

UNIVERSITY OF CAPE COAST

LAND TENURE SECURITY, SOIL IMPROVEMENT AND MAIZE
OUTPUT OF SMALLHOLDER FARMERS IN THE NORTHERN REGION
OF GHANA

MUNIRU AZUUG

2019

UNIVERSITY OF CAPE COAST

LAND TENURE SECURITY, SOIL IMPROVEMENT AND MAIZE
OUTPUT OF SMALLHOLDER FARMERS IN THE NORTHERN REGION
OF GHANA

BY

MUNIRU AZUUG

Thesis submitted to the Department of Economics of the Faculty of Social
Sciences, College of Humanities and Legal Studies, University of Cape Coast,
in partial fulfilment of the requirements for the award of Master of Philosophy
degree in Economics

MARCH 2019

DECLARATION

Candidate's Declaration

I hereby declare that this thesis is the result of my own original research and that no part of it has been presented for another degree in this university or elsewhere.

Candidate's Signature Date

Name:

Supervisors' Declaration

We hereby declare that the preparation and presentation of the thesis were supervised in accordance with the guidelines on supervision of thesis laid down by the University of Cape Coast.

Principal Supervisor's Signature..... Date

Name:

Co-Supervisor's Signature..... Date

Name:

ABSTRACT

The study is in two folds. It first examined the effect of land tenure security dimensions on households' soil improvement and subsequently explored the effect of soil improvement on maize output among smallholder farmers in the Northern Region of Ghana. The data employed for this study were obtained from the 2011 Innovation for Poverty Action survey. The endogenous switching regression model was employed for the analyses. The study found that, households who had full land right had a significantly higher probability of undertaking soil improvement than those with non-full rights. Again, relative to households whose lands were disputed, households with undisputed lands had a significantly higher likelihood of undertaking soil improvement. It was also found that soil improvement by households proved to be positive in influencing maize output of households in the region. It is recommended that government should strengthen land disputes resolution and arbitration bodies to amicably settle land related disputes as it adversely affects land tenure security. Again government is advised not to perceive land titling as the only means of improving land tenure security but should create a system that would check and recognise customary claims to land.

KEY WORDS

Land disputes

Land right

Maize output

Northern Region

Soil improvement

ACKNOWLEDGEMENTS

I would like to express my appreciation to my principal supervisor, Dr. Ferdinand Ahiakpor and co-supervisor, Dr. Benedict Afful Jr. for their support, motivation, critique and more importantly their patience which has made completion of this work possible.

I am also grateful to Innovation for Poverty Action (IPA) for making the data available for this study. My special thanks also go to Dr. Francis Taale for the advice and support he gave me during my study.

I would also like to thank Mr. Chei Bukari for his time, support and motivation. Finally, my sincere thanks go to my colleagues for their support and encouragement.

DEDICATION

To my parents

TABLE OF CONTENTS

Content	Page
DECLARATION	ii
ABSTRACT	iii
KEY WORDS	iv
ACKNOWLEDGEMENTS	v
DEDICATION	vi
TABLE OF CONTENTS	vii
LIST OF TABLES	x
LIST OF FIGURES	xi
LIST OF ACRONYMS	xii
CHAPTER ONE: INTRODUCTION	
Background to the Study	1
Statement of the Problem	4
Objectives of the Study	7
Hypotheses of the Study	8
Significance of the Study	8
Delimitations of the Study	9
Limitations of the Study	9
Definition of Terms	10
Organization of the Study	11
CHAPTER TWO: LITERATURE REVIEW	
Introduction	12
Theoretical Literature Review	12
The neo-classical theory of land tenure security	15

Empirical Literature Review	18
Approaches of the land tenure research in Ghana	18
Land tenure security and land improvement investment	21
Land tenure security and agricultural production	27
Research Gaps	29
Chapter Summary	30
CHAPTER THREE: RESEARCH METHODS	
Introduction	31
Research Philosophy	31
Research Design	33
The Study Area	34
Tamale metropolitan Area	35
Savelugu-Nanton	37
West Mamprusi	38
Justification for Choice of Study Area	40
Data Source and Type	41
Model Specification	43
Theoretical econometric model	43
Empirical model specification	49
Definition and Measurement of Variables and expected signs	54
Estimation Technique	63
Chapter Summary	64
CHAPTER FOUR: RESULTS AND DISCUSSION	
Introduction	65
Bivariate analysis of soil improvement and independent variables	69

Bivariate analysis of maize output and independent variables	75
Effect of Land Tenure Security (Land Right and Land Disputes) on Soil Improvement and soil improvement on maize output	78
Chapter Summary	91
CHAPTER FIVE: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS	
Introduction	92
Summary	92
Conclusions	94
Recommendations	96
Suggestions for Further Research	98
REFERENCES	99

LIST OF TABLES

Table		Page
1	Expected Signs of the Explanatory Variables	53
2	Summary Statistics of Continuous Variables used in the Study	65
3	Tabulation of Discrete Variables used in the Study	67
4	A t-test of Difference in Mean Output across Groups.	78
5	Results of the endogeneous switching regression	79

LIST OF FIGURES

Figure		Page
1	Northern Region	40
2	Map of the study area	42
3	Proportion of Household Soil Improvement by Land Dispute	70
4	Proportion of household soil improvement by Land right	71
5	Proportion of household soil improvement by Credit	72
6	Proportion of household soil improvement by gender	73
7	Proportion of household soil improvement by marital status	74
8	Proportion of household soil improvement by Education level	75

LIST OF ACRONYMS

CDF	Cumulative Distribution Curve
CIMMYT	International Maize and Wheat Improvement Centre
EUI	Examining Under Investment
ESR	Endogeneous Switching Regression
FAO	Food and Agriculture Organisation
GLSS	Ghana Living Standard Survey
GSS	Ghana Statistical Service
IPA	Innovation for Poverty Action
ISSER	Institute of Statistical and Social Research
LI	Legislative Instrument
LPM	Linear Probability Model
MiDA	Millennium Development Authority
MoFA	Ministry of Food and Agriculture
NGO	Non- Government Organisation
ODI	Overseas Development Institute
OR	Odd Ratio
TaMA	Tamale Metropolitan Assembly
TLU	Tropical Livestock Unit
UN	United Nations
VSLA	Village Savings and Loans Association

CHAPTER ONE

INTRODUCTION

Background to the Study

Agriculture remains a fundamental tool for sustainable development in this 21st century (Kibaara, Ariga, Olwande & Jayne, 2008, World Bank, 2007). Its impact in Africa has earned the conclusion that it is the backbone of many African economies. The food crop sub-sector of agriculture plays a vital role in ensuring food security (Mozumdar, 2012). One important crop under the sub-sector is maize. It is regarded as the third most important cereal in the world after rice and wheat but in sub-Saharan Africa (SSA), maize is the most important cereal crop (IITA, 2009). Maize is Ghana's number one food crop, accounting for more than 50 percent of the country's total cereal production (Ministry of Food and Agriculture (MoFA), 2011).

Given the importance of maize in Ghana, there has been several policy interventions aimed at boosting maize output in Ghana. Among these policies include, National Fertilizer Subsidy Programme and Maize Seed improvement Programme. The national fertilizer subsidy programme was introduced by the government of Ghana through the sector ministry, Ministry of Food and Agriculture and aimed at boosting food production by absorbing part of the cost of fertilizer and thereby reducing the cost of fertilizer to farmers (Akatey, 2015). On seed improvement, the Council for Scientific Research (CSIR) Crop Research Institute (CRI) has made interventions in improving maize seeds. The focus of the centre has been the breeding of stable and high-yielding maize varieties with the capacity to perform well in all agro-ecologies in Ghana (Louwaars & de Boef, 2012).

Despite these policy interventions, maize output in Ghana remains one of the lowest in the world (Ragasa, Chapoto & Kolavalli, 2014). In recent years, maize output has been stagnant in Ghana. According to the United States Department of Agriculture, Ghana in 2012, recorded a maize output of 1,950,000 metric tonnes. This figure however, has continuously declined (1,764,000 metric tonnes in 2013, 1,762,000 metric tonnes in 2014, 1,692,000 metric tonnes in 2015) to 1,672,000 metric tonnes in 2016. The shortfall between domestic production and consumption of maize reached about 267,000 metric tonnes in 2015 (MoFA, 2015). Projections by the Millennium Development Authority show that the annual domestic deficit in maize, the largest staple crop in the country, is estimated to be between 84,000 and 145,000 metric tonnes. This represents a shortfall in domestic production of between 9 and 15 percent of total human consumption. Yields have been growing by only 1.1 percent per annum in Ghana. In 2012, maize yield in Ghana averaged 1.2–1.8 metric tons (mt) per hectare (ha), far below the potential yield of 4–6 mt/ha achieved in on-station trials (Ragasa *et al.*, 2014). These figures indicate that maize output in Ghana has been low, far lower than the achievable potential to increase smallholder farmers' income, food and nutrition security. The principal limitations to maize production in the Northern Region include land tenure security, poor soil quality and among others (Fasdep, 2007; Sulemana, 2009).

Given that land for maize cultivation requires a certain level of fertility (Dlamini, 2015), Soil improvement is an important measure that is required to boost maize output by replenishing the land of its lost nutrients (fertility) required to support maize crop growth and hence output. Inadequate

replenishment of nutrients in the soil, affects maize yields (FAO, 2007). Farming without implementing sustainable soil fertility programmes to replace the nutrients removed by the crops can result in soil nutrient losses (Sanchez, 1997). Insufficient nutrient replenishment can render a previously fertile piece of land un-productive (Lynam, 1998; Cermak & Smatanova, 2012). An often resorted measure is the application of chemical fertilizer. However, continuous application of fertilizer in agricultural lands reduces soil fertility, evolving in nutrient deficiency in the soil; resulting in reduced crop output (Roy *et al.*, 2016). In most cases, soil nutrients drop below critical levels, causing agricultural land to become infertile and subsequently abandoned (McArthur & McCord, 2014).

However, households' decision to undertake soil improvement is believed to be greatly influenced by the security of land tenure. Land tenure security plays a vital role in determining households' land soil improvement (Adams, Sibanda, & Turner, 1999; Belay & Manig, 2004; Deininger, 2003). As a result, much land reform programmes within poor agrarian economies such as those in Sub-Saharan Africa and other parts of the world are premised on the assumption that improved tenure security will lead to increased agricultural productivity and thus reduce rural-poverty (Tenaw *et al.*, 2009).

Although, several theoretical papers suggest that secure rights to land such as those provided for under individualised title is likely to raise investments, induce greater effort on the part of the owners, raise output and among others, the literature backing these propositions have been both scarce and less convincing (Besley, 1995; Myra, Pietola & Yli-Halla, 2007; Gavian & Ehui, 1999; Jansen & Roquas, 1998). This lack of evidential support to the

hypothesized links between tenure-security, land investment and agricultural productivity could be due to several factors including, the inability to conceptualize tenure security accurately, measure outputs and inputs correctly, and the difficulties of trying to control for all possible factors that impinge on agricultural output (Chand & Yala, 2008). There is therefore the need for a local understanding of security of tenure and its effect on soil improvement and hence, maize output.

Statement of the Problem

Ghana's significant economic growth over the last twenty years seemed to create favourable conditions for increased agricultural output. However, agricultural output has failed to increase accordingly to reduce poverty, especially with respect to the maize sub-sector (Ragasa *et al.*, 2014). As a result, most increases in aggregate crop production have been achieved from the expansion of cultivated land rather than increased investment in Land improvements to raise crop output. Population growth and urbanization has led to scarcity of land as there is now competing demand for land for other purposes such as residential and commercial constructions rather than crop cultivations (Naab, Dinye, & Kasanga, 2013). There is therefore the need for land improvement to increase crop yield from the available land.

Poverty and hunger in Ghana's Northern savannah are significantly greater than in the southern half of the country (IFAD, 2012). To address this inequality, pro-poor development has become a focus in Ghana's Northern regions to reduce poverty and increase food and nutrition security (USAID, 2017). One strategy that aids in poverty reduction and increased food and nutrition security is improved agricultural production through innovative

technologies that support sustainable agricultural development (Al-Hassan & Diao 2007, Shepherd *et al.*, 2005).

A 1998 survey by CRI/CIMMYT found that maize is the primary source of income for 45% of households in the Northern savannah, and the second source of income for 21% (Morris *et al.*, 1999). In 2010, average maize output for Ghana was 1.7 metric tons per hectare (27 bushels per acre) (MOFA, 2011). An output of 1.7 metric tons per hectare is over 50% less than the achievable yield of popular improved maize varieties planted in Ghana, including 69% less than Obatanpa (5.5 metric tons per hectare), and 78% less than the Mamaba (7.5 metric tons per hectare) (Tengan, Obeng-Antwi, Ewool & Danso, 2011). Given the potential achievable output level, there is the indication that maize output can significantly be increased and has a great potential to increase smallholder farmers' income and food and nutrition security (Basera, 2015).

It has been argued that land tenure security (land documentation and titling) contributes positively to agricultural investment and hence output (Deininger & Chamorro, 2004; Feder *et al.*, 1988; Fort, 2008; Tenaw *et al.*, 2009). However, most studies (Giri, 2010; Hombrados, Devisscher, & Martinez, 2015; Platteau, 2000; Tsegaye, Adgo, & Selassie, 2012) in Africa did not find evidence of land tenure security (land titling) significantly and positively influencing land improvement and hence farm output. Although, both studies (elsewhere and in Africa) used the same measure (documentation and titling) of tenure security, their findings differed. Could this difference in findings be as a result of context?

Goldstein and Udry (2008) in their study of land right and agricultural investment established a positive relationship between land tenure security and agricultural investment. The study however, measured tenure security as the ability of households to undertake lands fallow. This means that land fallow is being used as an indicator of land tenure security and hence households that undertook land fallow were termed to be tenure secured while those who did not fallow their lands were termed to be tenure insecure. This measure of land tenure security is believed to be deficient and fundamentally flawed. This is because, households undertake land fallow as a means of replenishing soil fertility, and hence fallowing is a soil improvement measure among other measures a household could choose from, it is possible that a household will be land tenure secure but would not undertake land fallow. It is also the case that a household may be tenure secure but would not fallow land due to economic considerations such as having the income to cater for the food needs of its members while the land is under fallow. Therefore measuring land tenure security as the ability of households to undertake land fallow will under report the security of land tenure of households and hence analyses made from this conceptualization will not give a true reflection of the effect of tenure security on a given variable of interest.

Also, Holden and Yohannes (2002) in their study of farm households in Southern Ethiopia using a questionnaire and employing the probit model found that tenure (in)security variable did not have a significant effect on farm land improvement. The study used a self-reported binary indicator which represents some underlying variable. This indicator takes a value of 1 if the underlying variable takes positive values and 0 when the underlying variable

takes negative. The self-reported binary indicator of tenure security suffers from problems inherent in questions about people's perception of the security of their tenure. For example depending on how questions are posed, there is the likelihood that individuals may frequently report insecurity in expectation of some form of help or may not correctly understand the question. This has the potential of over reporting tenure insecurity and hence possibly undermines the effect of tenure security on household land improvement decisions as people who are captured as tenure insecure in actual sense are tenure secure.

