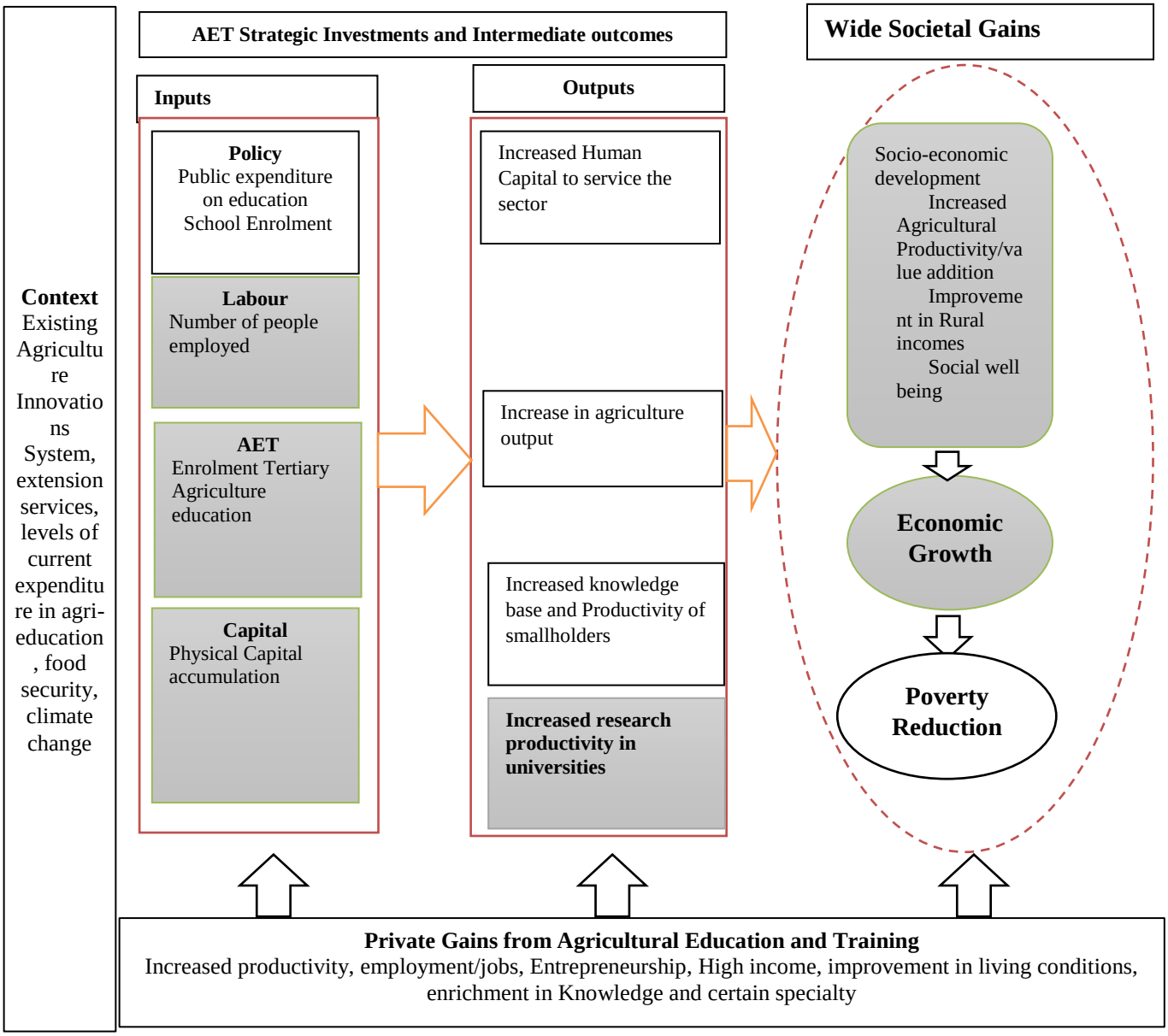
playing through their community engagement and outreach functions, the landscape of Agriculture Higher Education, food security and emerging effects of climate change that are now more severe than previously predicted.

Within the context of this study, key enablers are identified, namely; (a) enabling policy and legal framework that stimulate investment in Agriculture Higher Education by both the government and private sector, (b) proportion of training Investments in National Agriculture Research System (NARS), (c) the enrolment rates which is the general applied measurement in assessing the performance of education systems in agriculture and faculties, and, (d) contribution by specialised entities that provide scholarships in agriculture education such as RUFORUM, ASARECA, the CGIAR system among others. The shaded areas will be included in the quantitative analysis to estimate the economic impact of these investments.

The conceptual framework also makes recognition of the intermediate outcomes that accrue from these investments namely, accumulated human capital, and increased consumer spending and increased knowledge and research productivity of smallholders that spur the growth of the sector and by extension, socio-economic growth through increased agricultural productivity, improvement in rural incomes and social wellbeing. These parameters translate into national economic growth through GDP growth and poverty reduction. At the individual level of the trainees, the framework recognises increased productivity, employment/jobs, entrepreneurship, high income, improvement in living conditions, enrichment in knowledge and speciality that lead to sustained income. However, in the scope of this study, individual

earnings or benefits accruing from any qualification in agriculture and related fields will not be considered.

Figure 2.4 Conceptual Framework



2.21 Research Gaps

Evidence from the literature reviewed in this thesis reveals a glaring on broadly the effect of human capital development on agriculture sector output. But specifically there almost no literature on the effect of education spending, enrolment and agriculture tertiary education on the sector growth. This lack of literature on Uganda's specific context on human capital development and agriculture growth nexus is what this study seeks to address. It is hoped that this study has the potential to influence the national education policy environment to support agriculture-led rural transformation as observed from the literature on China, and many Asian countries' astronomical growth because of focused investment in education.

CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter outlines the Theoretical Framework, and Empirical models used to estimate the study objectives. The chapter also provides a detailed description of estimation methods, instrumentation variables, sources of data and data analysis methods. The last section of this chapter provides the study limitations and delimitations.

3.2 Analytical Framework

Despite the long-term research on the impact of human capital development on inter-generational economic growth, there are still disagreements on how to explain this in a formal model of economic growth. There are two main schools of thought. They are Keynesian and Neoclassical methods. The former stresses the role of demand factors in determining economic growth and seeks to understand the determinants of the long-term economic growth rate through the accumulation of factor inputs such as physical capital and labour. While the later and more recently the Schumpeterian perspective that postulates that innovation and progress are achieved through recombination and disruption of existing technologies (Buesa *et al*., 2010; Teixeira & Queirós, 2016a). Despite these theoretical contradictions, most scholars agree that the supply-side model aims to discover the production factors of economic growth, and therefore is considered more suitable for studying the impact of human capital formation

in the framework of aggregate production function (Diagne & Diene, 2011; Izushi & Huggins, 2004; Liu, 2014; Oxley *et al*., 2008).

3.3 The aggregate production function

The possible contribution of human capital on economic growth is often modelled using Aggregate Production Function (APF) framework. The model is flexible as it treats economic outcomes as a function of employment, physical capital, and technological growth (Judson, 2002; Abdih & Joutz, 2005). The model is quite simple and allows one to estimate the rate of technological change resulting from labour and physical capital (Lin, 2018). The model can as well be augmented with the variables of interest to make theoretical predictions about the relatively long-term activity as applied to estimate the impact of human capital on technical inefficiency. See (Osiobe, 2019; Tallman & Wang, 1992; Weil, 1992; Dimelis & Papaioannou, 2014; Mogues *et al*., 2012)**.**

Because of this flexibility, the APF is applied extensively in human capital studies. The framework takes into account the contribution of technical progress toward growth that is defined as an exogenous factor (Weil, 1992). Solow (1957) and Swan (1956) were the pioneers who first demonstrated using the aggregate production function exhibiting a constant rate of return to scale on labour and capital. Despite the model's simplicity and flexibility, Mcdonald & Roberts, (2002) argues that human capital is complex and consists of more than knowledge capital. Nevertheless, the general expression of the model is written as follows;

$$Y = F(K, L) \quad \text{..... (3.3.1)}$$

Where *Y* is the output, which in this study is the agriculture sector output as a proportion of GDP, K is the stock of capital (physical and financial) and *L* is the labour force. This model is anchored on the assumption that output *Y* determined under a defined state of knowledge and within a given range of available technology. Further, the model assumes a constant rate of return to scale, which does not hold for the aggregate production function that takes into account the diminishing returns on the accumulation of capital. Further, the model in reduced form suppresses micro-foundation and market structure components and assumes that the output per worker is directly dependent on capital denoted as *Y=Y/L* and larger human capital appears to be associated with faster economic growth (Lim *et al*., 2018).

Though the model has limitations because it does not take into account the large residual as observed by Solow (1957) as observed on the technological progress of the United States of America economy that was attributed to improved efficiency as a result of accumulation of knowledge and skills for production. See Romer (1990) and Weil (1992). This is because a quantitative accumulation of factors of production alone is not enough to assure sustained growth. Therefore, taking into account the diminishing returns on factor inputs, a Cobb-Douglas function can be derived as follows;

$$Y = L^{1-\propto} K^{\propto},\ 0 < \propto < 1 \quad \text{..... (3.3.2)}$$

The model presupposes that labour productivity increases with the capital increase. However, Caruso, (2002) while analysing the procyclical behaviour of Chinese Total Factor Productivity (TFP) established that the measured Solow residuals were correlated to the growth rate of real imports per worker

as well as to other macroeconomic variables that fluctuate at cyclical frequencies. Therefore, a modification of the neoclassical growth model is derived by introducing a technology parameter *A,* in the aggregate production function reflecting on the state of a firm or country's technological progress as denoted below

$Y = F(A, K, L)$ …… (3.3.3)

The above model is grounded on the following five assumptions;

a) There is only one output of society, which can be used for consumption or be used for investment

b) The depreciation rate of capital is greater than 0;

c) The production function is hicks-neutral where the average and marginal products of all factors increase in the same proportion and satisfies constant returns to scale

d) The available labour force is fully employed; and

e) Population growth, technological progress, and savings rates are exogenous variable (Lin, 2018; Stock, 2010).

3.4 Criticism of the Solow- Swan Model

The critics of the Solow-Swan Model highlight that the model has limitations to account for causes of technological progress and this led to the creation of the new endogenous growth theory (Edwards, 2004; Osiobe, 2019). However, it is argued that when the exogenous rate is set, technological progress emanates from knowledge producing centres such as universities, research institutions, think tanks, which are outside the domain of the economic ecosystem the model expresses (Wilson & Briscoe, 2004). Critical

to the agriculture sector, there is increasing criticism on how much productivity growth might be attributable to factors other than organized training and research and development initiatives including evolving weather patterns, institutional changes, or size of economies associated with changing structure of agriculture (Alston, 2010; Nin Pratt, 2015; Zasada *et al.*, 2015).

The other limitation of the Solow-Swan Model is the assumption that there is a constant rate of return and yet there is evidence of increasing returns on economic growth in a long run with positive marginal productivity (Abowd *et al*;., 2002; Liao, 2011; Lin, 2018; Meerah *et al*., 2012). Further, Caruso (2002), observes that measured TFP growth rates (Solow residuals) may not coincide with "true" variations in A_t due to the presence of three unobservable (and partially indistinguishable) factors: a) pro- cyclical measurement errors (from labour hoarding where highly qualified individuals move out of the sector, cyclical factor utilization) and systemic input factor measurement errors.

Despite these shortcomings, the Solow-Swan Model can be extended to include other instrumental variables of human capital which consider the qualification of the workers and labour *H* which is the rate of participation in the production process (Mankiw et al., 1992). Also see Lin, (2004) as applied to measure the effect of higher education output on the economic growth of Taiwan. Therefore, the equation 3.3.3 can be rewritten and expressed as shown below;

$$Y = K^{\alpha}(AH)^{1-\alpha} \quad \text{.....} \quad (3.4.1)$$

Where *A* represents the technical progress level and the benefits accrued from technological progress at a constant and exogenous rate α and $\alpha = \dot{A}/A$. Estimation of α which is the exogenous rate is set for technological progress originating from knowledge producing centres such as universities, research institutions, think tanks. To estimate the effect of human capital development via education sector investment and outputs on economic sector output, the assumption is made that the worker in a specific country can increase their qualification by dedicating a share of their time *u* to education to enhance their knowledge and skills instead of participating in the production. See equation 3.3.5 below.

$$H_t = h(u)L_t \quad \text{(3.4.2)}$$

The education allows workers to increase their qualifications, acquire new knowledge and effectively participate in economic activities hence human capital (*H*) that participates in the economy assuming $h \geq 1$. Where *L* represents the labour force without any academic qualification or with no level of academic attainment and *h* is the level of qualification of the labour force. The critical assumption is that the impact of education time on qualification consists of stylised facts on the labour market

$$h = e^{\psi U} \mapsto H_t = e^{\psi U}.L_t \quad \text{(3.4.3)}$$

Where $\boldsymbol{\psi}$ is a positive constant factor and if u=*0*, *H=L* it implies that production cannot benefit from any qualification of labour. Assuming that technology is labour augmented and is depended on the skills and knowledge embedded within the population attained through education, then workers create knowledge in a simple form expressed as;

$$\frac{dA}{dt} = \delta H_A A \quad \text{..... (3.4.4)}$$

Where H_A is the Human Capital of worker and δ is the parameter. This simple expression clearly shows that an increase in human capital will increase the development and stock of knowledge leading to externalities of new ideas channelled into production processes from efficiency improvements. This expression recognises the role of human capital in economic growth and that a country with a large stock of human capital will grow faster (Mankiw *et al*., 1992; Lim *et al*., 2018)**.**

In the context of the agriculture sector, the above expression denotes that investment in producing human capital will lead to the generation of new technologies, innovations, and patents that will lead to increased output from the sector. The innovations and patents produced by the existing stock of human capital lead to the exchange of knowledge and technologies that have a spill-over effect and its deployment will increase the productivity and output of the agri-food system (Huffman, 2002; Davis *et al.*, 2008; Balcombe *et al*., 2005; Bazylevych *et al.*, 2016)

3.5 Research Design

The study was quantitative and used longitudinal secondary and primary data obtained from national statistics and directly from Universities in Uganda, respectively. The time-series data used in this study was the period 1982 to 2018 to investigate the relationship between human capital investment via public education spending and stock of qualified agriculture human resource on agriculture net output in using an Autoregressive Distributed Lag (ARDL) cointegration modelling. The ARDL is an ordinary least square

(OLS) based model that can be applied to both non-stationary time series as well for those with mixed order of integration as long as they are no series with second-order integration (Shrestha & Bhatta, 2018).

The key advantage of the ARDL approach is its ability to identify multiple cointegrating vectors in the same estimation (Nkoro & Uko, 2016). The conventional cointegration methods estimate the long-run relationships within a context of a system of equations, whereas the ARDL method employs only a single reduced form of the equation.

The ARDL method is hailed as a remedy for spurious regression that often afflicts time-series investigations (Ghouse *et al*., 2018;). The popularity of the ARDL model stems from the very fact that the cointegration of nonstationary variables is comparable to an error correction (EC) process, and the model can as well be re-parameterised into an EC form (Kripfganz & Schneider, 2018). Therefore, the presence of a cointegrating relationship is tested based on EC representation. The ARDL is also advantageous in respect to cointegration of nonstationary variables as the existing unit root tests used to identify the order of integration are still highly questionable given the characteristics of the cyclical components of the data (Pesaran *et al*., 2001).