It is in the light of these knowledge gaps that this study is motivated. The study therefore seeks to investigate the effect of land tenure security on households' soil improvement and hence maize output by resolving these measurement deficiencies of tenure security. The study employed Place *et al.* (1994) definition of land tenure security which caters for undeveloped land market economy like Ghana and hence Northern region where norms and customs largely determine a household claim to land in measuring land tenure security.

Objectives of the Study

The main objective is to examine the dimension of land tenure security that influence households' soil improvement as well as the effect of soil improvement on maize output of smallholder farmers in the Northern region of Ghana.

The specific objectives are as follows;

1. Examine the effect of household's land right on soil improvements.
2. Investigate the effect of land disputes on soil improvements.
3. Evaluate the effect of soil improvements on maize output

Hypotheses of the Study

The following hypotheses were formulated in line with the objectives to guide the study.

1. **H₀**: Household's farmland right has no effect on soil improvements.
H₁: Household's farmland right has an effect on soil improvements.
2. **H₀**: Land dispute has no effect on soil improvements.
H₁: Land dispute has an effect on soil improvements.
3. **H₀**: Soil improvements do not affect maize output in the region.
H₁: Soil improvements affect maize output in the region.

Significance of the Study

The study will be useful in providing information on the dimension of tenure security that influences soil improvement on agricultural lands in the Northern region. It will as well inform policy makers on the important interventions that are required in ensuring tenure security under undeveloped lands market economy as in Ghana and for that matter the Northern region. This will improve the security of tenure of households and boost soil improvement and hence increase output. It would as well help households to understand the relevance of soil improvement on maize output. This study will as well add to literature on the land tenure security, soil improvement and crop output studies as it looks at these with particular reference to maize production.

Delimitations of the Study

This study examined the effect of tenure security dimensions on soil improvement and the effect of soil improvement on maize output of farm households in the Northern region of Ghana under indigenous customary tenure using a cross-sectional data obtained from Innovation for Poverty Action (IPA) data set. The study covered only the Northern region of Ghana. Variables included in the study are, the dependent and independent variables. The dependent variables include, soil improvement (I) and maize output (Y). The independent variables include, land rights, Land dispute, Labour, Age of household head, Sex of the head, Education level of household head, tractors ownership, farm income, credit, tropical livestock unit, farm distance, marital status of head, Household size, soil improvement, and farm size. Also, based on the objectives of the study, the study will employ the endogenous switching model estimation technique for the two dependent variables of the study, namely, Soil improvement and Maize output. The study expects a positive relationship between the tenure security variables (Land right and Land dispute) on soil improvement as well as a positive relationship between soil improvement and maize output.

Limitations of the Study

The first limitation of the study is the unit of analysis. The unit of analysis of the study is the household. Because the analysis is done at the household level, it was not possible to consider intra-household characteristics besides that of the household heads that could possibly explain the dependent variables of the study (soil improvement and maize output). It is obvious that within household characteristics of individual members that could explain the

dependent variables exist, but was not captured by this study, which serves as a limitation.

Another limitation of the study is on variables that could as well have explained soil improvement and maize output but were not captured by the study. Variables such as soil erosion, soil type and land slope that could as well explain soil improvement and maize output were excluded because the data used in this study did not capture them. This as well may serve as a limitation of the study.

Definition of Terms

Land tenure security: Refers to the individual certainty of his or her claim to a parcel of land on a continual basis free from imposition.

Soil improvement (I): Soil is said to be improved if the household undertakes any of the following, terracing, fallowing, crop rotation, manuring or levelling the land terrain.

Output: This measures the amount of maize produced by households in bags.

Land rights: This refers to the right that a household has over a given parcel of land. It could be a full right or a non-full right.

Land dispute: This refers to the state of a household claim to a given parcel of land. The claim of a household to a parcel of land could either be disputed or undisputed.

Age: This refers to the number of years attained by the household head

Gender: This captures the sex of the household head. The head of household could either be a male or a female.

Household size: This captures the total number of people living in the household.

Marital status: This refers to whether the head of household is married or unmarried.

Educational Level: This refers to the level of education attained by the household head

Farm Size: This refers to the size of the farm measured in hectares.

Farm Labour: This entails the labour used by the households. This includes hired and unhired labour.

Farm income: This refers to the earnings realised by households from their farms.

Credit: This refers to the money borrowed by households from lenders for farm production which is bound to repayment.

Tropical livestock unit: This refers to all the livestock owned by a household.

Farm distance: This refers to the distance that households cover to their farm site and is measured in kilometres (km).

Organisation of the Study

The study is organized into five chapters. Chapter one covers the background of the study, Problem statement, objectives of the study, hypotheses, significance, delimitation of the study, limitations of the study, definitions of terms, and organisation of the study. Chapter two presents the review of relevant literature that investigate the relationship between land tenure security and investment in land and hence agricultural productivity. Chapter Three discusses the research methods adopted in the study. Chapter Four presents and discusses descriptive results and the empirical results of the study. Chapter Five provides a summary of the research findings, conclusions, policy recommendations and suggestions for future study.

CHAPTER TWO

LITERATURE REVIEW

Introduction

This chapter presents the review of related literature for the study. The literature review is divided into two sections. The first section deals with the theoretical literature on conceptualizations of land tenure security and the neoclassical theory of land tenure security. The second section presents empirical literature review on the approaches of the Land tenure research in Ghana, land tenure security and land investment, and tenure security and agricultural production in Africa and elsewhere.

Theoretical Literature Review

This presents the theoretical literature on which the study is based

Conceptualisations of tenure security

Land tenure security has been defined as the individual's perception of his/her rights to a piece of land on a continual basis, free from imposition or interference from outside sources, as well as the ability to reap the benefits of labour or capital invested in land, either in use or upon alienation (Place *et al.*, 1994). Because tenure security is not directly observed, devising an objective index of tenure security to correlate with agricultural performance and other outcome variables has so far been problematic (Roth & Haase, 1998). Several measures of tenure security have been employed by researchers. The most common is a self-reported indicator which represents some underlying variable. This indicator takes a value of 1 if the underlying variable takes positive values and 0 when the underlying variable takes negative (Alemu, 1999; Holden & Yohannes, 2002; Matchaya, 2009).

The self-reported binary indicator of tenure security suffers from problems inherent in questions about people's discernment of the security of their tenure. For instance depending on how questions are asked, there is the likelihood individuals may often report insecurity in expectation of some form of assistance or may not correctly understand the question (Matchaya, 2009). The second problem with the self-reported binary indicator of tenure insecurity has to do with the failure to take into account the underlying cause of insecurity. The binary perception of security is usually obtained by asking individuals whether they fear losing their land in the future. It is obvious that the answer to this question will vary significantly.

Some studies have conceptualized land tenure security as documentation or registration of land rights (Feder & Onchan, 1987; Hayes *et al.*, 1997). Under this classification, registered lands with titles or deeds are considered as secure while unregistered lands without titles are seen as insecure. This definition is condemned for assuming that land title is analogous to land tenure security and disregarding the fact that context specific customary laws and institutions are also vital in determining land tenure security.

Other studies have also measured land tenure security as the ability to fallow land (Goldstein & Udry, 2008). This definition assumes that individuals who are able to fallow their land are tenure secure whilst those who do not fallow land are tenure insecure. This definition is fundamentally flawed in that fallowing is a land soil improvement measure which is undertaken by households to improve soil and not as an indication of their tenure security. It is proper to consider the bundle of rights that the household has over a land

that assures them the land while it is under fallow. It is these rights that inform the household decision to improve land (fallow). It also holds, that a household may have these rights to land that make it tenure secure but does not fallow lands (as land fallowing is an option of soil improvement among numerous options as outlined in this study that the household can choose from). Therefore, conceptualizing tenure security as those who fallow their lands automatically excludes those having these right but did not fallow land and hence, analysis made from this conceptualization would understate the impact of land tenure security.

Considering the weaknesses posed by measuring of land tenure security as documentation, perception of security, binary response indicator and as land fallow, this study proposes a more appropriate measure of land tenure security that does not reduce security of land tenure to the possession of title deeds and takes into account the undeveloped land market of Sub -saharan Africa and for that matter Ghana. This measure follows the definition of land tenure security by Place *et al.* (1994), thus, the bundle of rights definition. For this study, if a household can sell land, use land for collateral and transfer land, it is termed as having full right to land and hence tenure secure, and if the household can neither sell land, use for collateral nor transfer land is termed as having non-full rights and hence tenure insecure. Also, another measure of tenure security is the incidence of land disputes. The study sets land dispute as a measure of tenure security. By this definition, households whose lands are not disputed are termed to be tenure secure whilst households whose lands are disputed are termed as being tenure insecure. This definition

follows the assurance dimension of land tenure security as defined by Place *et al.* (1994).

The neo-classical theory of land tenure security

Neo-classical theory has over the years profoundly articulated the privatisation of land rights as a precondition for investment and economic growth (Alemu, 1999; Bromley, 1991). Individualisation of land rights is perceived to provide incentives for agricultural investment, improve access to credit as well as reduce fragmentation and conflicts over land. The theory argues that well-defined and protected land rights influences efficiency and economic growth by providing security that increases the willingness of individuals to invest, improves credit demand and supply, and facilitate efficient land transactions that enable producers with higher abilities gain access to land (Barrows & Roth, 1990).

In theory, tenure security (often equated to individualisation and land title registration) is assumed to engender both demand and supply side effects on productivity (Platteau, 1995). On the demand side, it provides incentives for investing in soil conservation measures, land improvements and other productivity-enhancing operations since farmers are assured of reaping the stream of benefits associated with their investments.

On the supply side, land tenure security is expected to facilitate farmers' access to credit to finance farm investment projects (Barrows & Roth, 1990). The neo-classical hypotheses imply that tenure insecurity constraints the household by limiting their willingness to invest and produce at optimal levels. Coase (1960) initiated a flurry of property rights research that perhaps reached its peak with Alchian and Demsetz (1973). Barzel (1989) and

Eggertsson (1990) provided useful discussions of the early property rights research literature. Much of this early property rights literature (with Demsetz, 1967 serving as an example of the neoclassical economics tradition) was quite optimistic about the evolution of property rights toward economic efficiency. Three important criteria for efficiency of property rights are (1) universality—all scarce resources are owned by someone; (2) exclusivity—property rights are exclusive rights; and (3) transferability—to ensure that resources can be allocated from low to high yield uses.

Property rights are the social institutions that define or delimit the range of privileges granted to individuals of specific resources, such as parcels of land. Private ownership of these resources may involve a variety of property rights, including the right to exclude non-owners from access, the right to appropriate the stream of economic rents from use of and investments in the resource, and the rights to sell or otherwise transfer the resource to others. Property rights institutions range from formal arrangements, including constitutional provisions, statutes, and judicial rulings, to informal conventions and customs regarding the allocations and uses of property. Such institutions critically affect decision making regarding resource use and, hence, affect economic behaviour and economic performance (Mahoney, 2004; Jongwook & Mahoney, 2005).

Property rights theory does not emphasize who owns land, but rather analyzes the formal and informal provisions that determine who has a right to enjoy benefit streams that emerge from the use of land and who has no such rights (Libecap, 1989; Eggertsson, 1990; Bromley, 1991). Thus, property rights involve a relationship between the right holder, others, and a

governance structure to back up the claim. Property rights consist of two components: the rule and its enforcement mechanism. The rules may derive from state law, customary law, user group rules, and other frameworks. Enforcement of statutory law is usually the responsibility of the State, which means that the rights ground on formal laws. Property rights based on other types of rules may be enforced by customary authorities or by a user group, which manages the distribution of rights or members of that group define or enforce rights among themselves. The nature and strength of property rights (land rights) profoundly condition economic decision making. There is strong consensus that well-defined and well-enforced property rights (security of tenure) internalize externalities and thereby, guide decision-makers to consider the social consequences of their actions (Alemu, 1999; Bruce, 1998).

Secured property rights give sufficient incentives to the farmers to increase their investment in land improvement which in turn increases productivity (Deininger, 2003), It is natural that without secured land tenure, farmers do not feel emotionally attachment to the land they cultivate, and hence do not invest in land improvement. Even though the ability to make productive use of land will depend on policies in areas beyond land tenure security that may warrant separate attention, it is important to examine the effect of secure land rights on household soil improvement and output. The theoretical basis of this study is therefore drawn on the neoclassical theory of land tenure security but under indigenous customary tenure.

Empirical Literature Review

This study presents a review of literature on the land tenure security studies in Africa and elsewhere.

Approaches of the land tenure research in Ghana

In Ghana, the approaches adopted by studies investigating the tenure security-productivity hypotheses reveal a certain degree of inclination to perceptions of superiority of individualised land rights or the necessity for land titling. As a result, the inquest into the apparent failures of the land title security hypotheses of neoclassical theory appears lopsided with emphasis on identifying analytical and modelling deficiencies as opposed to interrogating issues that border on conceptualisation and operationalization of land tenure security, the most significant parameter of the Neo-classical theory of land tenure security. The common response to the failure to observe expected relationships between tenure security, land improvement and hence productivity is the attempt to argue that tenure security is endogenous and that earlier studies lacked the econometric rigour to adequately account for the perceived endogeneity of tenure security. Many of the more recent investigations of the tenure security- land improvement and productivity hypotheses have therefore focused on resolving the issues of endogeneity in tenure security mostly through the use of the robust econometric modelling (Besley, 1995; Hayes *et al.*, 1997; Twerefou, *et al.*, 2011). The findings of these studies have done little to resolve the inconclusiveness surrounding the relationship between tenure security and soil improvement.

Most of the findings are mixed and in some cases contradictory (Besley, 1995; Migot-Adholla *et al.*, 1991). Using the same data set as Migot-Adholla *et al.* (1991), Besley (1995) assumed that land rights were endogenous with farmer investment aimed at improving their rights over land. The study concluded that better land rights facilitated investment in Wassa but not in Anloga, a direct opposite of the findings made by Migot-Adholla *et al.*, (1991). Twerefou, *et al.* (2011) in their study of tenure security, investments and the environment in Ghana, set tenure security as endogenous. The findings of the study were mixed in terms of the relationship between tenure security and farm investments, with the conclusions raising doubts about the endogeneity of tenure security assumption. They found that investment in farmlands in Ghana were low, appeared not to enhance tenure security and argued that the reverse causation assumption of tenure security enhancing investment seemed non-existent. Twerefou *et al.* (2011) concluded that tenure security appeared to be an incentive for investment when endogeneity was not controlled; the study established a significant positive effect of tenure security on farm investment, though the authors alluded to challenges with the robustness of the result. This conclusion is however contradicted by Dzanku (2008) even though he treated tenure security as exogenous.

Goldstein and Udry (2006) employ an innovative approach to investigating the tenure security productivity nexus. In their study of investment and productivity in agriculture in Ghana, they demonstrate that individuals who hold powerful positions in a local political hierarchy have more secure tenure rights and as a consequence invest more in land fertility and have substantially higher output. They further show that the intensity of investments on different plots cultivated by an individual corresponded to that individual's security of tenure over those specific plots and, in turn, to the individual's position in the political hierarchy relevant to those specific plots. The underlying difference in approaches used has little or nothing to do with the mechanics of models used but with the definition and measurement of tenure security. The variation in approaches and findings make the question of what constitutes tenure security within the context of Sub-Saharan African in general and Ghana in particular crucial for both research and land policy reform. The security of property rights in land is a process involving customary legitimisation of rights followed by formal or statutory validation of those rights. Toulman (2005), as cited in Dzanku (2008), asserts that the processes of securing land rights is a two-step process with the first step involving the recognition of a claim as being legitimate by neighbours and others within the neighbourhood, usually in accord with local norms and values. The second step involves validation, thus, recognition of the claim to land by the state. He argued that in practice, the absence of state recognition may not matter if land is not under particular pressure, and if local systems work reasonably well. It is essential to stress that the latter validation without

the former may not be enough to secure even usufruct rights in several African jurisdictions.

Land tenure security and land improvement investment

To begin with, Fort (2008) examined the homogenization effect of land titling on investment incentives in Peru. The study employed Difference-in-Difference estimation technique. The results showed that there is a positive effect of land titling on land investment as well as the value of investment made. Land titling proved to be effective in providing the needed security of tenure in this case and induced investment in land improvement. The implication of this finding is that land titling is the avenue through which land holders can be made tenure secure hence people without land titles are perceived as been tenure insure.

Do and Lyer (2008) examined the impact of land tenure security (land titles) in Vietnam using a household survey data and employing econometric analysis found a significant statistical relationship between land titling and land investment and its positive effects in the Vietnamese case.

Another study by Deininger and Chamorro (2004) examined the impact of land tenure security (land titling) on land investment in Nicaragua using a survey data of 1360 farmers and supplemented with 461 households that were randomly sampled and employing OLS, and as well the random and fixed effect techniques found that tenure security (titling) increased the propensity of farmers to invest in land improvement.

Similarly, Alston, Libecap and Schneider (1995) examined property rights to land in the Brazilian Amazon, using survey data and found that land

tenure security (land titling) increased the incentive of settlers to undertake land improvement.

Furthermore, Carter and Olinto (2003) in their study of the impact of property right on the quantity and composition of land investment, using a farm-level panel data set derived from a stratified, multi-stage random sample of 300 producer household distributed across three distinctive regions of rural Paraguay in 1991 and 1994. The study used panel data econometric methods and found that formal land rights had a positive and significant effect on land improvement investment. The implication of this finding in the Paraguay experience is that people with title deeds are in the best position to invest in their lands while those without such title deeds are deemed tenure insecure and did not have any motivation to invest in their lands.

In the same direction, Li, Rozelle and Huang (2000) in their study of land Rights, Farmers Investment incentives and Agricultural Production in China, using a questionnaire that covered 1073 plots from 612 households found that formal land rights had a positive and significant effect on productivity enhancing investment in land, including soil improvement which led to higher agricultural productivity.

Also, Van den Broeck, Newman and Tarp (2007) in a cross-sectional study of land titles and rice production in Vietnam found that formal land rights positively and significantly influenced land improvement investment which led to higher rice productivity.

According to Laiglesia (2004) in Nicaragua, possession of legal property documents in enhancing agricultural investment incentives increased the probability of carrying out land-attached investments by 35%. Bruce and

Migot-Adholla (1994) also found that land titles and clarity of land rights played an important role for providing incentives for investment in land use. Besides, a study by Feder *et al.* (1988) in Thailand shows that certification of land titles to farmers provided not only tenure security but also higher level of land investment and higher land price. Titled land had higher capital stocks of 56-250% and use of labor (increased by 8-15%), draft power (increased by 25-39 %), and fertilizers and pesticides (increased by 23-34%) as compared to untitled land, resulting in higher output and productivity

In Costa Rica, tenure security as a result of protected land right had brought about increased farm investment per unit of land. Increased investment and higher output and income were also realized on titled land in Costa Rica, Brazil, Ecuador and Paraguay (Salas *et al.*, 1970; Feder & Nishio, 1998). Also, the study by Vilamizar (1984) at three Brazilian states shows that investment per hectare is substantially greater on titled land than untitled land. Similarly, a survey study made by Inter-America Development Bank (IDB) (1986) in Jamaica revealed that there was a greater incidence of permanent and semi-permanent crops among farmers with titled lands than untitled lands. According to the IDB's report, following the bestowing of certificates farmers planted more permanent and semi-permanent crops. The measure of land tenure security as the possession of land title deeds seem to be an effective indicator of land tenure security in the above mentioned empirical studies.

However, the African experience of land titling appears somewhat different. Hombrados *et al.* (2015) examined the impact of land titling on agricultural production and investment in Tanzania using household data of 2008 and 2009 and employing a theory-based approach and a propensity score

matching technique found no significant impact of land tenure security (land titling) on agricultural production and investment.

Tsegaye *et al.* (2012), in their study on the impact of land certification on sustainable resource management in Dryland Areas of Eastern Amhara Region, Ethiopia. Fifteen Kebeles from three Woredas and 20 households per Kebele were selected using stratified random sampling techniques. The study employed the probit model and found that land tenure security (land certification) did not increase crop productivity in the study area. This means that land certification did not incentivise households to invest enough in their farm lands to boost yields.

In the same vein, Giri (2010) examined the effects of land certification on farmers' soil improvement and conservation in the central Rift Valley in Ethiopia using a questionnaire and employing descriptive statistical analysis found that land tenure security (land certification) did not influence investment in land soil improvement and conservation in Beressa, Ethiopia.

Adding to the findings in the African experience, Jacoby and Minten (2007) in their study of Land Titling in sub-Saharan Africa, using a questionnaire covering over 1,700 households in 38 communities of Lac Alaotra in Madagascar in April-May, 2005 found that there was no significant positive effect of land title on plot-specific improvement and a corresponding no impact on crop production. The study suggested that formal land titling should not be seen as a magic bullet in raising land improvement investment and Productivity in Rural Madagascar.

Moor (1996) in his study in Manicaland province of Zimbabwe argued that there was no positive impact of land rights status on land

investment activities and productivity. The study demonstrated that tenure security has no significant positive effect on farmers' land investments and hence increment in yield.

Evidenced from Kenya, where titling has been systematically implemented show that there has been no clearly discerning impact from titling on land improvement (Barrows & Roth, 1989; Carter, Wiebe, & Blarel, 1989; Platteau, 2000).

In Zimbabwe, Harrison (1987) found little variation in soil improvement and the productive performance between smallholder farmers with no land title and large scale commercial farmers with land titles.

Following these findings, it holds that the conceptualization of land tenure security as the possession of title deed in the African context where customary tenure is predominant does not hold and the impact of (informal) security of tenure on land soil improvement may not be realized. Therefore, there is the need to consider context specific indicators of tenure security. This study therefore seek to address this reductionist view of land documentation as analogues to security of tenure by looking at dimensions of local indicators of land tenure security (Land Rights and Land Disputes) that influences soil improvement investment and hence, output of maize households in the Northern region of Ghana.

Goldstein and Udry (2006) in their study the profits of power, examined the impact of ambiguous and contested land rights on investment and productivity in agriculture in Akwapim, Ghana. They concluded that individuals who hold powerful positions in local political hierarchy were more tenure secure and invested more in land fertility (soil improvement) and hence

achieved higher output. Though, the study took into account the customary tenure nature of the study area, as they did not reduce security of tenure to possession of title deed, they did not consider other dimensions of land tenure security that can influence land improvement investment and hence farm output.

Twerefou *et al.* (2011) in their study of tenure security, investment and the environment in Ghana found that investment in farmlands in Ghana were low, appeared not to enhance tenure security, and the reverse causation of tenure security enhancing investment seemed non-existent. They further concluded that tenure security appeared to be an incentive for investment in farmland improvement. This again affirmed the hypothesized link between tenure security and land improvement investment. The study captured tenure security as a bundle of rights and it best catered for an undeveloped land market economy like Ghana where agricultural lands are mostly not registered. However, they did not consider land disputes which is common in African and for that matter Ghana and the northern region as an indicator of land tenure security and hence its effect on land investment.

Muyanga and Gitau (2014) in their study in Kenya using a farm plot level data and employing a truncated normal hurdle model found that land disputes affected smallholder farmers' optimization behaviour. This means that land disputes adversely affect security of land tenure and reduces the incentives of land holders to undertake land practices (soil improvement) that are optimizing. This study therefore includes land dispute as a dimension of land tenure security in its analysis.

Land tenure security and agricultural production

There has been considerable literature in Sub-Saharan Africa on the uncertainty as to land rights. A study in Mpigi District by Aluma *et al.* (1995) found that individual rights of sale were claimed by only 55 percent of Mailo households in Uganda. However, studies of the effect of differences in tenure systems and tenure security on agricultural investments and productivity were lacking. Studies (Feder *et al.*, 1988; Feder & Nisho, 1999) have also found that tenure security may have an impact on investment and productivity through its effects on size of holdings. Place and Hazell (1993), Carter *et al.* (1994) and Patel *et al.* (1995), found that farm size was inversely related to productivity in the low-input farming systems.

A large majority of research examining the linkages between tenure security and productivity found there to be little relationship. The first study of this was by Place and Hazell (1993) which found no evidence of productivity differences across different bundles of land rights in Rwanda, Ghana, and Kenya. Hunt (2003) also finds similar results for Kenya, in that the registration programme of land failed to yield significant results on productivity though soil improvement due to reasons such as an undeveloped credit system. Pender *et al.* (2004) similarly did not find evidence that land tenure security had an effect on agricultural intensification in a national level study in Uganda. In the same way, Place and Otsuka (2002) found no impact of tenure security variables on productivity in Uganda. However, Gavian and Ehui (1999) found that total factor productivity (TFP) was similar across plots under different tenure arrangements in Ethiopia as efficiency measures and input use offset each other. Pender and Fafchamps (2006) confirmed this relationship using

different econometric techniques. Deininger, Ayalew and Yamono (2006) found that tenure security variables did impact on productivity in Uganda through their impact on investments in land improvement, but had no other direct effect.

Deininger and Jin (2006) found that stronger transfer rights have a positive effect on terracing investment in Ethiopia which itself is found to have a significant impact on productivity. In another study, Deininger and Castagnini (2006) found that the presence of land conflicts had a debilitating effect on agricultural productivity across Uganda of the order of reducing it by half on disputed plots. This is because land tenure security does not directly affect agricultural productivity but through its indirect effect on inducing landholders incentives of investing in productivity enhancing practices such as land improvements and conservation, and hence the effects of land dispute on land investment is negative as it poses tenure insecurity.

A study on land tenure security and natural resource management and productivity in semi-arid areas in Kenya by Mwakubo (2002) revealed the importance of land tenure security on land management. The study was carried out in Machakos and Kitui Districts; Two modelling strategies were used, Tobit to determine both probability of farmers deciding to terrace and the intensity of terracing; while, three stage Least Squares to establish the direct and indirect effects of tenure on terracing levels and productivity. The study findings showed that intensified terracing is significantly influenced by tenure security, and terracing levels and productivity was directly related. Generally, it can be viewed that, land tenure security is an important ingredient in land

investment specifically for the investment that conserve soil, improves its fertility and hence productivity.

The article by Abdulai, Owusu and Goetz (2011) on land tenure differences and investment in land improvement measures (theoretical and empirical analysis), develops a theoretical framework to examine the relationship between land tenure security and households' investment in soil-improvement and conservation measures. With the use of multivariate Probit model; the study tested the hypothesis that investment in productivity-enhancing and conservation techniques are influenced by land tenure arrangements. Both theoretical and empirical results generally disclose that land tenure security significantly influence farmers' decisions to undertake land improvement and conservation measures. However, the findings of the study revealed that land tenure security does not affect farm productivity. It is the investment in land improvement that is expected to relate to farm productivity and not the tenure variable directly per se. All other things being equal, when a farmer undertakes soil improvements (mulching, terracing, manuring, fallowing) the land is expected to become more fertile and hence boost farm output.

Research Gaps

Most of the studies did not consider the tenure security, land improvement and agricultural output with reference to a particular crop. This lack of disaggregation with a crop specific reference may not give the true reflection of the effect of land tenure security on land soil improvement and hence agricultural output.

Another gap identified bothers on the conceptualization of tenure security in the context of an undeveloped land market economy such as those of Sub-Saharan Africa and for that matter Ghana.

It was also found that the dimensions of tenure security that influences investment in farmland soil improvement were not adequately explored.

Chapter Summary

In this chapter, the theoretical literature on conceptualisations of land tenure security and the neoclassical theory of land tenure security has been explored. The Chapter also looked at empirical literature review on the following; approaches of the Land tenure research in Ghana, land tenure security and land investment, and tenure security and agricultural production in Africa and elsewhere. It was found from the literature that there exist knowledge gaps that bother on the conceptualisations of land tenure security.

CHAPTER THREE

RESEARCH METHODS

Introduction

The purpose of this chapter is to explain the methodology used in investigating the link between land tenure security and soil improvement as well as the link between soil improvement and maize output. The order of presentation was as follows: research philosophy, research design, description of the study area, justification of choice of study area, source and type of data used. The rest of the chapter focused on the theoretical and empirical models of the study, estimation procedure and estimation method that were carried out in the study.

Research Philosophy

The term epistemology (what is known to be true-legitimate knowledge) (Davidson & Tolich, 2003; Sarantakos, 2005) as opposed to ontology (what is believed to be true-reality) (Davidson & Tolich, 2003; Patton, 2002; Sarantakos, 2005) encompasses the various philosophies of research approach. The objective of every scientific research, is to expand the frontiers of knowledge by a process of transforming things believed into things known. Two major research philosophies have been identified in the tradition of science, namely positivist (sometimes called scientific) and interpretivist (also known as anti- positivist) (Galliers, 1991).The positivist and post-positivist paradigms are ‘reality-oriented’, with both assuming that there is a ‘real’ world that can be understood, analyzed and measured (Patton, 2002). These two paradigms distinguish unaffected (scientific knowledge) and belief (no empirical verification)

According to Campbell and Russo (1999), as cited in Patton(2002), the focal difference between the positivist and post-positivist paradigms is that, the latter confesses knowledge about the ‘real’ world is limited and relative (rather than absolute). The interpretivist approach, however, contends that only through the subjective interpretation of and intervention in reality can that reality be fully understood. The positivist argued that reality is stable and can be observed from an objective viewpoint, without interfering with the phenomenon under study. They expound further that a phenomenon should be isolated and that observations should be repeated.

Patton (2002) illuminates that constructivism is an alternative paradigm that proposes that the human world is different from the natural world, and studies on these should be different too. This is in sharp divergence with what the positivists believe. Constructivism assumes that reality is socially constructed founded on the way people making accounts of the world and gain impressions based on culturally defined and historically situated interpretations and personal experiences (Sarantakos, 2005).

A qualitative methodology naturally follows from the constructivist-interpretivist paradigm, whereas quantitative methodology follows positivist. The qualitative approach in this study is focused on to the exploration and discovery of the phenomenon under investigation (land tenure security, soil improvement and productivity). Hence, inductive logic is predominant, pointing at theory generation rather than theory testing. The inductive approach is not steered by theoretically derived hypotheses, but by questions in the search for patterns within the subjects (Patton, 2002). Deductive logic may also be applied for specific situations.