Further, unlike other cointegration techniques like the short-term Vector Autoregressive (VAR) and the long-term Vector Error Correction Method (VECM), the ARDL method is advantageous as it does not impose a restrictive assumption that all the variables under study must be integrated of the same order. This characteristic allows the application of ARDL modelling regardless of whether the underlying regressors are integrated of order I (1),

order zero I (0), mutually or is fractionally integrated. However, the model collapses in the presence of I(2) regressors. Further, the ARDL approach removes problems associated with both omitted variables and auto-correlation and the procedure allows the cointegration relationship to be estimated by Ordinary Least Squares (OLS), once the lag order of the model is specified. For instance, the Johansen cointegration test cannot be applied if variables of interest have a mixed order of integration or all of them are non-stationary (Shrestha & Bhatta, 2018).

In terms of sample size, whereas other cointegration approaches are sensitive to sample size, the ARDL test is generally acceptable econometric analytical method for even small samples sizes. The approach provides unprejudiced estimates that yields dependable and robust results for both long-run and short-run relationships between growth and test variables. Similar arguments were advanced by Malangeni & Phiri, (2018) while estimating education investment and economic growth in post-apartheid South Africa, and Ifa & Guetat, (2018) while understudying public expenditure on education on GDP per capita growth of Tunisian and Morocco, and Mustafa *et al*., (2018) in investigating the role of foreign aid in promoting economic growth in Sudan.

3.6 ARDL Model specification

The econometric model takes the form of augmented Cobb-Douglas function within labour augmented theoretical framework that considers human capital as an independent factor of production (Edwards, 2004; Mankiw *et al*., 1992)

$$Y_t = K_t^{\alpha} H_t^{\beta} (AL)_t^{1-\alpha-\beta} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ (3.6.1)$$

With the assumption that;

α< 0, β>0, α + β < 1

Where *Y* is output, *K* is physical capital, *H* is human capital, *L* is the number of workers in the country and *A* level of technology. In this model, the $(AL)_t$ component signifies the effective units of labour; α is the elasticity of capital with respect to *Y, β* is the elasticity of human capital with respect to *Y*. The model assumes that *α + β < 1*, which implies a diminishing, return to capital.

3.6.1 Objective 1. Model Specification

Under objective 1, estimating the effect of public education expenditure on agriculture sector net output, *Y* is substituted with agriculture sector output (*AGR*), *H* with proxies of public expenditure in Primary Education (*Prim*), Secondary Education (*Sec*) and Tertiary Education referring to post-secondary education level to include university level and Business and Technical Vocational T (*Tert*). After substituting the instrumental variables in the equation above and taking the natural logarithm, the following equation is derived.

$$ln\,AGR_t = \ \alpha lnK_t + \beta lnH_t + (1 - \alpha - \beta)\ \ ln(AL)_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots (3.6.2)$$

Further, substituting H proxies *Prim, Sec* and *Tert*, in the above equation, equation 3.5.1 was derived.

$$lnAGRI_t = \ \alpha lnK_t + \beta(lnPrim_t + lnSec_t + lnTer_t\,) + (1 - \alpha - \beta)\ \ ln(AL)_t + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots . (3.6.3)$$

From equation (3.5.2) an ARDL model was derived as shown in 3.6.4 to estimate both the long-run and short-run regressions using $\emptyset_i$ and β_i respectively with the assumption that the error correction term ε_t lies between 0-1.

$$\Delta lnAGR_t = \propto_0 + \sum_{i=1}^{n} \emptyset_1 \Delta lnYAGR_{t-1} + \sum_{i=1}^{n} \beta_1 lnAGR_{t-1} +$$

$$\sum_{i-1}^{n} \emptyset_2 \Delta\, lnK_{t-1} + \sum_{i-1}^{n} \beta_{2_2}\, lnK_{t-1} + \sum_{i=1}^{n} \emptyset_3 \Delta lnL_{t-1} + \sum_{i-1}^{n} \beta_3\, lnL_{t-1} +$$

$$\sum_{i-1}^{n} \emptyset_4\, \Delta lnPrim_{t-1} + \sum_{i-1}^{n} \beta_4\, lnPrim_{t-1} + \sum_{i-1}^{n} \emptyset_5\, \Delta lnSec_{t-1} +$$

$$\sum_{i-1}^{n} \beta_5\, lnSec_{t-1} + \sum_{i=1}^{n} \emptyset_6\, \Delta lnTer_{t-1} + \sum_{i=1}^{n} \beta_6\, lnTer_{t-1} + \varepsilon_t \quad \text{....(3.6.5)}$$

3.7 Bounds Testing

Before estimating the ARDL models, the initial step was to conduct a bounds test using OLS to investigate if there is a long-run relationship in the model variables. The bound test can either apply F or t statistics and this estimates the joint significance of the coefficients using OLS and the existence of a long-run relationship. In this, both *F* and *t* statistics were applied to test the hypothesis below.

$H_0: \beta_1 = \beta_2 = \cdots \beta_i$ ..... (3.7.1)

$H_i: \beta_1 \neq \beta_2 \neq \cdots \beta_i$ ..... (3.7.2)

In case H_0 was rejected, an error correction parameter would be introduced to measure the speed of adjustment towards the long-run equilibrium. The error correction term (*ECT*) is derived from the corresponding long-run model whose coefficients are obtained by normalising the equation. The unclosing of an error term transforms the model into an error correction model (ECM). The advantage of the ECM model is that it combines short-term dynamics with long-term equilibrium without losing long-term

information. The ECM model also avoids problems of spurious relationship resulting from non-stationary time-series data that is normally experienced in linear multivariate regressions. The δECT_{t-1} is the error correction term, which measures the speed of adjustment back to steady-state equilibrium in the face of external shocks to agriculture output. The model was also subjected to misspecification tests, which included a normality test, serial correlation test, heteroscedasticity test to check robustness and stability and as well validate the bound test hypothesis.

Therefore, the objective 1 model on account of H_0 rejection can be rewritten and specified as an ECM model as shown below.

$$\Delta lnAGR_t =$$

$$\propto_0 + \sum_{i=1}^{n} \emptyset_1 \Delta lnAGR_{t-1} + \sum_{i=1}^{n} \beta_1 lnAGR_{t-1} + \sum_{i-1}^{n} \emptyset_2 \Delta\, lnK_{t-1} +$$

$$\sum_{i-1}^{n} \beta_{2_2} lnK_{t-1} + \sum_{i=1}^{n} \emptyset_3 \Delta lnL_{t-1} + \sum_{i-1}^{n} \beta_3\, lnL_{t-1} +$$

$$\sum_{i-1}^{n} \emptyset_4\, \Delta lnPrim_{t-1} + \sum_{i-1}^{n} \beta_4\, lnPrim_{t-1} + \sum_{i-1}^{n} \emptyset_5\, \Delta lnSec_{t-1} +$$

$$\sum_{i-1}^{n} \beta_5\ lnSec_{t-1} + \sum_{i=1}^{n} \emptyset_6\, \Delta lnTer_{t-1} + \sum_{i=1}^{n} \beta_6\, lnTer_{t-1} +$$

$$\delta ECT_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.7.3$$

3.7.1 Objective 2 Model Specification

Similarly, objective 2, the following ARDL model was derived

$$\Delta lnAGR_t =$$

$$\propto_0 + \sum_{i=1}^{n} \Delta lnAGR_{t-1} + \sum_{i=1}^{n} \beta_1 lnAGR_{t-1} + \sum_{i-1}^{n} \emptyset_2 \Delta\, lnK_{t-1} +$$

$$\sum_{i-1}^{n} \beta_{2_2} lnK_{t-1} + \sum_{i=1}^{n} \emptyset_3 \Delta lnL_{t-1} + \sum_{i-1}^{n} \beta_3\, lnL_{t-1} +$$

$$\sum_{i-1}^{n} \emptyset_4\, \Delta lnPrimE_{t-1} + \sum_{i-1}^{n} \beta_4\, lnPrimE_{t-1} + \sum_{i-1}^{n} \emptyset_5\, \Delta lnSecE_{t-1} +$$

$$\sum_{i-1}^{n} \beta_5\ lnSecE_{t-1} + \sum_{i=1}^{n} \emptyset_6\, \Delta lnTerE_{t-1} + \sum_{i=1}^{n} \beta_6\, lnTerE_{t-1} +$$

$$\varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (3.7.4)$$

Where *PrimE*, *SecE* and *TertE* is the number of students enrolled for Primary Education, Secondary Education and Tertiary Education (post-secondary education level to include university level and Business and Technical Vocational), respectively and where β_i are the long-run regression coefficients, $\emptyset_i$ are the short-run coefficients and ε_t is the error term. In case H_0 was rejected, an error correction parameter would be introduced to measure the speed of adjustment towards the long-run equilibrium. The unclosing of an error term transforms the model into an error correction model (ECM).

$$\Delta lnAGR_t =$$

$$\propto_0 + \sum_{i=1}^{n} \emptyset_1 \Delta lnAGR_{t-1} + \sum_{i=1}^{n} \beta_1 lnAGR_{t-1} + \sum_{i-1}^{n} \emptyset_2 \Delta\, lnK_{t-1} +$$

$$\sum_{i-1}^{n} \beta_{2_2}\, lnK_{t-1} + \sum_{i=1}^{n} \emptyset_3 \Delta lnL_{t-1} + \sum_{i-1}^{n} \beta_3\, lnL_{t-1} +$$

$$\sum_{i-1}^{n} \emptyset_4\, \Delta lnPrimE_{t-1} + \sum_{i-1}^{n} \beta_4\, lnPrimE_{t-1} + \sum_{i-1}^{n} \emptyset_5\, \Delta lnSecE_{t-1} +$$

$$\sum_{i-1}^{n} \beta_5\, lnSecE_{t-1} + \sum_{i=1}^{n} \emptyset_6\, \Delta lnTerE_{t-1} + \sum_{i=1}^{n} \beta_6\, lnTerE_{t-1} +$$

$$\delta ECT_{t-1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3.7.5$$

3.7.2 Objective 3 Model Specification

Under objective 3, estimating the effects of agriculture graduates on agriculture sector output, *H* and is substituted with the total number of agriculture graduates AGRg, while the rest of the independent variables are retained in the model. The model is reconstructed as shown below;

$$\Delta lnAGR_t =$$

$$\propto_0 + \sum_{i=1}^{n} \emptyset_1 \Delta lnAGR_{t-1} + \sum_{i=1}^{n} \beta_1 lnAGR_{t-1} + \sum_{i-1}^{n} \emptyset_2 \Delta\, lnK_{t-1} +$$

$$\sum_{i-1}^{n} \beta_{2_2}\, lnK_{t-1} + \sum_{i=1}^{n} \emptyset_3 \Delta lnL_{t-1} + \sum_{i-1}^{n} \beta_3\, lnL_{t-1} +$$

$\sum_{i-1}^{n} \emptyset_4 \, \Delta lnAGRg_{t-1} + \sum_{i-1}^{n} \beta_4 \, lnAGRg_{t-1} + \varepsilon_t$ ……

(3.7.6)

Similarly, in case H_0 was rejected, an error correction parameter is introduced to measure the speed of adjustment towards the long-run equilibrium. The equation is thus rewritten as shown below;

$\Delta lnAGR =$

$\propto_0 + \sum_{i=1}^{n} \emptyset_1 \Delta lnYAGR_{t-1} + \sum_{i=1}^{n} \beta_1 lnAGR_{t-1} + \sum_{i-1}^{n} \emptyset_2 \, \Delta \, lnK_{t-1} +$

$\sum_{i-1}^{n} \beta_{2_2} \, lnK_{t-1} + \sum_{i=1}^{n} \emptyset_3 \Delta lnL_{t-1} + \sum_{i-1}^{n} \beta_3 \, lnL_{t-1} +$

$\sum_{i-1}^{n} \emptyset_4 \, \Delta lnAGRg_{t-1} + \sum_{i-1}^{n} \beta_4 \, lnAGRg_{t-1} + \delta ECT_{t-1} \, \varepsilon_t$…….... (3.7.7)

3.8 Research Scheme and Data collection

The figure 3.1 shows the research scheme of the study and provides a laid-out procedure from data collection, model testing, ARDL model estimation and stability tests. The data used was obtained from official statistics and national databases. Bearing in mind that the data was macroeconomic time series, it was, therefore not a methodological requirement to construct any form of sampling frame apart from defining time span of the data sets. Data was collected from the Uganda National Bureau of Statistics (UBOS), Ministry of Education Database, World Bank indicators and for the agriculture graduates, directly from universities. The data collected was for each financial year for the period 1982-2018. The choice of the period was informed by studies that applied the ARDL model that show a period of over 20 years is appropriate (Ifa & Guetat, 2018). The datasets were cleaned, missing values imputed and natural log transformed before uploading on STATA Version 14 program. All further actions and analytical tests were conducted using STATA version 14.

Each series had 37 records with a total of 444 data points that were used in the analysis.

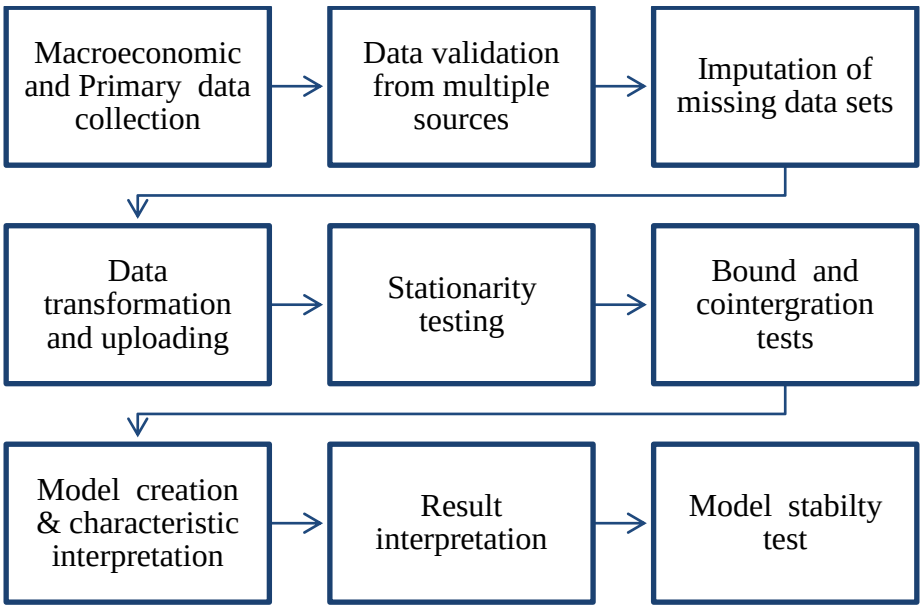


Figure. 3.1 Research Schema

The choice of variables used in this study was based on the Cobb-Douglas model instrumentation using both primary and secondary data sets. Data was obtained from multiple sources, namely; the Uganda Bureau of Statistics for national statistics, Annual statistical abstract publication for the period 2004- 2018, UNESCO statistics for education statistics, ILO for employment. Prior, permission was sought from the UBOS to use the national statistics in this study and was granted. The same applied to the discipline disaggregated data obtained from the annual publication on the state of higher education in Uganda published by the National council and graduation lists from agriculture faculties, Colleges and schools. Below is a description of the variables used in the study.

3.9 Data cleaning

A two-stage process of error detection and repairing was applied. The study took into account the consideration that any missing data in the time series is usually problematic, as some measures cannot be computed. This challenge is made worse with data transformations that are a necessity to stabilise the variance across time as well as simplifying the historical pattern of time series data. As a remedy, a natural log function was used to transform the data for each of the variables and differenced. Each degree of difference reduced the length of a series by the order of one. Taking into account the above concerns, the period for the study was stretched to 1982 as opposed to 2000 as earlier anticipated. Further, using fewer series it was deemed problematic if seasonal differencing was to be considered during further analysis. However, seasonal differences were not considered in this study as all the series was based on annual national account statistical data.