The researcher is in no way related to the respondent, and is also not part of the enumerators, but just adopt the existing data to test hypotheses and in the end, the predictions of the theories are verified. This process is driven by positivist conception of the scientific method, which rest on the formulation of theoretical hypotheses. The hypotheses are then subjected to empirical tests, in order to either accept or reject the theory.

Research Design

The study sought to analyse the link between tenure security and farm soil improvement as well as the link that exist between soil improvement and maize output of households in the Northern region of Ghana. This was a non-experimental study which relied on quantitative analysis of household cross-sectional data collected by the Innovations for Poverty Action (IPA) in the three districts (Savelugu-Nanton, Tamale Metropolis and West Mamprusi) in the Northern region of Ghana in 2011 cropping season.

Using a cross-section survey design implies the researcher has no control over the respondents but collects the responses of the household unit within the time under consideration. Using a cross-sectional data have some benefits and limitation. Some of the benefits include, more efficiency, able to identify and measure effects of variables, used to prove and/or disprove theories and among others. Its limitations include inability to analyse behaviour or effects over a period to time, Potential for selection bias and among others.

The Study Area

The study was conducted in the Northern region which is the largest region in Ghana in terms of landmass (Ghana Statistical Service (GSS), 2012). It covers an area of 70,383km² making up close to 30 percent of the entire land area of Ghana and lying between 8-10⁰N and 0-2⁰W (GSS, 2012; UN, 2014; Yaro, 2013). The study area lies between sub-humid and semi-arid climatic regimes. The region is drained by the black and white Volta Rivers and their tributaries. The land is mostly flat, with an altitude of about 150m above sea level.

The vegetation is guinea savanna which is gradually transforming into Sudan savanna woodland characterized by drought-resistant trees, interspersed with grasses (Blench & Dendo, 2004). The region lies in the dry woodland savanna ecological zone with warm temperatures of between 14⁰C and 42⁰C (Kranjac-Berisavljevic, *et al.*, 1999) all year round. It has a single rainy season with intermittent droughts from April to October. The amount of rainfall recorded annually varies between 750 -1050 mm. The dry season starts in November and ends March/April. Maximum temperatures occur towards the end of the dry season and minimum temperatures in December and January, with an annual mean temperature of 25⁰C. The Northern region is bounded by the Upper East and Upper West to the north, the Brong Ahafo and Volta regions to the south, the Republic of Togo to the east, and La Cote d'Ivoire (Ivory Coast) to the west.

According to Nyari (2008), agriculture accounts for more than 90 percent of household income in the northern region. It is mainly rainfed, and production is mainly for subsistence (Hasselberg, 2013). Empirical evidence

(ODI, 2005; World Bank, 2011; Yaro, 2013) shows that agricultural production for export does not exist in the region. The farming system usually involves a combination of growing food crops and keeping animals for multiple purposes. Among the major crops grown are maize, millet, rice yam, cassava, and various pulses and vegetables. The cropping system practiced in this region include multiple cropping, and intercropping (Kombiok, Buah & Sogbedji, 2012).The major staple food crop (maize) is grown by families for consumption at home and/or for sale. In addition to the cultivation of crops, the rearing of cattle, sheep, goats and fowls is an integral component of agricultural systems in the Northern Region.

The 2010 Ghana census put the population of the Northern region at 2,479,461, representing over 10 percent of the total population of the country (GSS, 2012). The region currently has 25 districts including one Metropolis and three Municipalities (GSS, 2010). Specifically, the IPA used in its sampling and data collection, one metropolitan, one municipality and one districts, thus, Tamale Metropolitan, Savelugu-Nanton municipality and West Mamprusi district respectively. The study employed IPA 2011 dataset to ascertain the relationship between land tenure security, soil improvement and maize output in the Northern of Ghana. The characteristics of each area are presented briefly below.

Tamale metropolitan Area

Tamale is the capital and medium-sized city of the Tamale Metropolis as well as the Northern region of Ghana. Traditionally, Tamale is called Gulkpegu (part of Dagbon) headed by the Gulkpe-Naa (Chief). The Tamale Metropolitan Assembly (TaMA) was set up in 2004 under the Legislative

Instrument (LI) 1801 but was established under Legislative Instrument (L.I) 2068 of 2012. It is the only Metropolitan Assembly in the three northern regions and has 3 sub-metros under its jurisdiction. It is divided into three Sub-Metros; Tamale North Sub-Metro, Tamale Central Sub Metro and Tamale South Sub-Metro.

The Metropolis lies between latitude 9°18'N and 9°26'N and between longitude 1°15'E and 1°23'W. The Metropolis has a total landmass estimated at approximately 720 km², making up a little over 1 percent of the landmass of the Northern Region and approximately 180m above sea level. The Metropolis is boarded to the North by the Savelugu-Nanton municipal, South by Central and East Gonja Districts, East by the Yendi Municipal and West by Tolon-Kumbungu District (see fig. 1`).

According to GSS (2012), Tamale metropolis is the largest settlement in Northern Region and also reported to be one of the fastest growing cities in West Africa. The population of Tamale Metropolis is reported as 371,351 with 185,995 (50.09 %) being males and 185,356 (49.91 %) being females (GSS, 2012). Tamale Metropolis, the most urbanized district has an average household size of 7 (GSS 2012).

The Metropolis experiences one rainy season starting from April/May to September/October with a peak period in July/August which is believed to have been influenced by the moist South-West monsoon winds. It has a unimodal rainfall pattern with mean annual rainfall is 1100 mm within 95 days of intense rainfall. The dry North-East Trade winds (Harmattan) influence the metropolis dry season which begins in November and ends in March. The mean day temperatures range from 33 to 39°C while mean night temperature

range from 20 to 22° C. The mean annual day sunshine is approximately 7.5 hours.

Savelugu-Nanton

The Savelugu-Nanton Municipality is one of the 26 administrative areas of the northern region and its administrative capital is Savelugu. Savelugu-Nanton Municipality was carved out of the Western Dagomba District Council in 1988 under the Local Government Act 462, 1993 by Legislative Instrument (LI) 2071. The Savelugu-Nanton Municipality is located at the northern part of the Northern Region of Ghana with a total land area of about 1790.70 sq. km. It shares boundaries with West Mamprusi District to the North, Karaga District to the East, Tolon/Kumbungu District to the West and Tamale Metropolitan Assembly to the South (see figure 1).

The Municipality has about 149 communities with a lot of the communities concentrated at the southern part. Most of the communities are rural and about 80 percent of the population reside in these rural areas. According to GSS (2012), the population of the municipality is one hundred and thirty nine thousand two hundred and eighty three (139,283) with a growth rate of 3 percent. The commonest type of livelihoods in this municipality is agriculture which rely primarily on rain fall.

The municipal is characterized by cultivation of staples like rice, millet, groundnuts, yams, cassava, maize, cowpea and sorghum. But the most cultivated staple crop is maize. Cash crop production is very minimal and includes shea nut, Soya beans, cotton and cashew. Agriculture employs about 97 percent of the economically active population found in the municipality (GSS, 2012). The agricultural season start with the first rain in / late April or

early May through to late August or early September. The amount of rainfall (600mm to 1000mm) received is said to be very low compared to other parts of the country yet enough for one planting season (SNDA, 2015). However, maize yield are expected to be high due to improved seedlings varieties (Ragasa *et al.*, 2014) but one way or the other maize yield are low which is believed to have come from land tenure related concerns. The region has been prone to land disputes and other related land insecurities (Sulemana, 2009) that have seen large tracks of land left uncultivated and even where there is cultivation, much is left to be desired.

Agricultural activity in the district is highly dependent on family labour while hired labour is also used, and the use of implements like tractors, and among others is common. Households' sizes remain large in the district to meet the family agricultural labour requirement. The largest household size comprises twenty two (22) members and the smallest house comprising one (1) member. On the average six (7) members constitutes a household. The Savelugu-Nanton Municipality largely reflect the characteristics of the Northern region of Ghana.

West Mamprusi

The West Mamprusi District is one of the 26 administrative areas of the northern region and its administrative capital is Walewale. The districts' administrative capital can be located along the Tamale-Bolgatanga trunk road, 109 kilometers away from Tamale. Administratively the district has 49 Assembly persons, 7 sub-districts thus 6 Area Councils and 1 Town Council and lies within the Northern Region. The district was carved out of the old Gambaga district in the Northern Region in 1988 under LI 2061.

The district lies roughly within latitude $9^{\circ}55'N$ and $10^{\circ}35'N$ and longitude $0^{\circ}35'W$ and $1^{\circ}45'W$. It has a total landmass estimated at approximately 5,013 km². It is boarded to the north by Builsa, Kasena-Nankana and Bolgatanga districts, in the Upper East Region; to the south by North Gonja, Karaga, Tolon/Kumbungu and Savelugu -Nanton municipal in the Northern Region; to the west by the Sissala East and Wa East districts; and to the East by East Mamprusi district.

The district is characterized by a single rainy season, which starts in late April with little rainfall, rising to its peak in July-August and declining sharply and coming to a complete halt in October-November. Mean annual rainfall ranges between 950mm - 1,200mm. The dry season is characterized by Hamattan winds. The district records its maximum day temperatures between March-April which is around about $45^{\circ}C$ while minimum night temperatures is around $12^{\circ}C$ normally recorded in December- January.

The district lies within the Guinea Savannah Woodland, composed of short trees of varying sizes and density, growing over a dispersed cover of perennial grasses and shrubs. The vegetation is usually affected by bush fires, which sweep across the savannah woodland each year. The district has allocated 45,781 hectares to cultivation and roughly the average farm size is between 0.5 - 2.4 hectares. Land is normally acquired either by inheritance, from the chief or family heads. About 77.4 percent of the people depend on agriculture for their livelihood. Large amounts of land are therefore put to the cultivation of major crops like maize, millet, guinea corn, groundnuts and cotton. Important minor crops cultivated include legumes, cassava and yams. Figure 1 below shows the map of the study area.

improvement on maize output. It was again selected because of the availability of data (IPA data set) that captures most of the variables of interest of this study.

It must be stated that the data from all the three areas were combined for analysis rather than treating them as individual cases. This is because; the three areas are homogeneous in areas like agro-ecological zones, land tenure systems, cropping system, and crop portfolios.

Data Source and Type

The data used in this study originated from a household-level survey by the Innovation for Poverty Action (IPA) in the three districts (Savelugu-Nanton, Tamale Metropolitan and West Mamprusi) in the Northern region of Ghana in 2008/2009, 2009/2010, 2010/2011. For this study (cross-sectional) the 2011 data set of the said data sets was used. In order to have a rich set of background data on individuals and a representative sample frame, IPA initially drew a sample from the Ghana Living Standards Survey 5 plus (GLSS5+) survey data which was conducted from April to September 2008 by the Institute of Statistical, Social and Economic Research (ISSER) at University of Ghana-legon in Collaboration with the Ghana Statistical Service. The GLSS5+ was a clustered representative random sample, with households randomly chosen based on a census of selected enumeration areas in the 23 Millennium Development Authority (MiDA) districts. From the GLSS5+ sample frame, IPA selected communities in the Northern region of Ghana in which maize farming was dominant to undertake a survey “Examining under Investment in Agriculture (EUI)” survey in these three districts. Figure 2 shows the map of study area.

other income and transfers). Data was also collected on rainfall in each community. For the purpose of this study, the 2011 data set was used.

Model Specification

The neo-classical theory of land tenure security holds that security of land tenure significantly affects farmers' land improvement decisions and output (Barrows & Roth, 1990). Thus, the theory holds that, tenure insecurity constraints an individual or the household by limiting their willingness to invest and produce at optimal levels. Therefore, soil improvement depends on tenure security, and output depends on soil improvement. Tenure security is defined by whether or not the farmer has full right to the land (bundle of rights definition) and again as whether the land is being disputed or undisputed (assurance definition) (Barrows & Roth, 1990; Burgess, 2001; Otsuka, 1993; Place *et al.*, 1994). Employing the neoclassical theory and taking inspiration from Kille (1993) discrete and limited dependent variable model on farm investment, specifies a theoretical model of soil improvement.

Theoretical econometric model

Soil improvement is modelled as

$$I_i^* = X_i \beta + \alpha T_i + u_i \quad (1)$$

Where, X_i is a vector of exogenous explanatory variables, β is a vector of parameters of the variable contained in X , T is the tenure security variables, α is a vector of parameters of the tenure security variables and μ_i is a stochastic error term.

However, in a binary outcome model, the dependent variable I_i takes the form;

$$I_i^* = \begin{cases} I = 1 & \text{if } I^* > 0 \\ I = 0 & \text{if } I^* < 0 \end{cases} \quad (2)$$

Discrete and limited dependent variable follows the logit or probit approach. The logit model is systematically specified below: Beginning from a Linear Probability Model (LPM):

$$P_i(I = 1/X) = P(I = 1/X_1 + X_2 + \dots + X_K) \quad (3)$$

P_i is the probability that a household improve soil $X_1, X_2 \dots X_K$ denote explanatory variables. $I = 1$ means the event does occur (household did improve soil) $I = 0$ means the event does not occur (the household did not improve soil) The LPM above assumes that $P_i(I=1/x)$ increases linearly with X i.e. the marginal or incremental effect of X remain constant throughout. This seems impracticable since most economic variables tend to be nonlinearly related. Moreover, since $E(I=1/x)$ in linear probability models measures the conditional probability of an event occurring given X , it must necessarily lie between 1 and 0. Although this is true a priori, there is nothing in the procedure that guarantees that \hat{I}_i , the estimators of the estimated probabilities, $E(I/x)$ will necessarily fulfil this restriction, and this is the real problem with OLS estimation of the LPM.

The more common and practical procedure is to model the probabilities by some distribution function other than the cumulative normal. The logit model which uses Cumulative Distribution Frequency (CDF) to model regressions where the response variable is dichotomous, does not only guarantee that the estimated probabilities fall between the logical limits 0 and 1 but also ensures that the relationship between P_i and X_i is nonlinear. Then the logistic model specifies that the probability of a household improving soil is given by:

$$P_i(I=1/x_i) = \frac{\exp(x\beta)}{1+\exp(x\beta)} \quad (4)$$

Where, $X\beta$ is $\beta_1X + \dots + \beta_kX_k$

Equation (4) implies that the probability of a household not improving soil ($1 - P_i$) can be written as;

$$1 - P_i = \frac{1}{1 + \exp(x\beta)} \quad (5)$$

$$\text{We can therefore, write } \frac{P_i}{1 - P_i} = \frac{\exp(x\beta)}{1 + \exp(x\beta)} \left(\frac{1 + \exp(x\beta)}{1} \right) = \exp(x\beta) \quad (6)$$

$\frac{P_i}{1 - P_i}$ is simply the **odds ratio** (OR) in favour of the household undertaking soil improvement, thus, the ratio of the probability that a household will improve soil to the probability that a household will not improve soil. The odds ratio is equal to $\exp(x\beta)$. This shows the probability of a household undertaking soil improvement for a given value of an explanatory variable, holding all other explanatory variables in the model constant. When both the dependent variable (Y) and the explanatory variable (X) are dichotomous, the odds ratio is the probability that Y is 1 when X is 1 compared to the probability that Y is 1 when X is 0.

Taking the natural log of equation (6) gives the Logit Model as specified below:

$$L_i = \ln\left(\frac{P_i}{1 - P_i}\right) = Z_i = \beta_1 + X_i \beta_2 + u_i \quad (7)$$

Since the maximum likelihood is used; the estimated standard errors are asymptotic. The standard normal (Z statistic) is used, instead of the t statistic, to evaluate the statistical significance of the coefficient. The reason is that if the sample size is large enough, the t distribution converges to the normal distribution. If L_i , the logit, is positive, it means that when the value of the regressor (s) increases, the odds that the regressand equals 1 (meaning that some event of interest occurs) increases. If L_i is negative, it means that the odd

that the regressand equals 1 decrease as the value of X increases (Greene, 2000).

In practice, the Logit and Probit models are chosen to analyse variables for which dependent variable has binary response. The Logit and Probit models are very similar and close to each other. In practice the logit and Probit model yield similar results, the only observed different between them is the variance, whereby in the Probit we assume $(\varepsilon/x) = 1$ and in the Logit model we assume $(\varepsilon/x) = \pi^2/3$. For this case, the logit and probit cumulative curve differ in tails whereby one has a thicker tail and the other has a thin tail (Long, 1997). Thus, using either model leads to the same result (Maddala, 1983).

However, the objectives of this study is to investigate the effect of land tenure security variables (land right and land dispute) on households' soil improvement and subsequently estimate the effect of soil improvement on maize output and hence estimating soil improvement which is a dummy ,1 for those who improve and 0 for those who did not, by logit model and feeding it in a maize output model in examining the effect of soil improvement on maize output will result in biased and inconsistent results as the decision to improve or not to improve may suffer from selectivity bias and hence endogeneous. The best way to cater for this is to use a model that addresses the endogeneity problem of the soil improvement variable. A number of models (Heckman selection, instrumental variable (IV), propensity score matching (PSM)) have been suggested in addressing endogeneity (Alene & Manyong, 2007). The most effective of the models is the endogeneous switching model (Kleenman & Abdulai, 2013). This model enables us to achieve the first and second objective of the study by estimating the soil improvement decision (selection

equation) using the probit maximum likelihood estimation and the third objective by estimating maize output (outcome equation) using the full information maximum likelihood method (FIML).

The maize output is given as:

$$y = X\beta + Z\tau + \varepsilon_i \quad (8)$$

where y refers to maize output measured in bags, X is a vector of explanatory variables (excluding soil improvement) which influence the outcome variables (maize output), and it includes household, farm and socioeconomic characteristics such as age, gender and educational level of household head, household size, farm size, access to credit, farm income etc. Z is a vector of variable including a dummy for soil improvement and its coefficient τ measures the effect of soil improvement on maize output. The above mentioned socioeconomic factors including the tenure variables (land right and land dispute) affect the decision of households to undertake soil improvement.

The soil improvement variable (Z) is potentially endogenous since it is not randomly assigned and households might have decided whether or not to improve soil. This could result in self-selection bias. Consequently, estimating equation (8) with ordinary least squares (OLS) regression technique might produce biased results. In order to overcome such biases Heckman selection, instrumental variable (IV) and propensity score matching (PSM) have often been suggested. However, some limitations have been observed with these methods. For instance, there is a problem of model functional form imposition by either the Heckman selection or IV methods. This assumption implies that household participation only has an intercept shift but not a slope shift in the

outcome variables (Alene & Manyong, 2007). Another approach often used to tackle selection bias is propensity score matching (PSM). Although this does not impose functional form assumptions, it assumes selection is based on observable variables (Asfaw, 2010). The PSM, therefore, tends to produce inconsistent result when there are unobservable factors that affect both soil improvement and maize output.

In order to overcome these issues, the study employed the endogenous switching regression (ESR) technique. It (ESR) was first used by Lee (1978) and Maddala (1983) to address self-selection as well as any systematic differences across groups. In this approach outcome equations are specified differently for each regime, conditional on the soil improvement decision of households (Kleenman & Abdulai, 2013). The ESR method is recently being applied in evaluating the impacts of decisions of farmers on farm performance and household welfare (; Asfaw *et al.*, 2012; Di Falco *et al.*, 2011; Kleemann & Abdulai, 2013; Negash & Swinnen, 2013).

The study specifies a model of soil improvement and maize output, in the setting of a two-stage framework. In the first stage, a probit model of soil improvement is specified to investigate the effect of tenure security variable and other socioeconomic variables on the decision to improve or not improve soil. The second stage estimate the determinants of maize output for those who improve soil and those who did not improve soil conditional on a specific criterion function.

Empirical model specification

Let $A^* > 0$ be the latent variable that captures the soil improvement decision function. We specify the probit model of soil improvement as (Di Falco, *et al.*, 2011):

$$I_i^* = \tau Z_i + \varepsilon_i \quad \text{with } I_i = \begin{cases} 1 & \text{if } I_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (9)$$

Where, \mathbf{Z} is a vector of factors influencing the decision to improve soil or not to improve soil, τ is a vector of unknown parameters, ε_i is an error term with a zero mean and variance of σ_n^2 .

From equation (9), soil improvement is further empirically presented as;

$$I_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \dots + \alpha_n Z_n + \varepsilon_i \quad (10)$$

Where, Z_1 is farm size, Z_2 is farm income, Z_3 is credit access (dummy), Z_4 is basic education, Z_5 is secondary education, Z_6 is tertiary, Z_7 is age of head, Z_8 is age squared of head, Z_9 is sex of head, Z_{10} is marital status of head, Z_{11} is household size, Z_{12} is tractor ownership of head of household, Z_{13} is farm labour type, Z_{14} is farm distance, Z_{15} is land right, Z_{16} is land dispute, and Z_{17} is livestock unit.

Probit maximum likelihood estimation is employed to estimate the parameters of equation (10).

The decision to improve soil or not is influenced by maize output potentials. Let the maize output function be $y = f(X)$, where y is maize output and X is a vector of inputs. To estimate a separate regression function for each of the two situations, we specify the following production functions:

$$\text{Regime 1: } y_{1i} = X_{1i} \beta_1 + u_{1i} \text{ if } I_i = 1 \text{ (improved soil)} \quad (11a)$$

$$\text{Regime 2: } \ln y_{2i} = X_{2i} \beta_2 + u_{2i} \text{ if } I_i = 0 \text{ (did not improve soil)} \quad (11b)$$

Where, y_{1i} and y_{2i} represent vectors of maize output for those who improved soil and those who did not respectively. β_1 and β_2 are parameters estimated for soil improvement and no soil improvement regimes respectively. X_i represents a vector of explanatory variables such as production inputs (e.g., farm income, credit, labour), household head's and farm households' characteristics. From 11a and 11b, maize output is further empirically presented as;

$$y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + u_i \quad (12)$$

Where, $\beta_1 \dots \beta_n$ are parameters to be determined, $X_1 \dots X_n$ are explanatory variables included in the model and u_i is an error term. Output of maize is logged as a form of data transformation. Transformation of data is one way to soften the impact of outliers as the most commonly used expressions, squared root and logarithms change the larger values to much greater extent than they do to the smaller values. Therefore equation (12) is logged and is presented as follows;

$$\log y = \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \dots + \beta_n X_n + u_i \quad (13)$$

The error term ε_i in the selection equation (1) and (u_{1i}, u_{2i}) of the outcome equations (11a) and (11b) are assumed to have a trivariate normal distribution with zero mean and covariant matrix θ (i.e. $(\varepsilon, u_1, u_2) \sim N(0, \theta)$), with

$$\theta = \begin{bmatrix} \sigma_n^2 & \sigma_{n1} & \sigma_{n2} \\ \sigma_{1n} & \sigma_1^2 & \cdot \\ \sigma_{2n} & \cdot & \sigma_2^2 \end{bmatrix} \quad (14)$$

Where, σ_n^2 is the variance of the error term in the selection equation (1) which can be assumed to be equal to 1 since the coefficients are estimable only up to a scale factor (Lee, 1978; Maddala, 1983) σ_1^2 and σ_2^2 are the variance of the error terms in the maize output function (11a) and (11b) respectively; σ_{1n}

represents the covariance of ε_i and u_{1i} and σ_{2n} is the covariance of ε_i and u_{2i} . Since y_{1i} and y_{2i} are not observed simultaneously, the covariance of u_{1i} and u_{2i} is not defined and therefore indicated as dots.

Since the error terms of the selection equation (1) is correlated with error terms of the output functions (11a) and (11b), the expected values of u_{1i} and u_{2i} conditional on the selection are nonzero and are defined as (Fuglie & Bosch, 1995; Lokshin & Sajaia, 2004):

$$\left[E(u_{1i} | I_i^* = 1) = \sigma_{n1} \frac{\phi(Z_i t)}{\varphi(Z_i t)} \right] = \sigma_{n1} \gamma_{1i} \quad (15a)$$

$$\left[E(u_{2i} | I_i^* = 0) = -\sigma_{n2} \frac{\phi(Z_i t)}{1-\varphi(Z_i t)} \right] = \sigma_{n2} \gamma_{2i} \quad (15b)$$

Where $\phi(\cdot)$ refers to the standard normal probability density function and $\varphi(\cdot)$ the standard normal cumulative density function. If the estimated covariance σ_{n1} and σ_{n2} are statistically significant, then the decision to improve soil and the maize output are correlated. This implies there is evidence of endogeneity or sample selectivity bias (Madala & Nelson, 1975).

Equations (11a) and (11b) can then be specified as (Maddala, 1983, Di Falco et al, 2011):

$$E(\langle y_{1i} | I_i^* = 1, X_i \rangle) = X_{1i} \beta_1 + \sigma_{1n} \gamma_{1i} \quad (16a)$$

$$E(\langle y_{2i} | I_i^* = 0, X_i \rangle) = X_{2i} \beta_2 + \sigma_{2n} \gamma_{2i} \quad (16b)$$

$$E(\langle y_{2i} | I_i^* = 1, X_i \rangle) = X_{1i} \beta_2 + \sigma_{2n} \gamma_{1i} \quad (16c)$$

$$E(\langle y_{1i} | I_i^* = 0, X_i \rangle) = X_{2i} \beta_1 + \sigma_{1n} \gamma_{2i} \quad (16d)$$

In this model, there is a need for better identification which often requires an exclusion restriction (Lokshin & Sajaia, 2004). This implies there should be at least one variable that affects households' soil improvement decisions but does not directly affect the households' output. This study

includes variables such as livestock unit, and farm distance taking inspiration from common practice in the agricultural economics literature (Coelli & Battese, 1996; Solis *et al.*, 2007), allows us to use an exclusion restrictions variables related to the farm and farm household's characteristics. Many previous studies on impact of agricultural technology adoption have employed distance variable for identification purposes (Asfaw *et al.*, 2012; Di Falco *et al.*, 2011; Negash & Swinnen, 2013).

Given the assumptions of the distribution of the error terms in equation (11) above, the logarithmic likelihood function is stated as (Lokshin & Sajaia, 2004):

$$\ln L_I = \sum_{i=1}^N I_i \left[\ln \Phi \left(\frac{u_{1i}}{\sigma_1} \right) - \ln \sigma_1 + \ln \varphi(\theta_{1i}) \right] + (1-I_i) \left[\ln \Phi \left(\frac{u_{2i}}{\sigma_2} \right) - \ln \sigma_2 + \ln \varphi(\theta_{2i}) \right] \quad (17)$$

Where, $\theta_{ji} = \frac{(Z_i t + \rho_j u_{ji} / \sigma_j)}{\sqrt{1 - \rho_j^2}}$, $j=1,2$ and ρ_{ij} refers to the correlation coefficient

between the error term in the selection equation ε_i and the error terms u_{1i} and u_{2i} in the outcome equations of those who improve soil and those who did not improve respectively.

The signs of the correlation coefficients ρ_{1j} and ρ_{2j} have economic interpretations (Fuglie & Bosch, 1995). If ρ_{1j} and ρ_{2j} have alternate signs, then individual farm households improved soil on the basis of their comparative advantage: those who improve soil have above-average returns from soil improvement and those who chose not to improve soil have above-average returns (farm returns) from non-improvement in soil.

The impact of soil improvement was determined as follows: For a farm household that improve soil with characteristics Z_i and X_i , the expected maize output y_{1i} , is given as;

$$E(y_{1i}/I_i^* = 1) = X_{1i}\beta_1 + \sigma_{u1t}\gamma_{1i} \tag{18}$$

The same household if it had not improved soil (counterfactual) would have had expected maize output given as:

$$E(y_{2i}/I_i^* = 0) = X_{1i}\beta_2 + \sigma_{u2t}\gamma_{1i} \tag{19}$$

The change in maize output due to soil improvement is determined as:

$$ATT = E(y_{1i}/I_i^* = 1) - E(y_{2i}/I_i^* = 0) = X_{1i}(\beta_1 - \beta_2) + \gamma_{1i}(\sigma_{u1t} - \sigma_{u2t}) \tag{20}$$

The impact assessment literature refers to these estimates as average treatment effect on the treated (ATT) (Lokshin & Sajaia, 2004).

Table 1: Expected Signs of the Explanatory Variables

Variable	Type	Expected Signs	
		Soil Improvement	Logoutput
Logoutput	Continuous	N/A	N/A
Soil improvement	dummy	N/A	N/A
Farm income	Continuous	+	+
Credit	Dummy	+	+
TLU	Continuous	+	+
Tractor	Dummy	+	+
Farm size	Continuous	-	-
Marital status	Dummy	+	+
Gender	Dummy	+	+
Household size	Continuous	+	+
Labour	Dummy	+	+
Age	Continuous	+	+
Age square	Continuous	-	-
Education	Categorical	+	+
Farm distance	Continuous	-	-

Source: Author (2018)

Definition and Measurement of Variables and expected signs

The operational definition of variables and how they are measured in this study are presented. This is in two categorization, the dependent variables and the independent variable in the study. These are presented below;

Soil improvement (I)

This is the activities undertaken by a household to improve the soil. Improvements made in land are essential for soil fertility. For the purpose of this study, a household is said to have improved soil if it undertakes any of the following activities, levelling the land terrain, terracing, manuring, performs crop rotation on the land or fallow land. This is captured as a dummy with 1 if the farmer undertook any of these and 0 otherwise.

Output (Y)

This measures the amount of maize that the household produced during the crop season. This is a continuous variable and is measured in bags. Thus, it measures the number of bags of maize that the household produced. Output of maize is logged as a form of data transformation. Transformation of data is one way to soften the impact of outliers as the most commonly used expressions; square root and logarithms change the larger values to a much greater extent than they do to the smaller values.