All data were checked for consistency and missing values. Where there were missing data, values were obtained from multiple imputations using the IBM SPSS Statistic Software version 22 and applied the Markov Chain Monte Carlo (MCMC) simulation with nine iterations. The imputation was automatic with no interactions between variables. Imputation, as opposed to other conventional methods such as deletion, is recommended as the most appropriate approach that is factually based on logarithms that minimize bias. The imputation used series data from 1960 to 2018 after which, only the data from 1982- 2018 was extracted and used in this study. Therefore, all

statistical procedures hereafter that had missing values used the data from the 9^{th} iteration for the respective subsequent analysis.

3.10 Time Series characteristics

Theoretically, economic analyses involving time series have a long-run relationship that characterises the inherent feature of time series regression. The underlying assumption is that the series is stationary around a deterministic trend as well as exhibiting a long-run relationship. A non-stationary time series (longitudinal data) is a stochastic process with unit roots or structural breaks. The presence of a unit root implies that a time series under consideration is non-stationary while the absence of it entails that a time series is stationary (Nkoro & Uko, 2016). However, recent advances in econometrics have often observed that this assumption is not valid. See (Fama & French, 2020). Therefore, this demands a need to take into consideration the fact that the series poses trend and structural breaks and the analytical methods used to analyse other types of data may not be appropriate (Jordan & Philips, 2018; Asparouhov & Muthén, 2018).

Further, the data in the series can be related to its previous value. This is true for a set of national macroeconomic data that has a strong increasing or negative trend over time with no propensity to return to a fixed average. This is the autoregressive (AR) characteristic of time series, which indicates that the present value of any variable is determined by its past value. One way of estimating how the current series value is associated with the past is the use of autocorrelation and partial autocorrelation. The key assumption is that the observations made at a previous point in time are useful in predicting the value

at a subsequent set. As practice in growth accounting, using national macroeconomic data the current measures of economic performance are benchmarked on the immediate previous performance. This observation holds for this study as it solely relied on secondary macroeconomic data from national accounts.

3.11 Time series data plot

The first attempt to understand the characteristics of the time series is to draw graphical plots of the data. See (Balcombe *et al*., 2005; Khalil & Dombrecht, 2011; Jordan & Philips, 2018). Macroeconomic time series data and their log functions usually exhibit non-stationary characteristics with a stochastic trend that does not revert to the mean level. Therefore, the objective of this analysis was to assess whether the series had a stable variance and that differencing effectively eliminated trends and seasonality, which are the key characteristics of macro-economic data. Making the series stationary is also critical to obtain meaningful sample statistics such as means, variances, and correlations with other variables. The graphical plots were helpful to identify non-stationary series at first difference which in absence of stationarity at I(0) would have made the ARDL model to collapse.

3.12 Diagnostic Tests

The following diagnostic test was conducted.

3.12.1 Augmented Dicky Fuller test

Whereas there are many approaches to test for unit root depending on the assumption made about the data or the inherent knowledge of the phenomena that one want to test empirically such as Phillips-Perron, and

Kwiatwoski-Phillips-Shmidt-Shin (KPSS). This study used the Augmented Dickey-Fuller test to estimate whether the series is either I(0) or I(1) and no signal series is I(2). The first step in the data handling was to test and specify stationary and order of integrability of the series using Augmented Dick-Fuller Test (ADF). The ADF test requires augmenting with lagged differences of the series and terms specified by deterministic components. In this case, an intercept and time trend were considered. The test was conducted with STATA version 14. The augmented test regression is given as;

$$\Delta u_t = \alpha u_{t-1} + \sum_{j=1}^{p} \delta_j \Delta u_{t-j} + v_t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3.12.1)$$

Where p is a lag length to ensure that v_t is not autocorrelated. In this study, the first lag of the series was the most appropriate for all independent variables after the first difference, based on the modified Akaike Information criterion (MAIC) for selection of optimum lag with a lowest absolute value. The study also took note of the fact that the selection of p affects both the size and power properties of the unit root test. The ADF test involved first differencing of each variable on its first lag lagged difference terms and the specified component of intercept and time trend. This was done to detrend the series. The general inquiry into whether the series is stationary using the ADF test used the following equation to be estimated;

$$\Delta y_t = a_0 + a_t t + a_2 y_{t-1} + \sum_{i=2}^{k} \beta_i \Delta y_{t-i+1} + \varepsilon_t \ldots\ldots\ldots\ldots\ldots\ldots (3.12.2)$$

Where ε_t represents uncorrelated error term having a zero mean and constant variance, k being the optimum lag to ensure that the error term ε_t is not autocorrelated. In this study, the unit root test was conducted for both level and first differenced series to obtain coefficients y (a level form of the

variable) and differenced variable y_{t-1} in the regression. The Hypothesis tested was that the coefficient a is not significantly different from zero. That is, if $H_0: a_2 = 0$, then differenced variable has a unit root and this implied stationarity of the series.

The ADF analysis was conducted using the STATA/MP Version 14 for windows. The analysis used a drift and a single degree of freedom to estimate whether the series had an asymptotic distribution to render the variable normal. The significance of the drift term (constant) was tested at 95% and 99% confidence to ensure that the difference series posed no risk of spurious regression in the long run and that all variables in the model had a standard normal distribution in the long run. The study also acknowledged the counterintuitive notion that the unit root test has little power to discriminate between a unit-root and a near alternative, and that the pure unit-root assumption is often based on convenience rather than strong theoretical or empirical facts. Nevertheless, this is still an empirical debate that is outside the scope of this study.

3.12.2 Data Analysis and Interpretation

The initial step in the analysis involved conducting descriptive statistics for each of the instrumental variables in line with each of the study objectives. To improve variable distribution, reduce data outliers and remove the influence of the unit of account on the estimated coefficient, all variables were transformed to their natural logarithm form. The log transformation helped to convert the exponential growth pattern to a linear growth pattern,

and simultaneously converted the multiplicative (proportional-variance) annual pattern to an additive (constant-variance). Further, the transformation made it easier to estimate the series trend from the logged data than from the original dataset as changes in the natural logarithm are comparable to percentage changes in the original series. The ARDL implementation follows the four-stage process. See (Karaalp-Orhan, 2018; Menegaki, 2019). The first state is the stationarity test to determine unit roots and order of integration. The second step was the tests for cointegration to establish the maximum lag values in each model. The lag values in this study were estimated using Akaike Information Criteria (AIC) and applied to the F and t cointegration test. Based on the evidence of cointegration from both the F and T-test, a long-run relationship among the variables was estimated using the Error Correction Term (ECT) where the information that would be lost through differencing is retained.

3.13 Description of Variables

3.13.1 Gross Fixed Capital formation (K)

Gross fixed capital formation (K) is an integral part of the net spending and investment which includes the acquisition of fixed assets, minus the disposals, plus major improvements and costs of transferring land and other non-productive assets. The values includes the purchase and disposal of fixed assets by resident producers within a certain period of time, and certain increases in the value of non-produced assets made by the production activities of producers or institutional units. The data on the current price of *K* was assumed to be deflated by an appropriate investment

price index. The data was obtained from the world bank's development indicator database.

3.13.2 Labour force (L)

The study defines labour force based on the definition adopted by the 19th International Conference of Labour Statistics (19th ICLS, 2013) as the currently active population, comprising of all person who meet the requirements for inclusion in employment or unemployment. and work for pay or profit. This definition covers people of working age who actively participate in the labour market. The number of the working-age population represents the labour provided for the production of goods and services in exchange for remuneration at a specific time aged 15 year and above. period. Regular. The data was obtained from the International Labour Organization, ILOSTAT database.

3.13.3 Public expenditure on primary, secondary and tertiary level of education

Expenditure on primary, secondary and tertiary education was obtained as percentages of total general government expenditure on education at constant 2010 United States Dollars. These percentage points were applied to compute the actual public expenditure at all levels of education using the annual total government expenditure on education as a denominator. However, bearing in mind that the cost centres in Uganda's public expenditure framework are local, regional and central governments through their annual recurrent expenditure in all sectors, district-specific data was obtained from the Uganda Bureau of Statistics. This approach ensured that all education

investment data at all levels of education was as valid and accurate to the extent possible. It is also critical to note that public expenditure on tertiary education is centralised at the national government level. Therefore, only expenditures at the national level were considered as there were no local government expenditures recorded at this education level.

3.13.4 Agriculture sector output

The agriculture output is defined as output from the sector but explicitly exclude processed outputs. This is because of the integrated production of the agricultural and agribusiness sectors (including food and fiber processors, distributors, and stakeholders in the beverage industry such as wine and beer), all of which are reported as manufacturing in the national accounts. Therefore, this study defines the scope of Agriculture output to comprise actual annual yields primarily from crops and animal production and fish harvesting and other animals from a farm, ranch, or their natural habitats. The data used in this study is the net economic output of the sector. The value was calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The estimates take into consideration the challenge that a large share of agricultural output is not exchanged for money as it consumed at home. Primary data was obtained from the Uganda Bureau of Statistics.

3.13.5 School Enrolment at Primary, Secondary and Tertiary levels of education

The study borrows a classical definition of enrolment as a simple count of students registered at all learning centres, (primary, secondary and

tertiary levels of education) in the country and has access to schooling. The tertiary education in Uganda comprises broad two categories. These are the degree-awarding universities and other tertiary institutions. The latter offer technical courses that lead to the award of diplomas and certificates to qualifying candidates. Due to the liberalisation of the education sector, there are both private universities and other tertiary Institutions. While public universities and other institutions are established by an Act of Parliament. the private universities and other tertiary institutions are chartered, licensed or unlicensed.

3.13.6 Number of Agriculture graduates

The duration of agriculture tertiary courses ranges from two for the diploma course, three to four for other Bachelor course and five years for a Bachelor of Science degree in Veterinary Medicine and Surgery. The number of agriculture graduates at both degree and diploma awarding institution was compiled from multiple sources; namely the graduation list from the year at the Makerere, Gulu and Nkozi Universities, Uganda Council of Higher Education Annual reports. The data was collaborated with the National Council of Higher triennial data sets. It should be noted the data before 1987 was missing and the missing values were thus imputed to get complete data sets stretching back to 1982

3.14 Limitations and Delimitations of the study

Before any form of analysis and descriptive statistical estimation, data for public expenditure on tertiary (*tert*), secondary (*sec*) and primary education (*prim*) levels were not readily available. Instead, these variables were

presented first either as a percentage of GDP and secondly, as a percentage of overall education expenditure. The actual values were, therefore, derived as a percentage of GDP for all public expenditure variables on education. The same approach was also applied to obtain the actual labour force (L) employed in each of the economic sectors; namely, agriculture, industry and service sectors. The allocation of labour across all sectors was similarly presented as a percentage of the total labour force employed under each of the economic sectors. The descriptive statistics ignored the time stamp of the time series data and treated the data as a set of values with Mean, Maximum and Standard Deviation as measures of central tendency. Further, this study did not consider the analysis of the allocation of the resources within the agriculture sector to estimate the sectoral allocative efficiency based on the sector priorities as outlined in their respective Development Strategy and Investment Plans (DSIP). This level of analysis was beyond the scope of this study.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the qualitative results, descriptive statistics, test results of time-series properties and diagnostic tests of the models and findings of the study. The chapter is organised as follows; section 4.1 gives an account of the descriptive statistics using measures of tendency; Section 4.2 provides test results of time-series properties and diagnostic tests, and Section 4.3 presents estimates of the models under each objective and articulates the significant findings with plausible explanations.

Table 4.1 Descriptive Statistics

Variables	**Obs**	**Mean (000)**	**Std.Dev. (000)**	**Min (000)**	**Max (000)**	**Skew.**	**Kurt.**
Public Expenditure on tertiary education	37	56,400	36,800	15,100	178,000	1.18	4.33
Expenditure on secondary Education	37	137,000	90,000	36,900	471,000	1.55	6.14
Expenditure on primary education	37	192,000	132,000	15,900	449,000	0.46	1.83
#Tertiary Students	37	75.5	61.509	7,312	198.95	0.49	(1.24)
#Secondary Students	37	625.95	464.179	117.09	1,457.28	0.57	(1.31)
#Primary Students	37	5,442.42	2,762.353	1,616.79	9,708.67	(0.139)	(1.768)
# Employed in Service Sector	37	2,200	583.000	1,300	3,520	0.47	2.65
# Employed in Agriculture Sector	37	7,140	1,790	4,500	11,400	0.68	2.76
# Employed in industry Sector	37	737	201	388	1,190	0.24	2.54
Agriculture Sector output	37	3,150,000	1,850,000	1,094,000	6,840,000	0.88	2.24
Physical Capital formation	37	2,420,000	2,450,000	166,000,000	7,450,000,000	0.93	2.14
#Students-Agric Forestry &Fisheries		1.439	1,226	94	4910	1.06	0.68

All monetary unit are in US Dollar at 2010 constant price

4.1 Descriptive Statistics

The results of the descriptive statistics are presented in Table 4.1 below.

4.1.1 Overall Public Expenditure on Education

From the descriptive statistics in table 4.1 it is clear that in the last 20 years, (see also appendix 5) education has dominated Uganda's public spending, representing an average of around 18% of state spending. Between fiscal years 1997/98 and 2012/13, expenditures in this sector increased on average 13 times in nominal terms. The increase in the nominal growth rate is attributable to the increase in enrolment, especially in primary education. (UNESCO, 2015). When examining public expenditure in the education sector, it is critical to note that in Uganda, the governance of public sector practices a mix of decentralisation of executive powers to lower governments at the district level. This ranges from devolution, de-concentration, delegation, and fiscal decentralisation. The fiscal decentralisation gives budgeting, spending, and accounting mandates to districts, municipalities and sub-counties hence creating a dichotomy of multiple public sector expenditure avenues in the education sector. It is because of this fact that the study approach combined both district and national public expenditure to arrive at a consolidated resource allocation for the education sector.

The total public expenditure on education ranged between 10-12.5% of the total government expenditure between the period 1999-2018. Under the education sector, public investment was assessed based on the investment made by the national and local governments at primary, secondary and tertiary

education levels. The public expenditure through budgetary allocation to education grew from 9 Million USD to 1.098 Billion USD in 2018. The growth was in tandem with the increase in net enrolment rates at primary, secondary levels of education and the intentional reduction in teacher-student ratio. The latter was to improve the quality of education. The government continues to implement the universal primary education programme that currently stands at 8.4 million pupils' enrolment from 6.5 million in 2000. The following subsections below, provide a summary description of public expenditures under each of the education sub-sector; namely primary, second and tertiary levels.

i. Public expenditure on tertiary education

The descriptive statistics for the public in tertiary education are presented in table 4.1. Public expenditure on the entire tertiary education sub-sector was a paltry 54 million United States Dollars in 1980 with a total enrolment of 13,338 students compared to over 200,000 students enrolled in 2018, with an annual average expenditure of 178 million US dollar at 2010 constant prices. In the 1980s till early 1990, the country had only one public university, Makerere University, though with several vocational institutions offering diploma and certificate courses. Therefore, the computation of public expenditure on tertiary education includes investment costs incurred by the public sector to run post-secondary institutions and not exclusively university level. This conforms with the classical definition of tertiary education that refers to any type of education pursued beyond the high school level. This

comprises all institutions awarding diplomas, undergraduate and graduate certificates, bachelor's, master's, and doctoral degrees.

ii. Public expenditure on Secondary Education

Public expenditure on secondary education increased tremendously between 1982-2018 from USD 60.9 million USD to 291 million. The phenomenal increase after 2007 was attributed to the policy directive that introduced universal secondary education for purposes of increasing access to secondary education for economically vulnerable families and communities as well as increasing transition rates from primary to the secondary level of education. In the study period, the transition from primary to secondary education level was less than 10% on average. In effect, Uganda was the first country in all Sub-Saharan Africa to implement such a policy.