Land rights

The household is said to have a full right or a non-full right. For the purpose of this study, a household is said to have a full right if the head can sell the land and as well can use land for collateral and a non-full right if can neither sell the land nor uses it for collateral. A household with a full right is therefore said to be tenure secure while those with a non-full right is said to be

tenure insecure. This definition of land tenure security follows closely that by Place *et al.*, (1994) that defined tenure security as a bundle of rights held on land, thus the right of sale, transfer and the right to collateralize land. This is captured as a dummy with 1 if the household has full right and 0 if the household has a non-full right. The study expects that land right will positively impact households soil improvement. Feder and Feeny (1991) found that land right affected the adoption of land improvement in crop cultivation with those having secure rights recording higher level of land improvement investment.

Land dispute

This is another important variable considered to influence land tenure security in the study. A household is said to have tenure security if its land parcel does not experience disputes while on the other hand, tenure insecure if the land experiences disputes. This is captured as a binary with 1 if the land is disputed and 0 if it is undisputed. This definition falls in line with Place *et al.* (1994) assurance definition of land tenure security. Thus, the certainty that an individual's claim to land would not be lost. It is this certainty that makes the household feels secure. Therefore, a household with a disputed farm land would be less certain of maintaining land compared to a household with undisputed land. Therefore, households with undisputed lands are more tenure secure and would improve soil more than those with disputed lands. Therefore, absence of dispute (undisputed) is expected to have a positive relationship with soil improvement. Muyanga and Gitau (2014) found that the presence of land dispute negatively affected smallholder farmers' incentives to undertake optimization behaviour such as land improvement which has a potential effect of optimizing farm output.

Age

This is a continuous variable capturing the years of the head of the household. The age of the head of household may have a lot of influence on the household soil improvement and conservation practices as well as on the output of the household. Wagayehu and Lars (2003) reported that younger heads of household would be more accommodative to new ideas and would invest in new innovations and hence soil improvement. Danso-Abbeam, Setsoafia and Ansah (2014) argued that younger farmers were more likely to be more enthusiastic in taking risk associated with innovations and as a result undertook farm investment and hence soil improvement and achieved higher output. The study therefore expect age to positively relate to soil improvement and maize output.

Age square

This is the square of the household head age variable. It is expected to negatively relate to soil improvement by households. Long (2003), Lichtenberg (2001) and Wagayehu and Lars (2003) have reported negative association between investment in soil and water conservation, as heads of household become older. According to Adebisi and Okunlola (2013), Shumet (2011), Anyanwu (2009), Abay and Assefa (2004) age can be related with farm experience and as age increases, farm experience also increases and hence farm investment as well as production will increase up to a certain age limit where further increases in age will have no impact. Shumet (2011) in Ethiopia and Amaza *et al.* (2006) in Nigeria reasoned out that, as agriculture in developing countries is more of labor intensive, after a certain age limit, where farmers' physical strength decreases, their ability to improve land as

well as their production will finally decrease. Nwaru and Iwuji (2005) reported that entrepreneurship gradually becomes less as the entrepreneur becomes older. This is because the innovativeness as well as the mental capacity and physical abilities of the entrepreneur are challenged and this negatively affect the investment incentive as well as the output of the entrepreneur. This finding is applicable to the farm setting with the heads of household serving as the entrepreneurs. The researcher therefore expect age square to negatively relate to farm soil improvement and maize output.

Gender

This captures the sex of the household head. It is captured as a dummy with 1 if the head is a male and 0 if the head is a female. It is believed that women often farm on marginalized and less fertile lands than males due to inequitable and biased access to land against women (Quisumbing, 1996). Since women farmlands are often less fertile, it is expected that women would undertake soil improvement than men. On the other hand, women farmers often face daunting constraints on access to productive resources, such as credit facilities, tractors, new technologies and among others (Bindlish & Evenson, 1993; Dey, 1994; Quisumbing, 1996) and these constraints negatively impact on their ability to undertake soil improvement as well as on their output. This variable is therefore expected to respectively influence soil improvement and output of female headed households negatively.

Household size

This captures the total number of people living in the household. It is measured as a continuous variable. Household size is expected to influence soil improvement as well as farm output of the household positively or

negatively. A larger family size means that a variety of labour capacity is available in the form of young, middle aged and elderly members used for production and hence more people will be engaged in the farms and hence higher output. This variable was measured by the actual number of people who stay together in a particular household and are subjected to the decision making of the household head in respect to contributing to the labour supply and sharing in the rewards of the farming activities. A hypothesis that is testable is that the larger households are more likely to have more available labour than smaller households.

On the other hand, the larger the household size the more likely is the household to come under pressure to make more land available for residential houses and that may lead to negative relationship with on farm soil improvement as well as output of the household. Similarly, although a larger family size puts extra pressure on farm income for food and clothing and other household necessities, it most certainly ensures availability of enough family labour for the labour-intensive farm operations to be performed when necessary and without the family's direct cash commitment (Parikh *et al.*, 1995). This study expects household size to have a positive influence on soil improvement and on farm output. Adeniji, Voh, Atala and Ogungbile (2007) found a positive relationship between household size and adoption of improved agricultural production technologies. Households with large family size readily adopt new agricultural production practices than those with smaller family size since labour force is available.

Marital status

This captures whether the head of household is married or unmarried. It is as well captured as a dummy with 1 if the head is married and 0 if otherwise. The marital status of the household head to a large extent would influence his or her planning in relation to his or her household soil improvement decisions as well as the output targets. Married people may benefit from the advantage of supporting each other with regards to productive resources more than those who are unmarried. Marital status (married) is therefore expected to positively influence investment in soil improvement as well farm output. Anigbogu et al. (2015) found that marital status is essential in influencing households' land improvement investment as well as output. They found that married status had a positive significant effect on both land improvement and output.

Tractor ownership

This variable looks at tractor ownership by households. It is captured as a dummy with 1 if the household owns a tractor and 0 if otherwise. It is expected to positively influence maize output. Takeshima, Houssou and Diao (2018) found that tractor ownership by maize household significantly increased output in maize production in Ghana. Tractor ownership by households is therefore expected to positively affect maize output.

Educational Level

This variable is categorical in nature. It captures the level of education the household head has attained. The categories of educational attainment are; no education, basic, secondary, and tertiary. Here, household heads with no education are used as the base category. Education is an important variable

that could influence the investment decision of households including their decision to improve soil as well as their farm output level. It has been documented that education enhances farmer's abilities to acquire new information and respond quickly to changes in their environment, hence, educated heads are more likely to adopt new agricultural technologies than their non-educated counterparts (Danso-Abbeam *et al.*, 2014). In their study in Ghana, Danso-Abbeam *et al.* (2014) reported that education had a significant positive effect on household's investment in agriculture. It is also the case that education of the head could greatly influence the household output level. Dengu and Lyne (2007) report a positive correlation between education and crop output in South Africa.

Farm Size

The variable reflecting the farm size is a continuous variable, and was measured in hectares. It was expected to negatively influence soil improvement by the household as well as their output levels because more land is usually associated with more resources and efforts requirement to undertake soil improvement and as well increase output. Given that productive resources are scarce, a larger farm size would eventually lead to low farm soil improvement as well as low farm output. It is therefore expected that the larger the size of land the less soil improvement takes place and the lower the chances of obtaining high maize output. Lamb (2003) found an inverse relationship between farm size and farm output. Also, Hazell, Poulton, Wiggins and Dorward (2010) observed a negative association between size of farm and output.

Farm Labour

This entails the labour used by the household. There are options available to the household when it comes to farm labour needs. The household can employ unhired labour (family labour, communal labour etc.) as well as hired labour. Under this study, labour is captured as a dummy with 1 for hired labour and 0 for non-hired labour. Hired labour refers to the man-hour that the household employed on their farm and whose services were paid for by the household while unhired labour refers to the man-hour that the household employed on their farm and whose services were not paid for by the household. This include, family labour, communal labour and among others. Theoretically, household labour that are usually farm owners are more motivated than hired labour and hence should be more efficient and productive even without supervision. However, according to Masterson (2007) “better” farmers opt to hire themselves out, rather than working on household farm and this reduces productivity on these farms. The impact of hired labour on output is expected to be positive.

Farm income

The variable reflecting farm income is a continuous variable. It is measured in Ghana cedis. This is another variable that is expected to positively influence soil improvement by households. A household with farm income is expected to undertake soil improvement. This variable is proxied by using household income expenditure financed by income from maize produce. The reasons for using this variable was informed by problems inherent in multiplying market price of maize by the quantity. It is clear that not all output produced by households are sold as part is consumed by the household and

since the amount consumed as well as the amount sold is not adequately captured by the data, straight- forward price-quantity multiplication will overstate the income of the households. Again, the households do not face the same market price for their produce and because of this possible variations in prices, the straight-forward multiplication of output by a common price is as well inappropriate. Therefore using expenditure as a proxy for farm income in this case is appropriate, though, it is not without challenges. It is expected to positively affect both soil improvement and maize output.

Tropical Livestock Unit (TLU)

This is measured as a continuous variable. TLU as proposed by Chilonda and Otte (2006) is a computation of all livestock owned by the household. It is calculated by using the formula; $TLU = 0.7 * \text{Cattle} + 0.2 * \text{Pigs} + 0.1 * \text{Sheep} + 0.1 * \text{Goats} + 0.02 * \text{Turkey} + 0.02 * \text{Ducks} + 0.01 * \text{Chicken}$.

The TLU therefore enables us to find the effect of all the livestock owned by the household in the analysis rather than including some livestock and excluding others. Apart from the possible income that can be derived from the sale of livestock, they also serve as a source of organic manure that is essential in improving the soil (Musafiri & Mirzabaev, 2014). It is therefore expected that TLU would positively influence soil improvement. It is also expected to positively affect maize output.

Credit

This captures whether the household had credit or not. It is as well captured as a dummy with 1 if the household had credit (from lending sources such as non-governmental organisations (NGOs), informal lender, formal lender (bank/financial institution), friends or relatives and Group based micro-

finance or lending including village savings and loans associations (VSLA)) and 0 if otherwise. Credit is expected to positively affect soil improvement by households as it avails finance to the households to undertake soil improvement. Also, it is expected that households that have credit would be able to purchase farm inputs that are output enhancing, such as weedicides, fertilizers etc. It is therefore expected that credit access will positively influence both soil improvement and maize output.

Farm distance

This variable captures the distance that households cover before they get to the farm site. It is a continuous variable measured in kilometres (km). This variable is expected to negatively influence households' soil improvement as well as maize output.

Estimation Technique

There are many methods to estimating models with endogeneity. These include the Heckman selection, instrument variable (IV) and propensity score matching methods. However, some limitations have been observed with these methods. The most efficient method to employ is the endogenous switching regression method (full information maximum likelihood method). This method first estimates the factors that influence the selection model, thus the decision to improve soil or not improve using the probit maximum likelihood estimation. The decision to improve soil is influenced by maize output potentials, so the model in the second stage sets two separate equations of maize output conditional on the decision to improve or not to improve soil. These two maize output equations are now estimated using the full information maximum likelihood method to determine the factors influencing

maize output of those who improved soil and those who did not. Using the ‘movestay’ command in STATA, the results of the selection equation and the outcome equations are displayed in a single table.

Chapter Summary

This chapter discussed the methodology for the study. The research design adopted for the study and the data used for the study. Secondary data was used for the study. This data was derived from Innovation for Poverty Action dataset for the three districts (Savelugu-Nanton, Tamale Metropolitan and West Mamprusi) of the Northern Region of Ghana. Since Soil improvement was believed to be endogeneous, the endogeneous switching regression model was employed to estimate soil improvement as well as the maize output.

CHAPTER FOUR

RESULTS AND DISCUSSION

Introduction

This chapter discusses the results obtained from the study. The chapter starts by reporting descriptive statistics of the variables used for the study and followed by descriptive analysis of variables. Finally, the chapter reports and discusses results generated from testing the hypotheses of the study (thus, the results obtained from the soil improvement Logit model and the maize output OLS model).

Descriptive Statistics

Table 2: Summary Statistics of Continuous Variables used in the Study

Variable	N	Mean	SD	Min.	Max.
Output	1,072	29.36	19.30	1	96
Farm Income	1,072	3990.24	1966.84	100	5000
Tropical Livestock	1,072	9.69	18.78	0.01	114.25
Unit					
Farm Size	1,072	0.64	0.58	0	4.25
Farm Distance	1,072	4.11	8.77	0	15
Household Size	1,072	7	3.40	1	22
Age of head	1,072	43.43	9.82	18	100
Age square of head	1,072	1982.61	1040.55	324	10000

Source: Author (2018)

From Table 2, on average, a household produced 29.36 bags of maize. The lowest output produced by a smallholder farm household in the region is 1 bag and the highest output of maize produced by the household is 96 bags. Also, on the average, a smallholder farm household in the Northern region has a farm income of Ghs 3,990.24. The least farm income a household can have in the region is Ghs 100.00 whilst the highest farm income a household can realized is Ghs 5,000.00. Generally, smallholder farm households' farm income in the study region can be said to be low.

Furthermore, it can be observed from Table 2 that, on the average, the tropical livestock unit of a household is 9.69 units. The lowest TLU of a household in the region is 0.01 units. And this from the conversion formula as proposed by Chilonda and Otte (2006) represents a household owning just a chicken.

Finally, from the study sample, the average size of a household in the Northern region consists of seven members. The lowest size of a household is one member and the highest size a household can consist of is twenty-two members.

Table 3: Tabulation of Discrete Variables used in the Study

Variable	Frequency	Percentage
Soil Improvement		
Yes	769	71.74
No	303	28.26
Land Right		
Full right	442	41.23
Non-full right	630	58.77
Land Dispute		
Undisputed	1,039	96.92
Disputed	33	3.08
Tractor		
Yes	209	18.81
No	902	81.19
Credit		
Yes	517	48.23
No	555	51.77
Farm Labour		
Hired labour	645	60.17
Unhired labour	427	39.17
Gender		
Male	596	55.60
Female	476	44.40

Table 3, Continued

Marital Status		
Married	790	73.69
Unmarried	282	26.31
Educ_Level		
No education	311	29.01
Basic	504	47.01
Secondary	217	20.24
Tertiary	40	3.73

Source: Author (2018).

From Table 3, approximately 71.74 percent of households undertook soil improvement whilst 28.26 percent of households did not undertake soil improvement. It can be observed from this study sample that majority (71.74%) of smallholder farm households in the Northern region undertook soil improvement. Also, on land right, about 41.23 percent of households in the region have full right to their lands whilst 58.77 percent of the households have non-full rights to their lands. It can be said from this study sample that majority (58.77%) of households in the Northern region do not have full right to their lands.

Moreover, about 73.69 percent of the head of households are married while 26.31 percent are not married. Majority of the head of households in the region are married. It can as well be seen from Table 3 that few (18.81%) households owns a tractor with majority (81.19%) of the households not owning a tractor. It can be concluded from this study sample that tractor ownership by households is not common in the Northern region.

Finally, about 29.01 percent of household heads in the region had no education whilst 47.01percent had basic education, 20.24 percent of the heads had secondary education and 3.73 percent had tertiary education. From these statistics, it can be observed that the education level attained by most household heads is secondary whilst a very few of the household heads had tertiary education. It is also evident that a significant proportion of household head in the region have no formal education at all.

Bivariate analysis of soil improvement and independent variables

Figure 3 presents results on the chi-square analysis of the association between land dispute and soil improvement. As can be seen, among households who farm on undisputed lands, 73.9 percent of them undertook soil improvement on their land compared to just 3.0 percent for the case of those whose lands are disputed. Besides, among those whose lands are disputed, an overwhelming majority (97.0%) did not undertake soil improvement on their lands compared to only 26.1 percent for the case of those whose lands are undisputed. The association between both variables is significant at one percent. This means that land dispute is crucial in explaining soil improvement by smallholder farm households in the Northern region. The implication of this finding is that having disputes on farmland adversely affect soil improvement by households in the region.

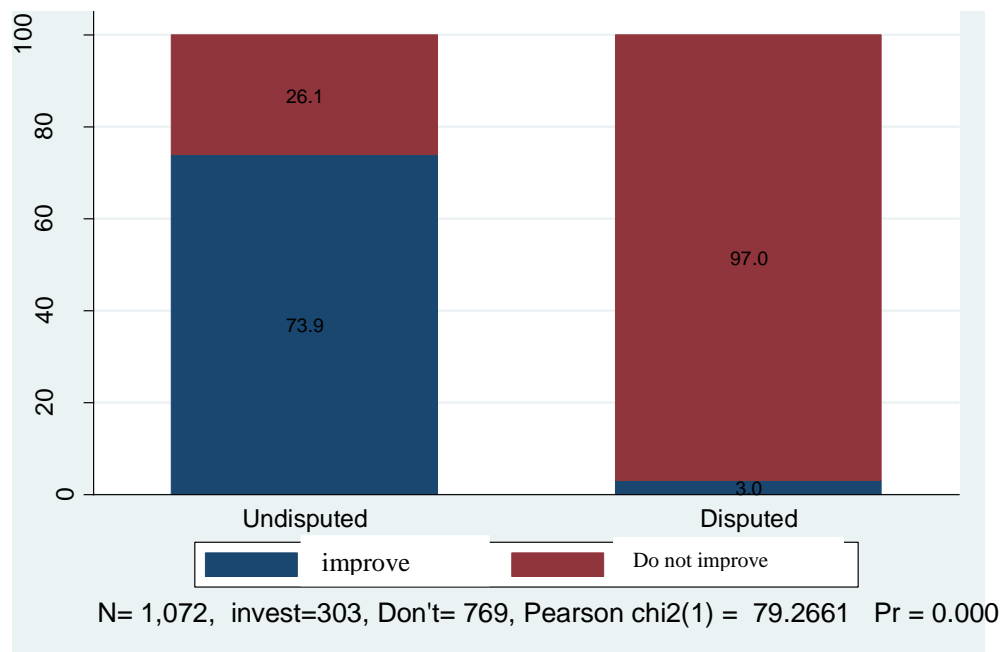


Figure 3: Proportion of Household Soil Improvement by Land Dispute

Source: Author (2018).

Figure 4 indicates the proportion of households who undertook soil improvement on their farmlands by land rights. As depicted in the figure, for households who have full right to their lands, majority (83.9%) of them undertook soil improvement compared to a figure of 63.2 percent on the side of those who do not have full land right. Again, just a few of the households (16.1%) who have full land right did not undertake soil improvement on such lands compared to a significant number of 36.8 percent for the case of households who did not have full land right. This association is statistically significant at one percent. This means that having full land right positively influences soil improvement by households in the region.

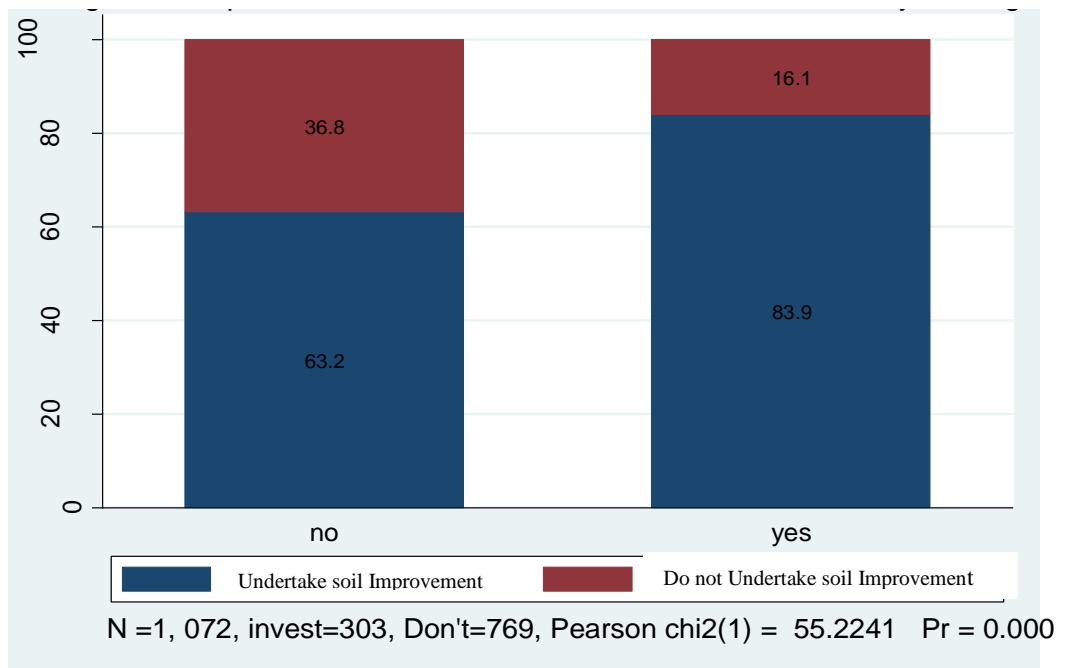


Figure 4: Proportion of household soil improvement by Land right

Source: Author (2018).

Figure 5 indicates the proportion of households' soil improvement by credit. As shown in the Figure 5, for households with credit, 80.7 percent of them undertook soil improvement compared to a figure of 63.4 percent for the case of those without credit. Again, only 19.3 percent of those with credit did not undertake soil improvement compared to a higher figure of 36.6 percent for the case of those without credit. The p-value from the chi-square test is significant at one percent. This means that credit access by households is essential in explaining soil improvement by households in the region. Thus, credit access positively influences soil improvement by households.

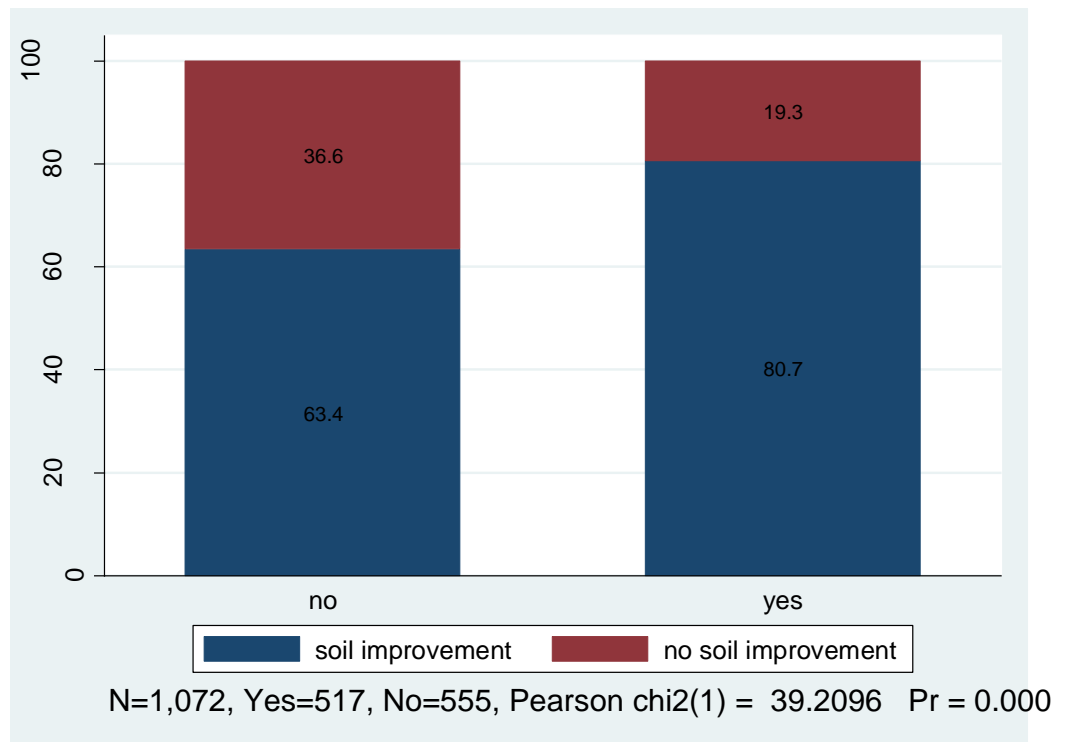


Figure 5: Proportion of household soil improvement by Credit

Source: Author (2018)

Figure 6 shows the proportion of households who undertook soil improvement by gender of the head. From Figure 6, among male headed households, 66.1 percent of them undertook soil improvement compared to 78.8 percent for the case of female headed households. Besides, 33.9 percent of the male heads did not undertake soil improvement compared to female heads with 21.2 percent. This association between gender of the head and soil improvement is significant at one. This means that the gender of the head of household matters in explaining soil improvement. It can be established that women undertake soil improvement more than men in the Northern region.

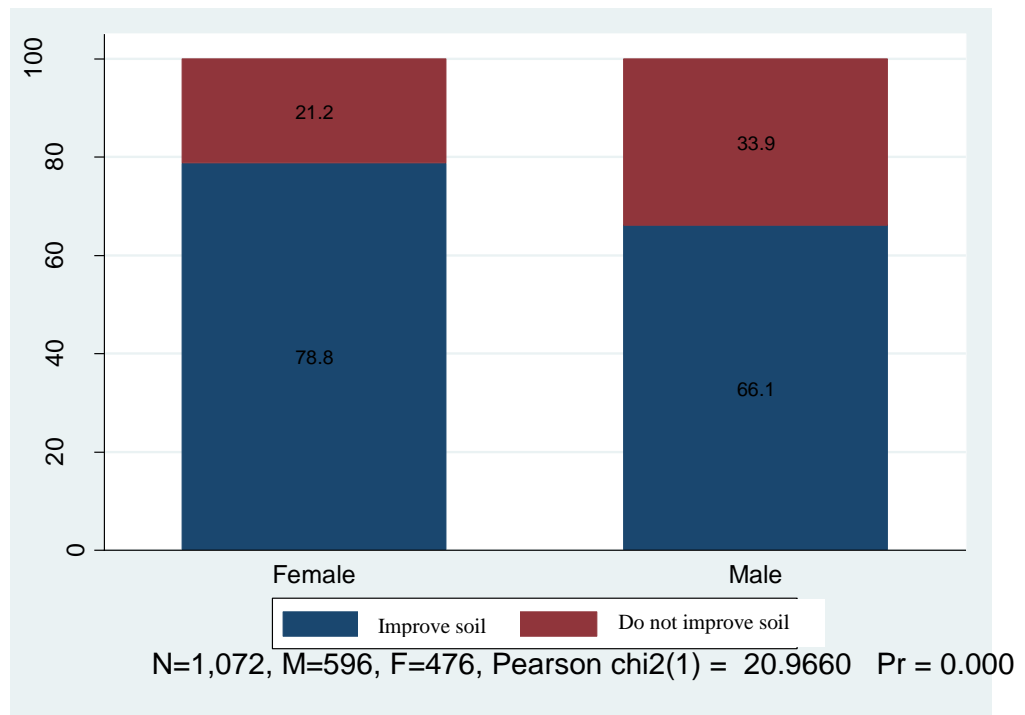


Figure 6: Proportion of household soil improvement by gender

Source: Author (2018).

Indicated in Figure 7, is the proportion of households heads who undertook soil improvement by marital status. Per figure 7, 73.7 percent of the married undertook soil improvement while 66.3 percent of the unmarried undertook soil improvement. For the married, 26.3 percent of them did not improve soil compared to 33.7 percent for the case of the unmarried. This association is equally significant at five percent. This means that marital status of household heads as well explains soil improvement by households. Thus, heads who are married are shown to improve soil than those not married.

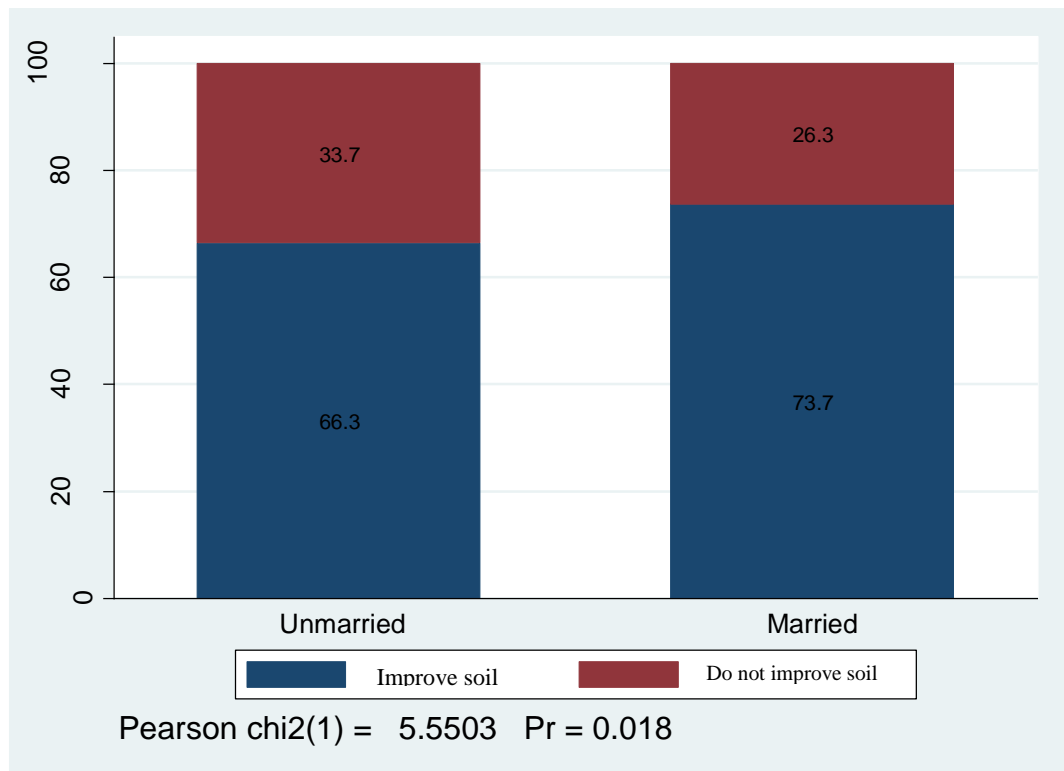


Figure 7: Proportion of household soil improvement by marital status

Source: Author (2018).

Figure 8 indicates the proportion of households' soil improvement by heads' education level. From Figure 8, among heads with no education, 69.5 percent improved soil while 30.5 percent did not undertake soil improvement. Also, 70 percent of those with basic education improved soil while 30 percent did not improve. Furthermore, among those with secondary education, 75.1 percent of them undertook soil improvement while 24.9 percent did not improve their soil. Finally, about 92.5 percent of those who had tertiary education undertook soil improvement while 7.5 percent did not undertake soil improvement. The association of soil improvement and education is significant at one percent. The implication of this, is that education is crucial in explaining soil improvement by households in the region. It can be established that secondary and tertiary education has proven to highly influence soil improvement by households in the region.