However, the assessment of this policy implementation had mixed outcomes according to some development analysts (Huylebroeck & Titeca, 2015). The impact evaluation conducted on Uganda secondary education established that USE considerably increased public secondary school enrolments especially for girls from poor households though the same study emphasized the need for further improvement in terms of quality of secondary school education (Asankha & Yamano, 2011). There are also concerns that education performance declined after the implementation of the USE policy. The decline was attributed to congested classrooms and reduced teacher compensation as key-elements that negatively affected motivation, and influenced educational performance (Huylebroeck & Titeca, 2015). The same study also established that though the programme was designed within a

framework of co-responsibility of parents, teacher and the public sector, but little attention was paid to realistically improve the education infrastructure and learning environment in response to increasing enrolment rates.

Therefore, the observed increased public expenditure at the secondary education level was mainly allocated to the subsidisation of school fees and not necessarily infrastructural improvement or opening new schools. The expansion of secondary education space was taken up by the private sector following the economic liberalisation policies of a free market. This is confirmed the recent school census the indicated that Uganda has a total of 3,070 secondary schools of which 1592 (51.9%) are USE out of which 690 schools were private USE schools (UBOS, 2017).

iii. Public expenditure Primary education

Primary education has dominated public expenditure in the education sector over the years with a mean annual expenditure of 192 Million USD and a maximum of 449 million USD at 2010 constant prices the budget allocation to primary education has consistently been above 40% the total budget allocation to the education sector. In 1997 the public sector enacted and implemented the Universal Primary Education (UPE). The full implementation of UPE led to the doubling of public expenditure on primary education between 1997, the year of full implementation of the policy and 2000. The government education policy in the 1990s focused on increasing the poor's access to primary education and economic opportunities. (Fan & Zhang, 2008)

This public investment effort led to increased enrolment from slightly over one million to over eight million pupils from between the same period. There is evidence that the expansion of basic education improves social indicators of development and helps reduce spending on public health and social welfare programs, which also proves that the distribution of benefits to the transformation of primary education is reasonable (Varghese, 2009). This public expenditure model was mainly to meet the overwhelming demand for primary education, and the enrolment rate in the 2012/13 fiscal year increased by 110%. Secondly, close to 50% of the current population of Uganda is below the age of 15 years, with a considerable proportion being the primary level of education goers.

With the implementation of UPE, education expenditure increased from 2.1% of GDP in 1995 to 4.8 percent of GDP in 2000, while the education sector's share of the national budget increased from 13.7% in 1990 to 24.7% in 1998. The policy also had ramifications on the Education Sector Investment Plan, that demanded that least 65% of the education budget goes to funding primary education at the expense of other education subsectors and more critically the tertiary education which had a significant reduction in resource allocation with the introduction of the private sponsorship schemes (Bategeka & Okurut, 2006; Datzberger, 2018).

4.1.2 School enrolment

The entire education sector had less than two million learners in 1982 compared to over eight million in 2018. This increase in the number of enrolled students is partly driven by the increase in population coupled with

the astronomical expansion of the tertiary education sub-sector through the opening of more than eight public universities and the mushrooming of private sector-established degree offering institutions following the economic liberalisation of the education sector.

4.1.3 Labour force employment by economic sector

The proportion of people economically engaged in agriculture remained relatively stable and uninterrupted over the study period implying minimal economic structural transformation over time. In nominal terms, the numbers grew from slightly below two million in 1982 to close to 12 million in 2018. Over the same period, all economic sectors namely; agriculture, industry, and service sectors, exhibited a steady upward growth trend that is in accord with the growth in GDP corresponding to the labour force gainfully employed in each of the sectors. However, despite the consistent upward trend on the proportion of labour force engaged in each of the sectors of the economy there is no evidence of a transition from agriculture-based to industry to service or industry sectors as would be expected from a growing and diversifying the economy. Although the agriculture sector contribution to GDP declined from 48% to the current estimated level of 22%; the sector still employs a sizeable proportion of the labour force that is estimated at 70% with over 84% of the youth having their first job in agriculture (Epeju, 2020). The sector has a tremendous potential to spearhead sustainable development and poverty reduction and is a powerful means of reducing inequalities and reversing the growing divide between the rural and urban areas (Sebudde *et al.*, 2011).

The spatial distribution of the labour force in the three sectors has been consistent over time with 70 % of the total labour force is engaged in agriculture, 22% in the service and 8% in the industry sector. The service sector is increasingly becoming a dominant sector and lately employing close to 25% of the total labour force. The labour force engaged in the agriculture sector has been characterised by below-average labour productivity with limited potential for long-term productivity growth. The Industry and manufacturing sector has maintained a 5% employment, though with a real increase in the number of people employed. Over the same time despite enacting and implementing ambitious industrial promotion policies. This implies that any developments in the agriculture sector have the potential of improving the incomes and livelihood of agriculture-dependent employees.

4.1.4 Capital formation

As of 1982 Uganda gross physical capital which is net investment was only 166 million United States Dollars compared to the current 7.45 billion at the 2010 dollar prices. The annual average physical capital formation over the study period was 2.4 billion. Despite this phenomenal growth of 22% on an annual average, it is well below the 25% Barbados Programme of Action BPOA, (1994) recommended growth rate. Despite this lower performance, the growth is in tandem with the economic expansion as measured by GDP. The dismal capital formation may be attributed to allocative issues, such as the choice between current and future consumption. This argument was raised by Bosworth, (1982) in the observed dismal growth of physical capital in the United States. Physical capital formation is instrumental in driving economic

growth by imposing a long-run effect on economic growth. This observation was also made by Jiranyakul, (2014), while examining the determinants of economic growth in Thailand as well as Verma et al., (2007), the role of capital formation in promoting economic growth in Iran. The latter's empirical findings are critical as Iran's turbulent history mirrors that of Uganda with complex and interchanging interrelationships between output, and investment in physical capital formation for the period of the study.

4.1.5 Agriculture Sector Output

The Structure of Uganda's economy has not changed significantly over the study period even though the agriculture sector contribution to GDP declined from 45% to the current level of 21% (Jerven & Jerven, 2011). Uganda was one of the first countries that embraced the basket of market-led economic reforms dubbed the Washington Consensus. The reforms led to the deregulation of all sectors of the economy in pursuit of a "private sector-led economy" paradigm. It still unclear how these reforms have affected the agriculture sector output. The sector had an annual average contribution to GDP of USD 3.15 billion for the period under study. The sector contribution to economic growth cannot be underestimated as the sector has consistently employed close to 70% of the total labour force over the study period (Rogerson & Gollin, 2010; UBOS, 2018). The high proportion of the labour force employed in agriculture makes it a strategic sector through which rural poverty and transformation can effectively be achieved at scale.

According to the World Bank (The World Bank, 2018a), agriculture directly contributes to poverty reduction by lowering real food prices and

increasing real incomes of people who rely on agriculture as their primary source of income. This is critical as poverty remains a critical phenomenon in rural areas where poverty rates are at 34% compared to 14% in urban centres (Niringiye, 2009). The subsistence form of agriculture is still predominantly practised by 63% of agricultural dependent rural households leading to low productivity and earnings in the sector. Agriculture still commands a significant contribution to economic output though at a declining rate with an annual growth rate of 3.7%. The dismal growth in the sector has been attributed to institutional constraints with far-wide recommendations ranging from reforming the land tenure system to the architecture of the Ministry of Agriculture, Animal Industry and Fisheries (Bategeka *et al*., 2013). The on-going political interference in the sector has curtailed the delivery of the much-needed rural extension services (Afranaakwapong & Nkonya, 2015).

The NAADS programme which was a client demand-driven extension service delivery programme only targeted 'elite" farmers with the capacity to evolve into commercial farmers (Fan & Zhang, 2008). It is not surprising that though the programme had its successes, it only reached a few target farmers (Bahiigwa *et al*., 2005). Datzberger, (2018) also observed that apparently the NAADS programme did not at all involve young people engaged in agricultural activities. Further, the findings from the study on the trust and effectiveness of the NAADs programme showed that trust was the starting point to explain farmers' behaviour towards the effectiveness of extension service delivery programmes (Turyahikayo & Kamagara, 2016). This suggests the need to re-evaluate the current political support given to agriculture to

ensure that it builds on the achievement of NAADS and addresses its weaknesses. The current military-civil operation wealth creation that was ostensibly created, though without an enabling policy environment was intended to address some of the above challenges.

4.2 Diagnostic Tests

The results of the preliminary diagnostic test are presented in the subsection below;

4.2.1 Time series plots

The natural log differences of all variables used in the study are shown in the figures 4.2.1, 4.2.2, 4.2.3, 4.2.4, 4.2.5, 4.2.6 4.2.7, 4.2.8, 4.2.9 and 4.2.10 below. The graphical plots reveal that after first differencing all series did not exhibit a deterministic trend or stochastic trends. Identifying a trend in a time series is often a subjective process (Nkoro & Uko, 2016). Therefore, the graphical line plots provide a quick inspection for obvious trends in the data.

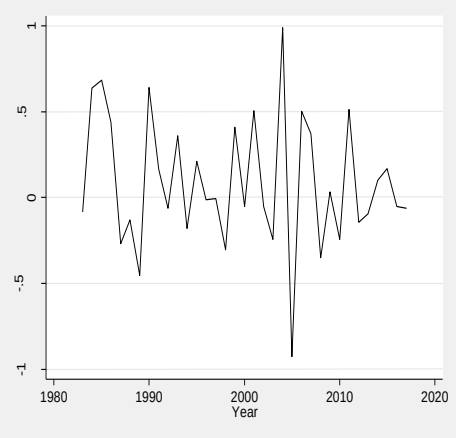


Fig 4.2.1 Plot of Nat.log Primary

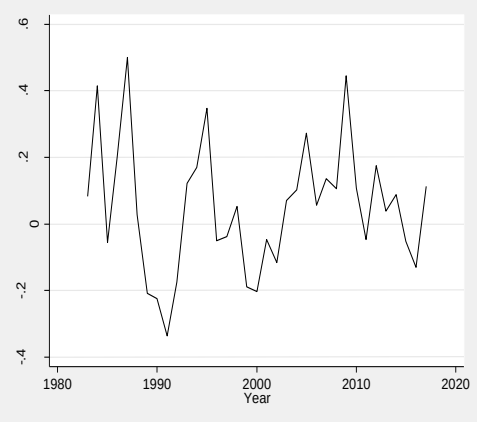


Fig 4.2.2 Plot of Nat.log Agriculture sector output

Fig 4.2.3 Plot of Nat.log Secondary education expenditure

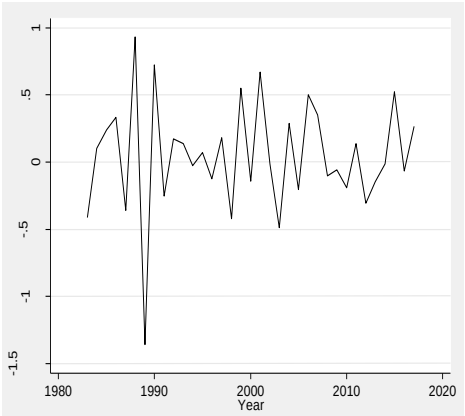


Fig 4.2.4 Plot of Nat.log Tertiary education expenditure

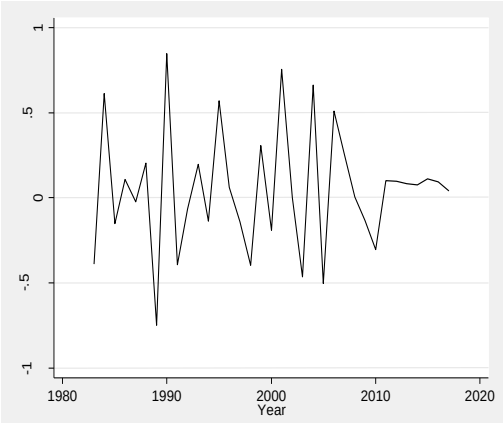


Fig 4.2.5 Plot of Nat.log Physical Capital formation

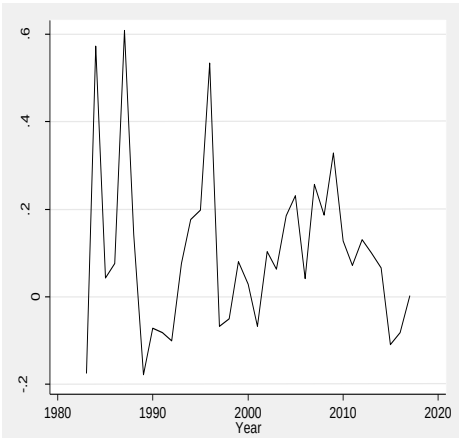


Fig 4.2.6 Plot of Nat.log Labour

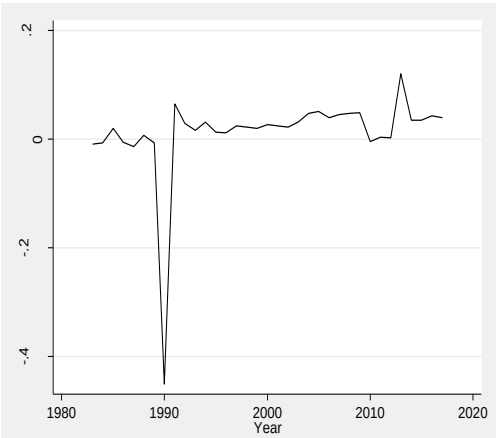


Fig 4.2.7 Plot of Nat.log Primary students' enrolment

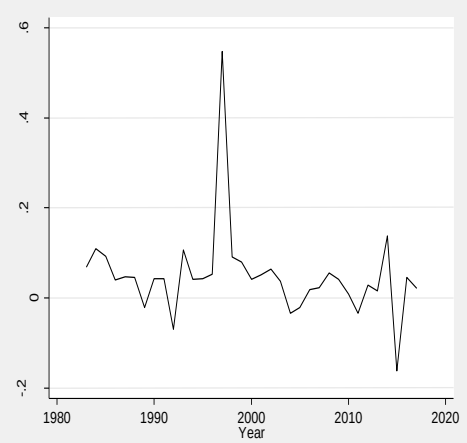
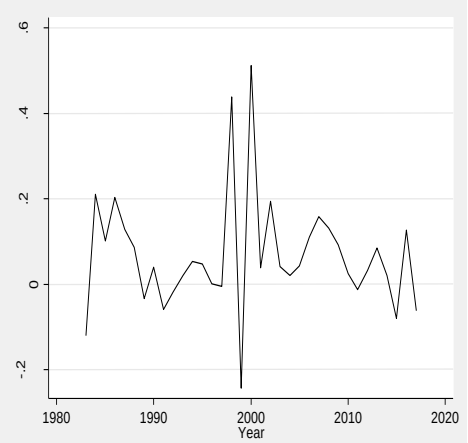


Fig 4.2.8 Plot of Nat.log Secondary Students' enrolment



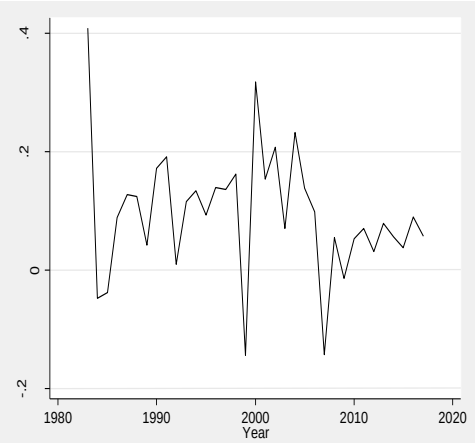


Fig 4.2.9 Plot of Nat.log Tertiary Students' enrolment

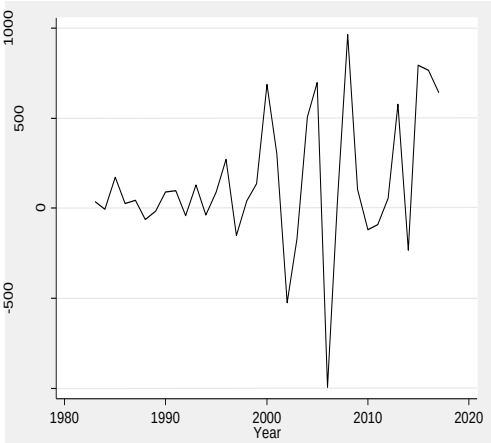


Fig 4.2.10 Plot of Nat.log Agriculture graduates

4.2.2 Testing of Unit Root

Whereas the unit root test is not a requirement when using ARDL modelling, it was necessary to establish the order of integration. As discussed in Chapter 3, the presence of 1(2), will lead to the collapse of the ARDL model. The presence of variables fractionally or wholly I (2) would have made the ARDL model fail structurally with regression analysis yielding a

reasonably higher R^2 value indicating that the model fits perfectly well which may not be the case.

The results of the unit root tests of all study variables are presented in Table 4.2 below. The critical threshold value was set at 5% test with a null hypothesis (H_0) stipulating that the variables were stationary in their level form, while the alternative hypothesis (H_1) stipulates that the variables are not stationary at level but they become stationary after differencing. The unit root test was conducted using the Augmented Dickey-Fuller unit root test methodology. The test was conducted with the drift and regress term with no lag difference. The purpose was to establish whether all variables were integrated in the order I (0) or I (1) and none I (2). However, when using ARDL modelling, the testing of a unit root is not a requirement. See the arguments advanced by Kripfganz & Schneider, (2018) and Nkoro & Uko, (2016). The only requirement for the unit root test is to concretely confirm that there is no single variable fractionally or wholly integrated in the order I (2), i. e. integration of the first order, at conventional significance levels, the estimated test statistics are shown to be less than the critical values in absolute terms, hence, the null hypothesis that each variable is intergrated in I(1) cannot be rejected.

The results indicate that the natural logs of the variables were not stationary at level apart from public investment in education (*prim*) which was stationary at I(0). Therefore, the null hypothesis was rejected on this account as the series were stationary at 1(0) after first differencing for the remaining variables. The results also show that the remaining dependent variables were

not stationary in their natural logarithm or at their level form. However, after the first differencing all the variables attained stationarity with t-statistic value significant at 0.01. An indication that the series was integrated with I (1) and none were of order I(2). These findings made the ARDL approach appropriate as it would not apply to variables which become stationary at second differencing and or interrogated in the order I(2). Consequently, the null hypothesis was rejected on the account of the presence of unit root in the variables after first differencing and not in their level form.

Table 4.2 Results for Unit root test

Variable	**Stationarity level I(0)**			**Stationarity at first difference I(1)**		
	t-stat	**Critical value 5%**	**P Value Z (t)**	**t-stat**	**Critical value 5%**	**P Value Z (t)**
Primary Education	-4.537**	-3.564	0.001	-5.435**	-3.568	0.0000
Secondary Education	-3.564	-2.884	0.057	-5.101**	-3.568	0.0000
Tertiary Education	-3.367	-3.367	0.0560	-5.962**	-3.568	0.0000
#Primary Students	-1.133	-3.564	0.9233	-3.591*	-3.568	0.0306
#Secondary Students	-1.176	-3.564	0.9152	-3.315	-3.568	0.0638
#Tertiary Students	-0.811	-3.564	0.9648	-4.141*	-3.568	0.0055
#Students Agric	-1.465	-3.564	0.8409	-6.760**	-3.568	0.0000
Labour force (L)	0.035	-1.691	0.5139	-5.468**	-1.692	0.0000
Physical Capital (K)	-0.990	-1.691	0.1645	-5.597**	-1.692	0.000
Output Agri)	-1.053	-2.969	0.7334	-4.043	-2.972	0.0012

*The * and ** denote rejection of the null hypothesis at 5% and 1% respectively. All variables were converted to natural logs*

4.3.1 Objective 1. Estimate the effect of public education expenditure on education on agriculture sector output

i. Bound tests lnagricout, lnPrim, lnSec, lnTert, lnK, lnL

Before estimating the effect of public education expenditure on agriculture sector output, a bound test was conducted using the approaches detailed in Chapter 3 to ascertain whether, in this model, there are both short and long- term relationships among the variables. The bound test applied both F and t statistics. The results of these estimates are presented in Table 4.3 below. The estimates reveal that the F-statistic of 2.309 was lower than the critical value of all 1(0) regressors of 2.62 and 3.41, respectively. Similarly, the F statistic was less than the I(1) regressors at both 5% and 1% level of significance. Similarly, the t-test statistic also estimated that the critical value was less than 1(1) regressors and greater than I(0) regressors at both 5 % and 1% significance level. This implies that the series are not cointegrated and as such, they do not exhibit long-run relationships. Therefore, accepting the H_0 hypothesis that postulates a no level relationship among the variables and hence justifying the application of the ARDL model. Hence Equation 3.6.3 was used for the estimates.

The model was further subjected to Breusch-Godfrey LM test for autocorrelation that confirmed the presence of serial correlation in its structure that was significant at 1%, though with a much smaller chi-squared value of 6.635. The presence of serial correlation was further confirmed by the Durbin Watson statistic of 2.653 that was higher than 1.35 and 1.05 critical values at 5% and 1% level of significance, respectively. However, as discussed earlier,

serial correlation is not an issue of concern when using ARDL modelling. The test for a linear form of heteroscedasticity was done using Cameron & Trivedi's decomposition of IM-test for unrestricted heteroskedasticity. The heteroscedasticity test had *p* values of 0.4180 that was not significant at all levels and therefore, accepting the null hypothesis that the model was homoscedastic.

Table 4.3 Bound test lnagricout, lnPrim, lnSec, lnTert, lnK, lnL

Bound test	**Level 0.05**		**Level 0.01**	
	1(0)	**I(1)**	**1(0)**	**I(1)**
F stat (2.309)	2.62	3.79	3.41	4.68
Breusch-Godfrey LM test				
Chi Squared		6.635 (0.01)		
Cameron & Trivedi's decomposition				
		Chi Square	P	
Heteroskedasticity		33.00	0.4180	
Skewness		10.77	0.9672	
Kurtosis		3.87	0.0492	

ii. Estimates of the effect of public expenditure on education on Agriculture sector output

The ARDL model for estimating the effects of public investment in education on agriculture sector output had a lag structure of (4,4,0,2,3,3) as shown in Table 4.4 below. The results indicate that a percentage point increase in the level form of the independent variables did not have any significant effect of the agriculture sector output. In the lagged form, the key determinants of agriculture sector growth were public expenditure on primary and tertiary education. A unit increase in primary and tertiary expenditure has a positive effect of 0.9% and 0.5% respectively, and this effect was significant at 1% holding other factors constant. Under primary education, a unit increase in

public expenditure leads to 0.904% increase in agriculture sector output after one year holding other factors constant and this increment was significant at a 1% confidence interval.

Table 4.4 ARDL Estimates of the effect of public expenditure on education on Agriculture sector output

Dependent variable	**ARDL (4,4,0,2,3,3) regression**			
Agric Sector output	**Coef.**	**Std.Err.**	**t**	**P>t**
lnAgricoutput (-1)	0.679**	0.273	2.480	0.030
lnPrim				
lnPrim (-1)	0.904***	0.208	4.350	0.001
lnTert				
lnTert (-1)	-0.746***	0.204	-3.670	0.004
lnTert (-2)	0.502***	0.159	3.160	0.009
lnK				
lnK (0)	0.648**	0.300	2.160	0.054
lnK (-1)	-0.719**	0.273	-2.630	0.023
lnK (-3)	-0.559*	0.280	-2.000	0.071
lnL				
lnL (-2)	0.805***	0.515	3.500	0.005
lnL (-3)	-0.818**	0.310	-2.640	0.023
_cons	-9.996*	5.297	-1.890	0.086
Prob > F	0.00			
R-squared	0.99			
Adj R-squared	0.96			
Log likelihood	46.65			
Root MSE	0.1019			

After two and three years, the returns to public investment in primary education declines and in the fourth year affects the sector output is negatively impacted, though with no statistical significance. Similarly, the effect of public investment in secondary education on agriculture output though positive, did not affect the agriculture sector output in statistically significant terms keeping other factors constant. While the effect of public expenditure on tertiary education on agriculture sector output showed mixed results. For instance, in the first year, there are no noticeable effects on the sector output. However, after one year, an increase in public expenditure on tertiary

education leads to a reduction of 0.7% in the sector output and this effect was significant at 1% confidence interval. After two years, doubling public expenditure on tertiary education leads to the growth of the sector by a margin of 0.5% and the effect is significant at 1% level of significance, holding other factors constant.

Overall, public expenditure on education has a net positive effect on agriculture sector output. These findings conform with similar studies conducted elsewhere on the causality between economic growth, human capital, and agriculture sector expansion. See; Bashir *et al*., (2018) for Indonesia, Christiaensen *et al*., (2011) in low-income Sub-Saharan Africa countries; Nchuchuwe & Adejuwon, (2012) in Nigeria, and Diao, (2010) for the case of Ghana. Education has been shown to have a positive impact on agricultural output by empowering farmers to adopt new productivity-enhancing technologies. Fan & Zhang, (2008), while investigating public expenditure and poverty reduction in rural Uganda, observed that whereas public expenditure on agriculture research and development was a key driver to rural poverty reduction, public expenditure on education effects ranked second. Grimaccia & Lima, (2013), while investigating the causal relationship between employment rates and public expenditure in education in selected countries in Europe.

The plausible explanation for the positive effect of public expenditure on education on agriculture sector output could be attributed to the fact that an educated farmer is more likely to adopt new and efficient means of production to maximise returns on investment consequently improve

the rural well-being and status (Nchuchuwe & Adejuwon, 2012). Communities with higher rates of adoption of improved agricultural technologies, and thus higher crop yields, benefit from lower food prices, higher real wages, and higher welfare indicators. See (Minten & Barrett, 2008) (Mwangi & Kariuki, 2015). According to the findings of the study on the determinants of farmer adoption of soil fertility management practices, increasing literacy level aided farmers in acquiring new knowledge and calculating appropriate input quantities in a rapidly changing environment (Aura, 2016). Similar observations were made by Freeman & Qin, (2020) while understudying the process of innovation diffusion the individual, social network, and community levels in selected district in Uganda.

Earlier on, Appleton & Balihuta, (1996), while investigating the education and agriculture productivity nexus in Uganda, observed that primary schooling of neighbouring farmworkers raised agriculture production. The underlying argument was that education complements capital and substitutes for labour. Agriculture productivity increases arise through education increasing physical capital and purchased inputs. Similar evidence was also observed elsewhere. Alene & Manyong, (2007) observed that only four years of education among rural households in Nigeria raised cowpea production under improved technology by 25.6% and concluded that education has a higher payoff. Similarly, Bezu, *et al*., (2013) while investigating determinants of maize variety adoption in Malawi using a correlated random effects model found that the likelihood of adoption was significantly correlated with the education of the household head among other determinants.

It is believed that with the rapid advancement of information and communication technology and the decline in prices, farmers in the future will need to receive a solid basic education to support adoption of new technology so that they can meaningfully participate in the new global information system of the 21st century, and recent evidence supports this argument (Huffman, 2002). For instance, in Uganda, the use of cell phones has been instrumental in promoting innovation at both the individual farmer and society levels. See (Freeman & Qin, 2020). Luh, (2017) using the switching regression model to examine the role of education on agriculture productivity in South East Asian countries, observed that for economies where agricultural productivity exhibits obvious improvements throughout the entire period, education is one of the main determinants of this productivity changes. This result confirms the long-held view that countries in sub-Saharan Africa to effectively diversify their economies, improve productivity and build value chains for agriculture will require significant investment in human capital (Darvas *et al*., 2017; Hanushek & Wößmann, 2007; Idrees & Siddiqi, 2013). Hanjra, *et al*., (2000) also acknowledges that physical, economic, social, biological, or climatic disfavour the poor and the lack of education reinforce conditions that perpetuate poverty traps.

In respect to physical capital accumulation, a unit increase leads to an increase of 0.648% in agriculture sector output, which estimates are significant at a 95% confidence interval. As mentioned above, this is attributable to the flow of investment in physical capital stock, including the improvement of agricultural production equipment, structure, inventory, and land by increasing

production efficiency (Abdih & Joutz, 2005). Investments in physical capital and capacity building have been considered as the two main cornerstones of a place-based approach to rural development. Physical capital reduces costs for economic agents to access urban markets leading to higher technical knowledge and the elimination of diminishing returns (Zasada *et al.*, 2015). At a national scale, Blundell *et al.*, (1999), concluded that accumulation of physical capital is a principal factor in national economic growth.

Physical capital complemented by human capital investments can be viewed as an indirect contribution of education to macroeconomic growth. Baier *et al*., (2006) made similar conclusions on the complementarity of human and physical capital while investigating the relative importance of the growth of physical and human capital on total factor productivity (TFP) using data from 145 countries that spans more than 100 years. It can as well be concluded that physical capital accumulation resulting from infrastructure facilities like irrigation, electricity, roads lead to increased sector output, and this creates the rationale for such investment to spur rural growth. See (Opeyemi *et al*., 2017). While estimating the effect of the labour force on agriculture sector output, the study did not apply concepts of labour productivity, which estimate the efficiency of resource use as well as cross-sectoral mobility. The empirical estimate reveals that in the first two years, any increase in labour has a negative effect on agriculture sector output though not significant. However, after a lag period of two years, a percentage increase in labour leads to a 0.18% increase in agriculture sector output holding other

factors constant, and these effects are significant at 5% level. While in the later years the effect is negative.

Whereas agriculture indeed employs close to 70% of the labour force, most of this labour force is unskilled, produce at subsistence scale and have low marginal productivity. As such, the agriculture sector seems to benefit less from school enrolment (Psacharopoulos & Patrinos, 2018). Grant, (2017), reinforces the argument that forcing the under-skilled segment of the population into the labour market is a no-win situation, as they will remain doomed to a subsistence existence based on vulnerable employment, and the economy will gain little in terms of increasing its labour productivity potential. de Pleijt & Weisdorf, 2017) on close inspection of the occupational structures and labour mobility observed that there was deskilling the agriculture, prompted by land concentration in agriculture and workshop-to- factory changes in the industry. This transitions could be happening since Uganda is still an emerging economy.

iii. Robustness test of the model

The test results are shown in the figure below. The result indicated the model was structurally stable as shown by the cumulative sum of recursive residuals with most of the data points lying within the confidence interval limits at 5% threshold hence showing no evidence of the ECM's instability.

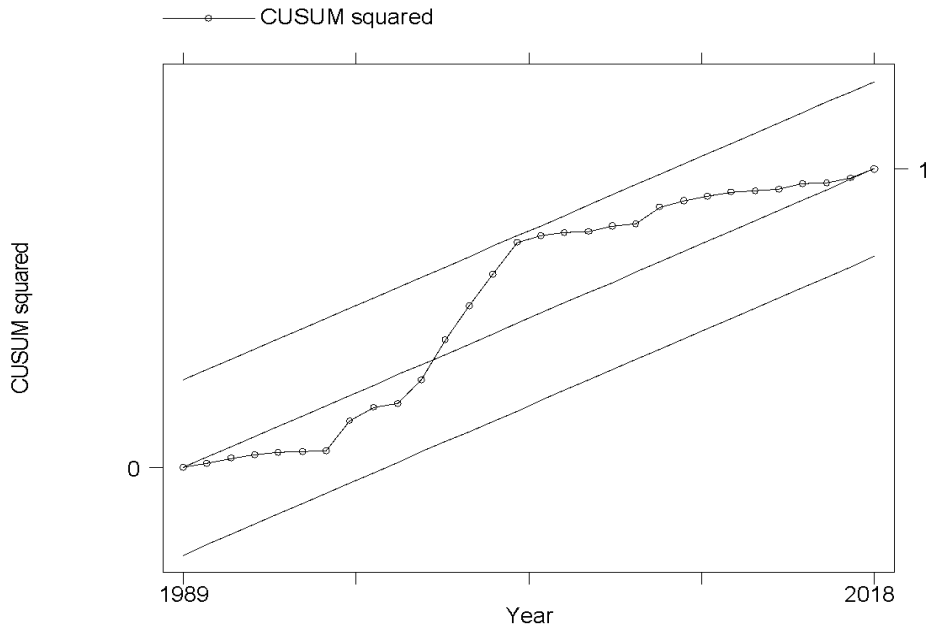


Figure 4.7. CUSUMSG test for lnagricout, lnPrim, lnSec lnTert lnK lnL cs(cusum) uw(upper

4.3.2 Objective two. Estimate the effects of school enrolment on Agriculture sector output

i. Bound test lnAgricout, lnK, lnL, school enrolment

The bound test for the model was premised on two hypotheses. The null hypotheses denoted as H_0, postulating that there is no cointegration among the variables and the alternative ($H_{1)}$ postulating cointegration. The presence of cointegration indicates the existence of a long-run relationship, that the series are related and can be combined linearly with the anticipation that any shock in a short run that may affect the movement of the individual series would converge in long-run. The results of the bound test for cointegration are shown in table 4.5 below.

Table 4.5 Bound test for cointegration

	Level 5%		**Level 1%**	
	I(0)	**1(1)**	**I(0)**	**1(1)**
F-statistic 11.635	2.62	3.79	3.41	4.68

The bound test result as shown in the table above indicates that the F-statistic is greater than the critical values of the upper bound I(1) at both 5% and 1% levels of significance. This implies that the variables in the model are cointegrated and have a long-run relationship. It is on this account that H_0 is rejected and model transformed into an error correction model (ECM) hence estimating both the short and long-run coefficients. Hence equation 3.7.6 was applied in the analysis.

ii. Short and long-run estimates on the effect of school enrolment on Agriculture sector output

The result for short-run estimates on the effect of school enrolment on agriculture sector output is shown in table 4.6, below. Overall school enrolment consistently presents negative effect on agriculture sector output that that was significant at 5% after a lag period of three years with a percentage point increase in the overall school enrolment, leading to a 1.4% decrease in the sector output. At the respective level of schooling, primary enrolment had similarly, a negative effect on agriculture sector output holding other factors constant. At the secondary level of education, there are mixed effects. During the first year, there are positive but not significant effects of secondary school enrolment on the sector output. However, after a lag period of one year, a doubling in secondary school enrolment leads to 1.24% increase in agriculture sector output and this effect is significant at 5% holding other

factors constant. On the contrary, after a two-year lag period, a percentage increase in secondary school enrolment leads to almost 2% reduction in the sector output which effect is significant at 1% confidence interval holding other factors constant. Similar observations were equally made for enrolment at tertiary level of education with negative effects that indicate a doubling in tertiary education enrolment leads to a significant reduction in the output of the sector ranging between 1% -1.4 % and these effects become more significant with increment in the lag periods.

Even though Uganda labour mobility is less 30% by the recent OECD estimates indicating lack of perfectly competitive market, these disparities can be attributed to labour mobility within the different sectors of the economy, with the more educated workforce moving to service and industry sectors (AUC/OECD, 2019). There is evidence to this argument based on the educational attainment of people employed in each of the economic sectors which shows that service industry is hiring more skilled workers and therefore more educated (UBOS, 2018). Whereas, (Hayman, 2005) also observed that low educational achievement is closely associated with poverty levels in Rwanda, empirical evidence about education enrolment and poverty reduction was weak. The findings also noted that only secondary education had a real effect which findings are in tandem with the short-run effects.

Table 4.6 Short-run estimates on the effect of school enrolment on Agriculture sector output

	Dependent variable : Agriculture output (4,1,4,4,4,4 regression)			
Regressors	**Coef.**	**Std.Err.**	**t**	**P>t**
Δ.lnAgricOut	-1.04	0.64	-1.61	0.17
Δ.lnAgricOut (-2)	-0.38	0.32	-1.19	0.29
Δ.lnAgricOut (-3)	-1.43*	0.42	-3.36	0.02
#Students Primary				
Δ. lnPrimEn (-1).	-1.10*	0.38	-2.92	0.03
#Students Secondary				
Δ. lnSecEn	0.32	0.59	0.53	0.62
Δ. lnSecEn (-1)	1.24*	0.56	2.20	0.08
Δ. lnSecEn(-2)	-1.85**	0.51	-3.67	0.01
Δ. lnSecEn (-3)	-0.16	0.21	-0.73	0.50
#Students Tertiary				
Δ. lnTertEn (-1)	0.07	0.34	0.20	0.85
Δ. lnTertEn	-1.05*	0.42	-2.49	0.06
Δ. LnTertEn (-2)	1.41*	0.46	3.09	0.03
Δ. lnTertEn (-3)	-1.40**	0.29	-4.87	0.01
Physical Capital formation				
Δ. lnK (-1)	-0.56	0.83	-0.67	0.53
Δ. lnK	0.84	0.63	1.34	0.24
Δ. lnK (-2)	1.08*	0.43	2.51	0.05
Δ. lnK (-3)	0.29	0.28	1.04	0.35
Labour				
Δ. lnL (-1).	-3.70**	0.80	-4.63	0.01
Δ. lnK	-2.39*	0.71	-3.39	0.02
Δ. lnK (-2)	0.38	0.42	0.91	0.40
Δ. lnK (-3)	1.02*	0.33	3.10	0.03
cons	-9.21	6.82	-1.35	0.24
R-squared	0.98			
Adj R-squared	0.90			
Log likelihood	74.40			
Root MSE	0.06			

The estimates for the long-run effects of school enrolment on sector output are shown in Table 4.7 below. The long-run coefficients are similarly negative indicating that a percentage increase in school enrolment at primary, secondary and tertiary levels of education lead to a reduction in agriculture sector output by magnitudes of 0.07%, 0.7% and 0.4% respectively. Further, at

both secondary and tertiary enrolment, these effects are significant at 1% and 5%, respectively.

Table 4.7 Long-run estimates on the effect of school enrolment on Agriculture sector output

	Dependent variable : Agriculture output (4,1,4,4,4,4 regression)			
Regressor	**Coef.**	**Std.Err**	**t**	**P>t**
Adjusted lnAgricOut (-1)	-2.55*	0.73	-3.50	0.02
Long-run effects				
lnPrimEn	-0.07	0.17	-0.42	0.69
lnSecEn	-0.66**	0.12	-5.30	0.00
lnTertEn	-0.35*	0.11	-3.10	0.03
lnK	1.06**	0.07	15.71	0.00
lnL	1.05**	0.20	5.33	0.00
cons	-9.21	6.82	-1.35	0.24
R-squared	0.98			
Adj R-squared	0.90			
Log likelihood	74.40			
Root MSE	0.06			

There is a long-run negative effect of school enrolment on the agriculture sector output are in stark contrast with the earlier observation that overall, public expenditure on education which in effect implies increased enrolment, has a net positive effect on agriculture sector output (Owuor *et al*., 2020). This negative aspect of the short-run effects on agriculture sector output could be attributed to the fact that school enrolment draws away available labour resource from the sector for the duration of one's schooling life. Earlier, Okidi & Mugambe, (2002), pointed out that despite the introduction of universal primary education that significantly increased primary school level enrolment, the living standards of the rural poorest comprised of 20% of the population did not significantly improve. Similar

observations were re-echoed by (Bahiigwa *et al*., 2005; Datzberger, 2018; Fan & Zhang, 2008).

Similarly, Datzberger, (2018) in the quest why education is not helping the poor in Uganda, observed that whereas significant investments and policy reforms in education subsector were made, these did not translate into the expected results with regards to poverty reduction through human capital investment. The most striking observation was that poverty alleviation did not only remain stagnant but the role of education was at best described as 'modest'. The poverty perspective is critical as the majority of the poor live in the rural area and are dependent on agriculture for survival (UBOS, 2018). Asadullah *et al*., (2018) argue that general education alone will not solve the problem of poverty and economic well-being.

It can as well be postulated that the negative effect of school enrolment is because individuals with decent literacy and numeracy skills are more likely to be hired out of the rural setting and migrate to an urban setting where they become consumers and not producers. Opeyemi *et al*., (2017), using an endogenous growth model, observed that human capital development through increased enrolment did not cause productivity growth. It is also probable that there exists a threshold at which school enrolment can have a positive effect on agriculture sector output making the study inconclusive. Indeed, Bhattarai & Shrestha, (2017), made similar and inconclusive econometric observations on the unexpected direction of agriculture output decline with the increase in school enrolment.

Luh, (2017), notes that whereas education is a primary determinant of productivity growth in both technological advancement and/or stagnation/recession regimes; however, the impact of agricultural productivity varies from economy to economy and regime to regime. Gebrehiwot, (2015), also observed negative coefficients for school enrolment and made a recommendation at the policy level advocating for significant improvements in institutional capacity and infrastructure development that increase the impact of education sub-sector outcomes.

The negative effect in the long-run can also be attributed to the long duration of schooling and the mobility of skilled and qualified labour from the agriculture sector to more rewarding and skills intensive service and industry sectors which are proven to have large employment multiplier effect determined by the higher meaningful labour absorption rate as compared to the agriculture sector. See (Mardalena *et al.,* 2019). The very nature of Uganda's agriculture system dominated by agrarian rural smallholders attracts low quality and inefficient human resource that are necessary not schooled demanding that necessary organizational and socio-economic measures are put in place to enhance the prestige of agricultural labour (Bazylevych *et al*., 2016).

On the contrary, both physical capital formation (*K*) and labour force (*L*) had a very significant effect on sector output. A percentage increase in each of these variables increases agriculture sector output by a magnitude of 1.05%. The gain can be attributed to increased efficiency emanating from improved labour productivity and use of capital intensive technology that

improves allocative efficiency causing a shift in the production frontier (Singh & Sharma, 2004). Anik et al., (2017), while examining the agricultural productivity growth and the role of capital in South Asia, observed that the key drivers of growth were natural, human and technology capital endowments and made a raft of recommendations which included improvement in natural capital and investments in education to improve human capital.

4.3.3 Objective three. Estimate the effects of agriculture graduates on agriculture sector output

i. Bound test lnAgricout, lnK, lnL, lnAgrgrad

As discusses in section 4.3.2.1, similarly, the bound test cointegration was estimated using two hypotheses. The H_0 postulating a no cointegration and the alternative, H_1- rejecting the null hypothesis. The objective was to establish if there was a long-run relationship between the variable. The results of the bound test are shown in table 4.7 below.

4.8 Bound test for cointegration

	Level 0.05		Level 0.01	
	I(0)	1(1)	I(0)	1(1)
F-statistic 12.527	3.2.3	4.35	4.29	5.61

The results indicate that the F-statistic is greater than the critical values of the upper bound I(1) at all levels of significance i.e. 1% and 5%. This, therefore, implies that the variables in the model are cointegrated and have both short and long-run relationship. It is on this account that H_0 is rejected and model transformed into an error correction model (ECM) to estimate both

the short and long-run coefficients of the regressors. On this account, equation 3.7.8 was applied. The model was further tested for serial correlation. The test results reveal 0.740 Chi square value with a probability of 0.389 indicating that there was no serial correlation among the instrumentation variables. Similarly, a white test for heteroskedasticity had a chi-square value of 33.00 and 0.418 probability indicating that the model was homoscedastic.

ii. Long-run estimates on the effect of Agriculture graduate on Agriculture sector output

The ECM for the long-run effect indicates that increasing both physical capital and labour had a positive significant effect on agriculture sector output while an increase in the number of agriculture graduates had a negative but significant effect, holding other factors constant. The long-run a percentage increase in the number of students offering agriculture-related courses leads to almost 2% contraction in agriculture output. Gollin *et al.*, (2012) using similar national accounts data observed that the value-added per worker is much lower in the agriculture sector that other sectors of the economy and more particularly in developing countries due to grave misallocations. With the postulated outward mobility of skilled graduates, there could be an on-going "deskilling" in Uganda's agriculture sector hence leading to a contraction in sector output despite concerted efforts to train more students in agriculture-related courses. This "deskilling hypothesis" was first postulated by de Pleijt & Weisdorf, (2017). The deskilling effect in the sector is caused by labour transitions and mobility out of the sector.

There is also additional evidence that skilled human resource is more efficient outside the agriculture sector. Dimelis & Papaioannou, (2014) while examining the effect of human capital on economic sector technical efficiency using a stochastic production frontier model observed that the highest contribution of human capital was in the service sector in a three-tier economy. Similarly, Alston *et al*.,(2010) while examining the shifting trends in global agriculture productivity observed that whereas agriculture labour productivity has grown four folds in developed countries, in Africa, it has dismally increased by less than 20% over 100 years. Earlier, Makki, (1999) observed that estimates of long-run rates of return to education and public research were much lower but justified public investments to raise short-run agricultural productivity.

The negative effect could also be could attributed to the outward mobility of skilled labour from the agriculture sector to service and industry sectors, and there is evidence to this effect. Nchuchuwe & Adejuwon, (2012) observed that the ongoing neglect of Africa's agriculture sector that is largely concentrated in the hands of smallholders and pastoralists has both qualitatively and quantitatively depleted rural areas and progressively made them less attractive for socio-economic investment. Therefore, the mobility of skilled human resource out of the sector deprives producers (farmers) of the tactical skills, knowledge, strategic and relational assistance hence limiting their competitiveness. And at an aggregate level, this considerably affects the sector output. See; (Von Brockdorff & Amaira, 2017; Thomas, 2018).

Further, outward mobility could be attributed to stronger growth in labour productivity outside the agriculture sector that has contained the growth in labour costs hence depriving decent wages for those primarily engaged in agriculture production with catastrophic consequences (Jacobs & Rush, 2015). For Uganda, this outlook is a cause to worry. The notable example is Russia. The post-communist Russia went through slowed rural economic growth as a result of contraction of the rural labour force, a shortage of skilled workers, and migratory outflow of the rural young to urban centres, see Wegren, (2014). This could be a pointer that despite the increase in investments in education, enrolment and graduate output, the performance of the agriculture sector is still dismal. It is based on these realities that Singh & Sharma, (2004) strongly recommends that there is need to keep a proper balance between demand and supply of man-power into the labour market.

However, in the short-run, there is a positive effect of training agriculture graduates on the sector output and these were significant at 1% confidence interval holding other factors constant. Doubling the number of agriculture graduate's increases agriculture sector output after a one-year lag period by 1.1% at 1% significant levels, holding other factors constant. In the subsequent phases, the increase drops to 0.64% holding other factors constant. These findings consolidate the empirically proven narrative that investing in agriculture higher education is critical for the transformation of the sector. See (Kotrlik, *et al.,* 2002; Anandajayasekeram, 2011; Sawyerr, 2007; Juma, 2012). Research has shown that increasing stock of the population with higher education, increases the prospects for the country's economic growth. See

(Pillay, 2011; Asadullah & Zafar Ullah, 2018). Graduates emerging from universities bring along other components of human capital, the specific capacity to disseminate innovative knowledge at the workplace in local firms and organizations (Vila, 2019). According to Albers, (2013), the effect of agriculture graduates on the sector growth is determined by both the quality knowledge and quantity of knowledge providers as estimates from the impact of German Agricultural winter schools on the sector. Bashir *et al*., (2018). Earlier in the 21st Century, Liu & Jiang, (2001) in a conceptual framework highlighted the effectiveness of technology transfer from agriculture higher education system and its strategic implication to strengthen the agri-food system.

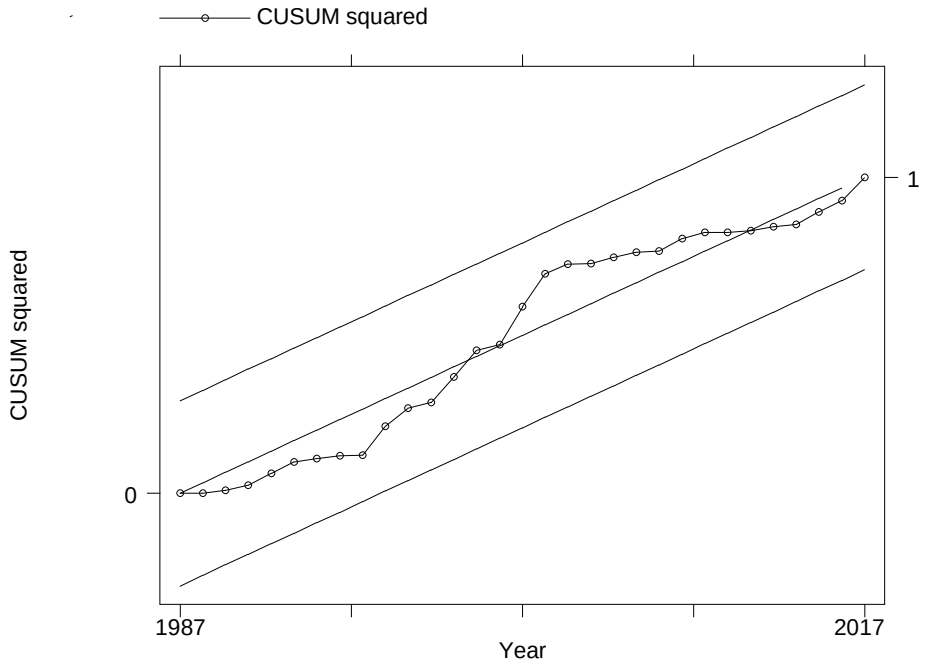
Lin, (2004), while estimated the impact of higher education in Taiwan where it was proven that higher education had a beneficial and considerable impact on the country's economic development, with engineering and natural science major graduates playing the most important role in this process. Similarly, (Sieng & Yussof, 2014) observed long-run relationship between the education level of the labour force and economic growth and concluded that labour force with high educational attainment (secondary and tertiary) contributed positively to economic growth. In the long-run, doubling physical capital increases agriculture sector output by 0.98% and this is significant at a 99% confidence interval. Similarly, doubling the units of labour increases agriculture sector output by 0.73% holding other factors constant.

Table 4.9 Short and long-run estimates agriculture graduates on agriculture sector output

	Dependent Variable lnAgricOut 0,0,3 regression				
Regressors	**Coef.**	**Std. Err.**	**t**	**P>t**	**[95% Conf.**
ADJ. lnAgricOut	-0.68**	0.10	-6.59	0.00	-0.89
Long-run effects					
lnK	0.98**	0.13	7.60	0.00	0.72
lnL	0.73**	0.27	2.74	0.01	0.18
lnAgricStudents	-1.98**	0.27	-7.32	0.00	-2.53
Short-run effects					
lnAgricStudents					
Δ. lnAgricStudents (-1)	1.10**	0.30	3.67	0.00	0.48
Δ. lnAgricStudents	0.64**	0.22	2.86	0.01	0.18
Δ. lnAgricStudents (-2)	0.64**	0.22	2.85	0.01	0.18
_cons	-3.17	1.92	-1.65	0.11	-7.15
R-squared	0.70				
Adj R-squared	0.62				
Root MSE	0.12				
Log likelihood	27.28				

iii. Robustness test of the model

In this study, the CUSUMSQ test was applied to test the structural change and stability of estimated coefficients and the long-run relation between agriculture sector output and at its determinants in the model. The robustness check was also to detect the presence of structural change or functional misspecification. The test results are shown in the figure below. The result indicated the model was structurally stable as shown by the cumulative sum of recursive residuals with most of the data points lying within the confidence interval limits at 5% threshold hence showing no evidence of the model's instability with no occasional period in which the data point moved outside the limits of significance interval at the 5% threshold revealing instability of the coefficients on the test variables.


CUSUM squared
CUSUM squared
0
1
1987
2017
Year

CHAPTER FIVE

CONCLUSIONS AND POLICY RECOMMENDATIONS

The study offers an alternative econometric investigation on the effect different measures of human capital development parameters on agriculture sector output using efficient ARDL modelling. The study confirms the education is relevant for Uganda agriculture sector growth especially under the agro-industrialisation agenda as outlined in the third cycle of the National Development Plan towards Vision 2040. Overall, public expenditure on education had a net positive effect on agriculture sector output. There is no doubt that growth in the sector can be stimulated from innovations emanating from the country's agricultural training and research innovation system. Even with the currently raging debate between economic growth and structural change, the study confirms that it is possible to increase agriculture output by a factor of between 5% and 12% and stimulate the transformation of the sector through having an educated population even in the face of labour mobility.

The study findings reveal that in the short run, public investment in tertiary and primary education significantly increases agriculture sector output. However, in the long run, the effect is negative as a result of "deskilling" effect in the sector occasioned by outward mobility of skilled labour force. The same observation was also made on the number of agriculture graduates churned out of universities annually. However, is critical to note that doubling the current number of agriculture graduates increases the agriculture sector output by a staggering 11% in the short run, while in the long run, the same

effect leads to a reduction of 6.5%. Similarly, school enrolment exhibits both short and long-run negative effect on agriculture output and these effect are significant. This is attributed to the role of the education system in retaining the productive labour force during one's schooling life.

Therefore, the study strongly recommends that in an agriculture driven economy, strengthening education is critical for the sector growth. The findings indicate that basic and advanced human capital development has a positive impact on agriculture output and therefore recommend a balanced educational policy that promotes basic education, as well as tertiary education, is perhaps still a viable public investment option. The study reaffirms that public expenditure on education and education outputs has a profound effect, though mixed in agriculture sector growth. Agriculture-led growth is still a viable means of fostering growth

At policy level, the study recommends the implementation of a policy framework that will lead to formation of quality jobs to retain the skilled labour force in the sector based on the evidence that more skilled labour force gets absorbed into the service sector where the pay is decent and the work environment is more conducive. The study further recommends that the current public finance model should consider the returns to the investment approach and not merely look at as provision of social services. The fact that education improves peoples' lives coupled with the increasing role of the service and industry sector economic output, this should be a rationale for investing in education to build a stock of sector-specific demanded skills that can be attained through individuals not only attaining formal education but

with specific skills relevant for the different sectors. A literate labour force with a substantial quantity of skilled labour has high marginal productivity and this should underpin any rationale for increased investment in education. The agriculture "revolution" that the government is spearheading should be supported by strong investment in high-level skills to support activation of critical value chains and the emergence of knowledge and technology-intensive agro-processing industries.

Therefore, it is instructive that the government continues to play a catalytic investment role in education financing. This strategy could be achieved through the implementation of public, private partnerships ventures as opposed to the current investment space across all sectors including education that is purely private sector-led as result of fully implementing liberal economic policies. The fact that Uganda has one of the most attractive public-private partnership policies in the education sector that has led to the expansion of the educational opportunities for students who otherwise did not have access to education before due to the very few government schools and institutions provides a foundation for constructive engagement of all stakeholders in the sector to ensure quality education outcomes as opposed to allowing the private to focus on their profit-oriented motive. The study fully recognises that education is just one of the pillars that can cause agriculture growth and that interventions in the agriculture sector are scattered making it is difficult to analyse the trends in public spending on agriculture. The allocation of the resources within the agricultural sector shows many gaps regarding allocative efficiency, though this was outside the scope of this study.

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Appendix 1. Enrolment Data 1982-2017

Year	Total enrolment in primary education,	Total enrolment in secondary education	Total enrolment in tertiary education,	% Students in tertiary education enrolled in Agriculture, Forestry, Fisheries and Veterinary programmes	students in tertiary education enrolled in Agriculture, Forestry, Fisheries and Veterinary programmes
1982	1616791	132051	7312	1.29	94
1983	1730300	117090	11001	1.18	130
1984	1930298	144526	29493	1.99	588
1985	2117000	160000	10103	2.94	297
1986	2203824	196012	11037	2.94	324
1987	2309000	223000	12531	2.94	368
1988	2417000	243000	14194	2.15	305
1989	2366666	235032	14806	1.86	275
1990	2470000	244762	17578	2.17	381
1991	2576537	231000	21281	2.25	480
1992	2403845	226805	21489	1.04	223
1993	2674965	231430	24122	2.36	568
1994	2789573	244248	27586	1.63	450
1995	2912473	256258	30266	1.05	319
1996	3068626	256731	34773	2.56	891
1997	5303564	255676	29860	1.86	556
1998	5806385	396544	46874	1.67	783
1999	6288239	311120	40591	2.26	919
2000	6559013	518934	55767	2.88	1605
2001	6900916	539786	65000	2.94	1908

Year	Total enrolment in primary education,	Total enrolment in secondary education	Total enrolment in tertiary education,	% Students in tertiary education enrolled in Agriculture, Forestry, Fisheries and Veterinary programmes	students in tertiary education enrolled in Agriculture, Forestry, Fisheries and Veterinary programmes
2002	7354153	655951	80000	1.73	1384
2003	7633314	683609	85836	1.41	1213
2004	7377292	697507	108295	1.59	1720
2005	7223879	728393	124313	1.95	2418
2006	7363721	814087	137190	1.04	1427
2007	7537971	954328	118910	1.23	1457
2008	7963979	1088753	105642	1.93	2036
2009	8297774	1194454	123887	1.04	1288
2010	8374648	1225692	120646	1.44	1740
2011	8098177	1210666	140087	1.55	2176
2012	8328643	1251507	124561	1.54	1917
2013	8459336	1362439	126351	1.88	2381
2014	9708668	1391250	165396	1.44	2382
2015	8264317	1284008	121822	2.04	2485
2016	8655924	1457277	107895	2.27	2452
2017	8840589	1370583	108953	2.47	2689

Appendix 2. Macroeconomic data

Year	GDP constant 2010 US$ (Y)	National Expenditure on Education (Current USD)	Govt Expenditure tertiary education (current US$)	Expenditure on secondary Education (current USD)	Expenditure on primary education (current US$)
1982	4,040,725,727	101,645,268	22,361,959	62,003,613	17,279,696
1983	4,272,847,548	72,172,241	15,156,171	41,138,177	15,877,893
1984	4,258,120,039	103,402,483	27,918,670	45,497,093	29,986,720
1985	4,117,330,409	141,305,137	24,021,873	57,935,106	59,348,158
1986	4,133,391,578	199,818,346	26,741,469	80,897,038	91,916,439
1987	4,297,152,534	152,625,316	26,099,349	56,471,367	70,207,645
1988	4,652,401,294	237,442,283	32,018,260	143,500,593	61,734,994
1989	4,948,384,331	91,127,151	15,148,166	36,936,009	39,184,675
1990	5,268,749,668	186,221,976	35,382,176	76,351,010	74,488,791
1991	5,561,381,056	170,658,438	23,892,181	59,285,760	87,778,384
1992	5,751,488,908	175,675,750	22,355,813	70,572,297	82,567,603
1993	6,230,374,699	226,981,432	27,237,772	80,935,085	118,477,712
1994	6,629,345,200	202,050,394	23,744,254	78,956,920	99,004,693
1995	7,393,260,811	249,134,850	41,959,937	84,729,180	122,076,076
1996	8,063,985,903	240,972,351	44,583,351	74,974,707	120,486,176
1997	8,475,249,334	249,592,044	38,746,475	89,798,474	119,804,181
1998	8,890,982,815	173,498,708	26,111,335	58,989,561	88,484,341
1999	9,607,057,981	272,551,835	35,431,739	102,460,184	133,550,399
2000	9,908,902,840	243,924,489	29,270,939	88,894,724	126,840,734
2001	10,422,546,785	446,783,597	62,160,508	173,635,026	209,988,291
2002	11,332,715,044	433,991,863	62,320,107	171,623,893	199,636,257
2003	12,066,311,003	300,949,972	39,123,496	105,332,490	156,493,986
2004	12,887,692,950	638,246,239	75,732,256	140,414,173	421,242,518

Year	GDP constant 2010 US$ (Y)	National Expenditure on Education (Current USD)	Govt Expenditure tertiary education (current US$)	Expenditure on secondary Education (current USD)	Expenditure on primary education (current US$)
2005	13,703,814,498	327,244,747	45,814,265	114,535,661	166,894,821
2006	15,181,735,862	541,537,647	76,360,978	189,538,177	276,184,200
2007	16,458,888,152	768,320,880	99,041,373	268,912,308	399,526,858
2008	17,892,251,887	625,721,317	99,389,784	243,431,207	281,574,593
2009	19,109,196,503	604,826,813	86,990,868	229,834,189	290,690,313
2010	20,186,496,527	482,257,421	64,142,504	190,157,911	227,957,006
2011	22,082,345,211	670,788,776	70,864,541	218,539,025	381,385,276
2012	22,929,745,405	569,377,680	78,017,838	161,242,293	330,117,606
2013	23,752,213,779	524,629,397	84,756,240	139,609,181	300,263,976
2014	24,965,074,811	561,883,946	91,559,045	137,942,228	332,382,673
2015	26,260,227,907	728,395,698	102,496,134	233,086,623	393,333,677
2016	27,515,729,480	704,077,989	112,652,478	218,264,177	373,161,334
2017	28,578,668,646	753,050,777	117,433,664	285,192,757	350,818,291
2018	30,319,150,878	1,095,690,201	178,316,181	471,146,787	449,232,983

Appendix 3. Labour Force by Sector

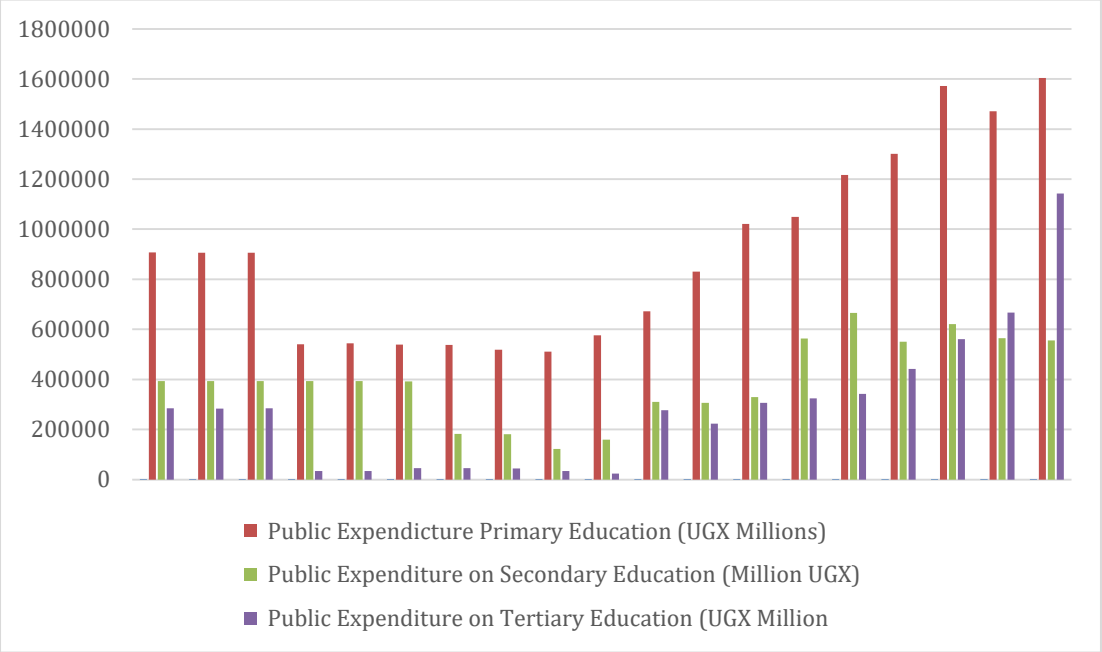
Year	Total Labour (L)	No. Employed in Service	No. Employed in Agriculture	No. employed in industry
1982	10,076,109	2,175,743	7,166,689	697,688
1983	10,077,757	2,217,107	7,098,770	808,035
1984	10,076,938	2,328,243	7,053,857	720,917
1985	10,078,182	2,116,418	7,196,048	806,255
1986	10,075,298	2,216,566	7,153,461	752,318
1987	10,075,582	2,300,051	7,058,951	736,166
1988	10,073,104	2,316,814	7,106,974	688,743
1989	10,080,795	2,217,775	7,056,556	773,557
1990	6,303,540	1,323,743	4,498,373	483,633
1991	6,481,408	1,295,439	4,798,057	387,912
1992	6,670,602	1,326,716	4,940,314	403,638
1993	6,867,687	1,417,559	5,018,356	431,771
1994	7,071,353	1,440,364	5,178,069	452,991
1995	7,281,641	1,540,941	5,247,442	493,258
1996	7,467,677	1,628,850	5,311,908	526,919
1997	7,662,452	1,671,487	5,440,878	550,087
1998	7,869,518	1,735,307	5,563,120	571,091
1999	8,092,899	1,812,081	5,675,793	605,025
2000	8,335,126	1,881,655	5,831,254	622,134
2001	8,591,172	1,969,698	5,973,528	647,946
2002	8,868,691	2,078,023	6,104,497	686,171
2003	9,165,895	2,153,985	6,296,970	714,940
2004	9,480,220	2,152,200	6,599,939	728,081
2005	9,810,357	2,127,768	6,945,340	737,248
2006	10,148,908	2,164,864	7,228,154	755,891
2007	10,505,958	2,170,006	7,558,826	777,126

Year	Total Labour (L)	No. Employed in Service	No. Employed in Agriculture	No. employed in industry
2008	10,882,118	2,156,836	7,923,379	801,903
2009	11,278,304	2,157,314	8,321,471	799,519
2010	11,695,833	2,540,452	8,280,767	874,497
2011	12,130,460	2,850,294	8,307,546	972,620
2012	12,590,295	3,254,465	8,326,718	1,009,112
2013	13,062,215	2,753,515	9,393,953	914,747
2014	13,569,831	2,886,981	9,727,533	955,316
2015	14,119,007	3,037,140	10,072,076	1,009,791
2016	14,726,387	3,159,104	10,512,432	1,054,851
2017	15,383,789	3,330,283	10,933,259	1,120,248
2018	16,099,606	3,517,925	11,392,082	1,189,600

Appendix 4. Agriculture Sector output and Physical Capital formation

Year	Agriculture forestry & fishing output (current US$)	Capital formation (K) (current US$)
1982	1,094,000,000	198,000,000
1983	1,188,666,667	166,000,000
1984	1,799,026,156	294,307,752
1985	1,702,663,858	307,337,914
1986	2,083,156,750	331,392,456
1987	3,432,839,582	609,284,674
1988	3,532,683,333	702,466,667
1989	2,869,151,318	587,600,954
1990	2,293,508,862	546,834,277
1991	1,640,022,029	503,948,322
1992	1,377,378,798	455,448,143
1993	1,554,985,198	490,981,260
1994	1,842,375,698	585,868,069
1995	2,607,120,502	714,413,708
1996	2,480,528,662	1,219,355,425
1997	2,389,867,336	1,139,674,298
1998	2,518,761,104	1,083,014,215
1999	2,086,658,940	1,172,666,368
2000	1,703,706,892	1,206,681,172
2001	1,626,594,431	1,127,337,527
2002	1,447,849,251	1,249,146,324
2003	1,552,935,590	1,329,701,321
2004	1,720,704,620	1,599,640,868
2005	2,260,213,212	2,015,055,821
2006	2,389,696,713	2,100,907,701
2007	2,738,606,989	2,714,628,822
2008	3,044,958,684	3,271,811,336
2009	4,750,473,059	4,541,754,465
2010	5,296,035,831	5,158,853,862
2011	5,056,622,345	5,539,778,644
2012	6,028,561,046	6,309,538,938
2013	6,267,953,777	6,974,173,045
2014	6,843,269,601	7,445,689,460
2015	6,499,644,543	6,671,697,878
2016	5,708,660,256	6,144,994,204
2017	6,389,754,810	6,157,795,350
2018	6,647,718,971	6,758,391,074

Appendix: 5 Public expenditure on Education in Uganda 1999- 2018



Appendix 6 : Publications

Journal of Scientific Research & Reports

26(7): 5-17, 2020; Article no.JSRR.59623
ISSN: 2320-0227

Output Growth of Uganda's Agriculture Sector: Does Public Expenditure on Education Matter?

Charles Owuor[1*], Eric K. Bett[1] and Gabriel W. Mwenjeri[1]

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Authors' contributions

This work was carried out in collaboration among all authors. Author CO designed the study, performed the statistical analysis, wrote the protocol, managed the literature searches and wrote the first draft of the manuscript. Authors EKB and GWM guided the entire research process, reviewed the draft manuscript. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

We examine the multiple dimensions of the effect of public investment in education on agriculture sector output in a multivariate econometric framework. The study is underpinned by the growing interest in empirical investigations on the effects of public education expenditure on economic growth in developing countries to inform the education sector policy environment. The research employed a longitudinal study approach to examine the extent of public investment in education and effects on agriculture sector output in Uganda. The study relied on data from national statistics for the period 1982- 2017. Overall, public expenditure on education has a net positive effect on agriculture sector output. The impact of education on agriculture output has been proven to promote agriculture output through supporting farmer adoption of new productivity-enhancing technologies.

Keywords: Auto-regressive distributed lag (ARDL); agriculture output; education; public expenditure; economic growth.

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A theoretical analysis of public expenditure on education and agriculture sector growth nexus: Case of Uganda

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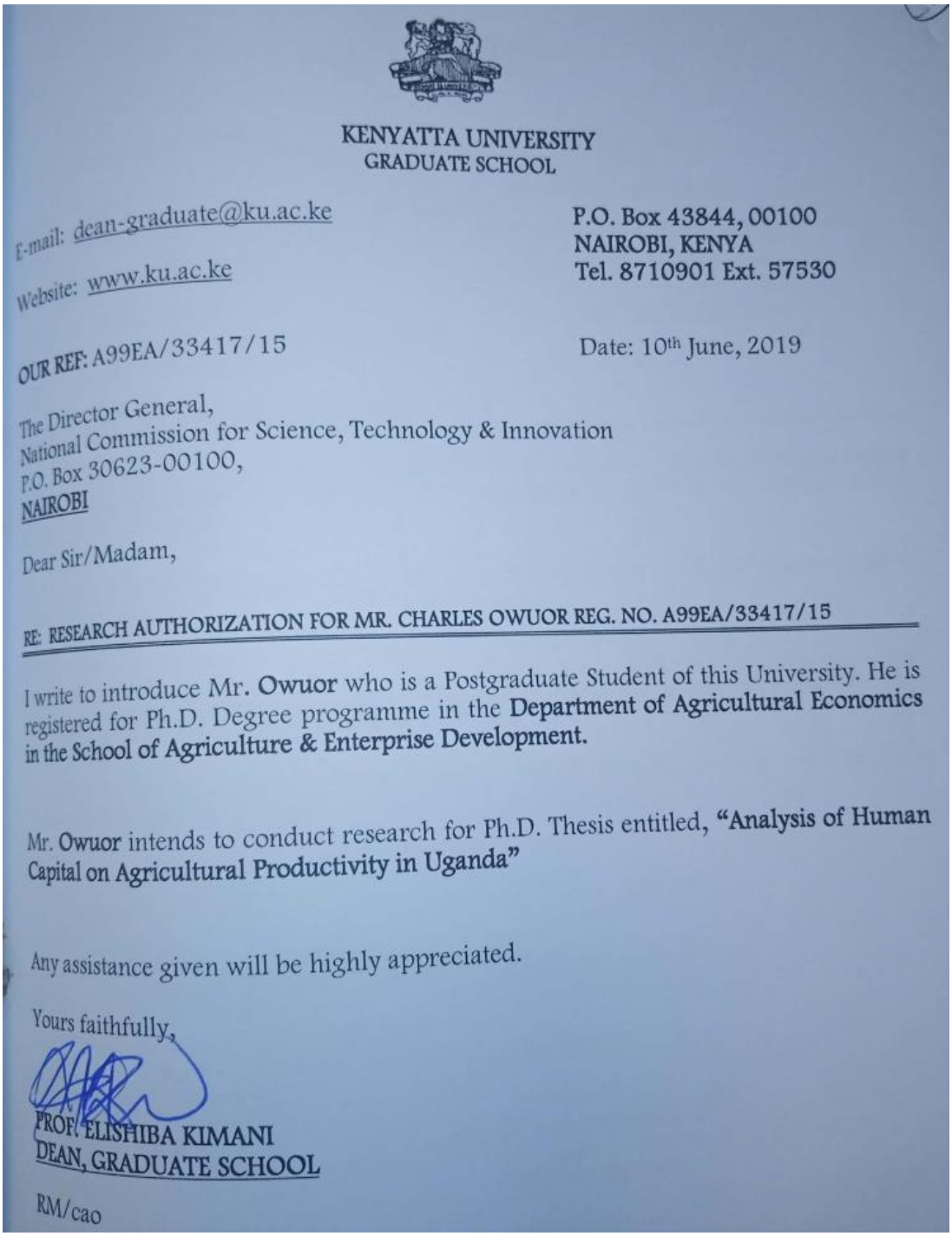
ABSTRACT
Uganda's economic development prospect is intertwined with agriculture sector growth. The country has 80% of the land, which is arable, but only 35% is being cultivated majorly using subsistence suboptimal methods. On the other hand, the country's population age structure is a paradox of its own. Census data indicates that close to 63% of the total population is below the age of 24 years and 50% below the age of 15 years. It is therefore imperative that the education expenditure as a proxy for human capital development should underpin policy and public investment choices. At the sector level, growth and prosperity are positively correlated to a reduction in rural poverty that is still a characteristic of rural households. This paper seeks to deepen the theoretical understanding of agriculture and education nexus and the low transformation of the agriculture sector in Uganda.

Key words: Agriculture Sector, economic development, education investment, human capital, Uganda

RÉSUMÉ
Les perspectives de développement économique de l'Ouganda sont étroitement liées à la croissance du secteur agricole. Le pays possède 80% des terres arables, mais seulement 35% de ces derniers est principalement cultivé en utilisant des méthodes de subsistance sous-optimales. En revanche, la structure par âge de la population du pays est un paradoxe en soi. Les données du recensement indiquent que près de 63% de la population totale a moins de 24 ans et 50% a moins de 15 ans. Il est donc impératif que les dépenses d'éducation en tant qu'indicateur du développement du capital humain sous-tendent les choix politiques et d'investissement public. Au niveau sectoriel, la croissance et la prospérité sont positivement corrélées à une réduction de la pauvreté rurale qui est encore une caractéristique des ménages ruraux. Cet article cherche à approfondir la compréhension théorique du lien existant entre l'agriculture et l'éducation ainsi que la faible transformation du secteur agricole en Ouganda.

Mots clés: Secteur agricole, développement économique, investissement dans l'éducation, capital humain, Ouganda

Appendix 7 : Kenyatta Universiry Research Authorization and Approval Letters



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OUR REF: A99EA/33417/15

Date: 10th June, 2019

The Director General,
National Commission for Science, Technology & Innovation
P.O. Box 30623-00100,
NAIROBI

Dear Sir/Madam,

RE: RESEARCH AUTHORIZATION FOR MR. CHARLES OWUOR REG. NO. A99EA/33417/15

I write to introduce Mr. **Owuor** who is a Postgraduate Student of this University. He is registered for Ph.D. Degree programme in the **Department of Agricultural Economics** in the **School of Agriculture & Enterprise Development.**

Mr. **Owuor** intends to conduct research for Ph.D. Thesis entitled, **"Analysis of Human Capital on Agricultural Productivity in Uganda"**

Any assistance given will be highly appreciated.

Yours faithfully,

PROF. ELISHIBA KIMANI
DEAN, GRADUATE SCHOOL

RM/cao

KENYATTA UNIVERSITY
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Internal Memo

FROM: Dean, Graduate School

DATE: 10th June, 2019

REF: A99EA/33417/15

TO: Mr. Charles Owuor
C/o Department of Agricultural Economics
Kenyatta University

SUBJECT: APPROVAL OF RESEARCH PROPOSAL

We acknowledge the receipt of your revised Research Proposal entitled **"Analysis of Human Capital on Agricultural Productivity in Uganda"** as per recommendations raised by the Graduate School Board of 22nd **May, 2019.**

You may now proceed with your Data collection, subject to clearance with the Director General, National Commission for Science Technology & Innovation.

As you embark on your data collection, please note that you will be required to submit to Graduate School completed supervision Tracking Forms per semester. The form has been developed to replace the progress Report Forms. The Supervision Tracking Forms are available at the University's Website under Graduate School webpage downloads.

By copy of this letter, the Registrar (Academic) is hereby requested to grant you substantive registration for your Ph.D. studies.

Thank you.

RUBEN MURIUKI
FOR: DEAN, GRADUATE SCHOOL

c.c. Registrar (Academic) Att. Mr. Likam
Chairman, Department of Agricultural Economics

Supervisor

1. Dr. Gabriel Mwenjeri
C/o Department of Agricultural Economics
Kenyatta University

2. Dr. Eric Bett
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