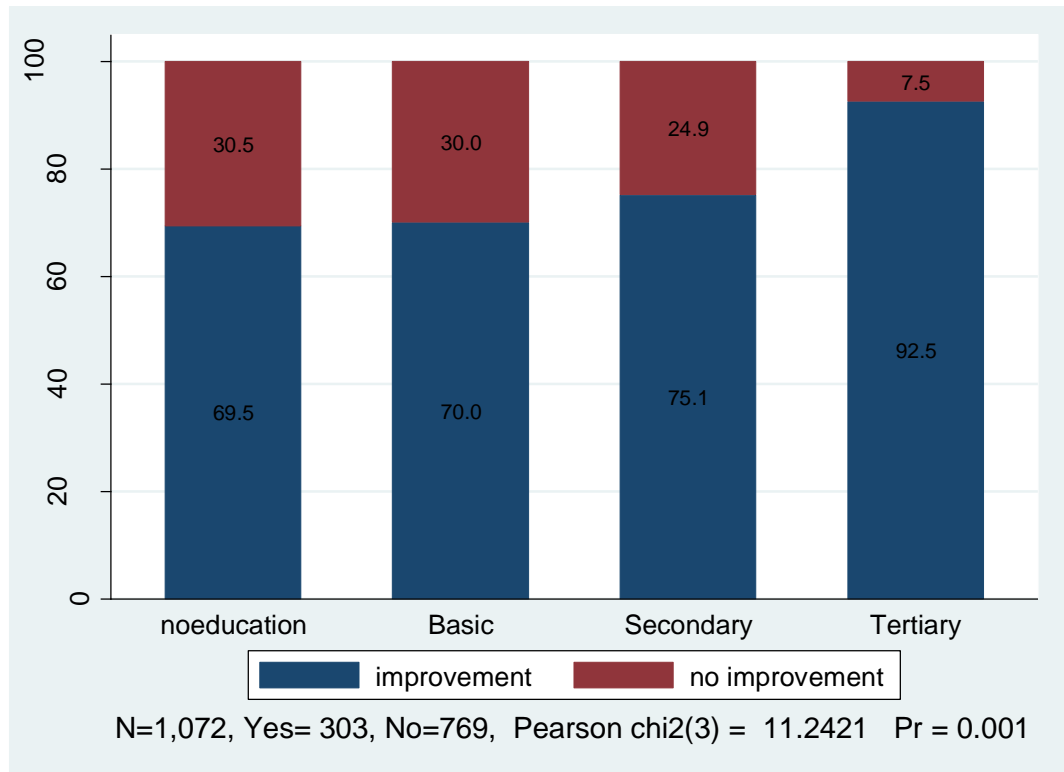


Figure 8: Proportion of household soil improvement by Education level

Source: Author (2018).

Bivariate analysis of maize output and independent variables

Table 4 shows a t-test of the difference in mean output of maize by soil improvement, Sex of household head, marital status of head, Credit, Labour, and Tractor ownership.

It is shown in Table 5 that, the mean output of maize for households who undertook soil improvement is 32 bags compared to 23 bags for those who did not undertake soil improvement on their farms. From these statistics, it is evident that household who undertook soil improvement on their farms recorded a 9 bags mean maize output more than those who did not undertake soil improvement. This is statistically significant at one percent. The implication of this finding is that soil improvement by households has proven to be effective in improving maize output in the Northern region

From Table 4, by gender, male headed households have higher mean maize output (30.19 bags) than female headed households (28.70 bags). There is a 1.48 bags difference in mean maize output in favour of male. However, this association is not significant. Though, there is no statistical significance in the association between sex of the household head and maize output, the difference in mean maize output in favour of male heads in the region is possibly accounted for by the fact that women face daunting constraints in accessing productive resources, such as credit, income, technological innovations and among others (Bindlish & Evenson, 1993; Dey, 1984 and Quisumbing, 1996) which negatively impact on their farm output. This finding is consistent with the finding of Udry, Hoddinott, Alderman and Haddad (1995) where output per hectare was higher for men farms compared to women farms.

For marital status, married heads have a higher mean output (29.99 bags) compared to the unmarried ones (29.14 bags). This difference of 0.857 bags in favour of those married is significant. The reason for this variation in output between those married and those not married may possibly be among other reasons the sharing of support in terms of productive resources. Anigbogu, Agbasi and Okoli (2015) found that marital status is essential in influencing output. They found that marriage has a significant positive effect on output level. Thus, the output of those who are married were found to be higher compared to those who were not married.

On the issue of credit, households with credit have higher mean output (30.48 bags) compared to those without credit (28.32 bags). The difference in mean output of 2.16 bags in favour of those with credit is significant at one

percent indicating the importance of credit in raising maize output. Thus, credit increases output of maize. This finding is consistent with the finding of Sedem, William and Gideon (2016) who found that credit access was a vital ingredient in boosting farmers output and hence their income in the Talensi district of Northern Ghana.

Households with hired labour have a mean output of 28.33 bags 30.88 compared to 30.88 bags of unhired labour. The difference in mean output of 1.89 bags in favour of unhired labour implies that hired labour negatively affect maize output of smallholder farm households in the region. However, this association between hired labour and maize productivity is not significant.

Finally, households with a farm asset like tractor have a mean output of 30.88 bags compared to the mean output of 28.99 bags for the case of those without tractor. The mean difference of 1.89 bags in favour of those with tractors implies that having a tractor increases maize output. This is statistically significant at five percent. Salam (1981) found that output on tractor farms were significantly higher than those on bullock farms in Pakistan.

Table 4: A t-test of Difference in Mean Output across Groups.

Variable	Output maize			
	Male	Female	Diff	p-value
Gender	30.19	28.70	1.48	0.2120
Marital status	Married	Unmarried		
	29.14	29.99	.857	0.0521
Credit	Yes	No		
	30.48	28.32	2.16	0.0671
Labour	Unhired	Hired		
	30.0457	28.33	1.72	0.1543
Tractor	Yes	No		
	30.88	28.99	1.89	0.0205
Soil improvement	Yes	No		
	32	23	9	0.0000

Source: Author (2018).

Effect of Land Tenure Security on soil improvement and maize output

To determine whether or not land right and land dispute respectively have effect on soil improvement and finally examine the effect of soil improvement on maize output, the endogeneous switching regression model was employed. Table 5 report estimates of the endogenous switching regression model estimated by full information maximum likelihood (FIML). The first column (1) presents the estimates of the selection equation (3) (soil improvement). It is estimated by a probit maximum likelihood method with soil improvement (I) being the dependent variable and all the other variables (including the instruments) being explanatory variables. The second and third

columns (column (2) and column (3)) report the estimates of the outcome equations, the maize production functions (4a and 4b) for those who improved soil (4a) and those who did not improve soil (4b) respectively. The likelihood ratio test indicates that the two equations are not independent (Prob>0.00). Here maize output is the dependent variable and explanatory variables do not include the chosen instruments. The estimations were implemented in STATA using the *movestay* command (Lokshin & Sajaia, 2004). The correlation (R_2) coefficient of the second outcome equation (4b) is significant, implying that we fail to reject the hypothesis of selection bias and hence the presence of endogeneity, indicating the need for the chosen estimation technique

Table 5- Results of the endogeneous switching regression

Variables	Soil		logOutput	
	improvement	Improved soil	Did not improve	
	(1)	(2)	(3)	
Farmsize	-0.869*** (0.150)	-0.217*** (0.029)	-0.264*** (0.0383)	
Logincome	0.318*** (0.048)	0.153*** (0.00829)	0.0872*** (0.0159)	
Credit	0.357*** (0.107)	0.00390 (0.0107)	0.0601 (0.0516)	
Educ. Level				
Basic	-0.039 (0.153)	0.0202 (0.0126)	0.303*** (0.0556)	

Secondary	-0.126	0.0305**	0.428***
	(0.263)	(0.0151)	(0.0728)
Tertiary	0.123	0.0397	0.474**
	(0.120)	(0.0262)	(0.240)
Age	0.0151***	0.00948***	0.00180
	(0.007)	(0.000875)	(0.00540)
Agesqr	-0.00157***	-0.00041***	-3.82e-05
	(5.38e-05)	(3.50e-05)	(5.18e-05)
Male	0.517***	0.163***	-0.0325
	(0.112)	(0.0110)	(0.0536)
Married	0.204	0.0465***	0.0677
	(0.132)	(0.0137)	(0.0554)
Hhsize	0.045***	0.0156*	0.00031
	(0.0174)	(0.0081)	(0.00165)
Tractor	0.011***	0.0498***	0.117
	(0.147)	(0.0139)	(0.0722)
Hired labour	-0.0666**	-0.00824***	0.00434
	(0.0299)	(0.00292)	(0.0130)
Distance	-0.048***		
	(0.168)		
Full land right	0.697***		
	(0.121)		
Undisputed	2.669***		
	(0.591)		
Livestock	0.0996***		

Table 5 continued

	(0.00338)		
Constant	-0.974*	3.242***	3.105***
	(0.513)	(0.0846)	(0.187)
R1		-0.00151	
		(0.059)	
R2			-0.300**
			(0.152)
Observations	1,072	1,072	1,072
L R test =3.16**			

Standard errors in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Source: Author (2018).

According to the results of the estimates of the selection equation (3) (soil improvement) in column (1) of Table 5, the following analyses can be made;

First, farm size shows a negative relationship with soil improvement. From column (1) of Table 5 of the probit maximum likelihood estimation, given a hectare increase in the size of the farm, the probability of a household undertaking soil improvement reduces by 88 percent and is significant at one percent. The implication of this finding is that the larger the farm size becomes the less likely households will improve soil. This finding is consistent with Byiringiro and Reardon (1996) who found an inverse relationship between farm size and soil improvement and conservation in Rwanda.

Also, farm income exhibits a positive relation with soil improvement by households. As shown in Table 5, holding all other variables constant, a smallholder farm household is 0.15 percent more likely to undertake soil improvement, given a percent increase in farm income. This is statistically

significant at one percent. This means that a household soil improvement decision is influenced by the household farm income. This finding is consistent with Koning, Heerink and Kauffman (1998) who asserted that farm income was essential for improving soil condition and increasing agricultural production in West Africa.

Credit access is another important factor that affects soil improvement by households. From the regression results as shown in Table 5, compared to households that did not have credit, a household with credit is 36 percent more likely to undertake soil improvement, holding all other variables constant and is statistically significant at one percent. The implication of this finding is that credit is very essential in determining soil improvement by smallholder farm households and those who had credit showed a more likelihood of improving soil. This finding is consistent with the finding of Kohansal, Ghorbani and Mansoori (2008) who found that credit access by farmers increased their investment in land improvement and by extension soil improvement in the Khorasan- Razavi Province.

The age variable shows a significant direct relation with household soil improvement. From Table 5, a household is 2 percent more likely to improve soil given a year increase in the age of the head. This means that as the household head age increases he or she gathers more experience that inclines him or her to proper farming techniques including soil improvement. It must however be acknowledged that this direct relation between age and soil improvement is not indefinite as there is a point in age increase that would not relate to soil improvement. The age variable exhibits non-linear relationship with soil improvement, the dependent variable. This is evident with the

behaviour of the age squared variable that would be discussed in the preceding paragraph. Wagayehu and Lars (2003) reported a direct relationship between age and farm land investment.

Age square variable shows a negative relationship with soil improvement. This means that households with older heads are less likely to undertake soil improvement. From Table 5, older heads are 0.2 percent less likely to undertake improvement in farmland soil. Long (2003) and Lichtenberg (2001) have reported negative association between investment in soil and water conservation and age squared of the head. However, the magnitude of the effect is not large.

Furthermore, the sex of the head of household also proved to be significant in explaining soil improvement by households. Thus, there is difference in the likelihood of undertaking soil improvement between male headed and female headed households. From Table 5, compared to a female headed household, a male headed household is 52 percent more likely to undertake soil improvement and is significant at one percent. ()

Household size shows a direct relationship with soil improvement. This implies that the larger the size of the household, the more likely the household to undertake improvement in soil. From Table 5, a household is 5 percent more likely to undertake soil improvement given a member increase in the size of the household. A possible explanation to this could be that as the household becomes larger, more labour is made available to support soil improvement by households. Again, as the household size becomes larger, the household becomes conscious of the need to intensify its food production in order to meet the food needs of its members and hence respond to an increase

in the size of the household by undertaking soil improvement to increase output (Ani, Kanya & Hassel, 2012). Similar finding was reported by Adeniji, Voh, Atala and Ogungbile (2007) who found positive relationship between household size and adoption of improved agricultural production technologies. Households with large family size may readily adopt new agricultural production practices than those with smaller family size since labour force is available.

As depicted in Table 5, compared to a household without full land right, a household with full right to land is 70 percent more likely to improve soil for maize cultivation and it is statistically significant at one percent. The implication is that, having full land right increases the likelihood of the household undertaking soil improvement. Feder and Feeny (1991) found that land right affected the adoption of land improvement in cultivation with those having secured rights (full) recording higher level of improvement investment in land cultivation. Adding to the same findings, Twerefou, Osei-Assibey and Agyire (2011) found that tenure security (land rights) had a positive and significant effect on land improvement investment. Evidenced from this study, having full right to land significantly and positively influences household soil improvement and hence the null hypothesis of land right having no effect on soil improvements is rejected.

Also, lands that are undisputed equally proved significant in explaining the likelihood of a household improving soil. For instance, as shown in Table 5, compared to a household whose land is disputed, a household with undisputed land is 2.7 times more likely to improve soil for maize cultivation and it is significant at one percent. This means that, land dispute has effect on

the probability of a household improving soil. Thus, those with undisputed land are more likely to improve their land compared to those whose lands are disputed. This finding is in line with the following findings. Muyanga and Gitau (2014) found that the presence of land dispute affected smallholder farmers' incentives to undertake optimization behaviour such as land improvement which had a potential effect of optimizing farm output. Kabubo-Mariara and Linderhof (2010) found that land tenure security (absence of disputes) is an important factor in influencing adoption of soil and water conservation investment. Goldstein and Udry (2008) found that those with secure tenure invested more in soil improvement (fertility) and achieved higher output. This implies that households with tenure security are more likely to improve their land, all other things being equal. Evidenced from this finding, the null hypothesis of land dispute having no effect on soil improvements is rejected.

The tropical livestock unit variable is also statistically significant at one percent and positively influences soil improvement by households. A unit increase in TLU will increase the probability of households improving soil by 10 percent. The implication is that TLU is also important in determining soil improvement by households. The possible explanation for this finding is the fact that the droppings of livestock serve as important organic manure which the households are likely to use in the improvement of their farmlands soil. It is also possible that household could generate additional income from the sale of livestock which can be used to improve soil. This finding is supported by the work of Musafiri and Mirzabaev (2014) who contended that land

fertilization (soil improvement) is facilitated by the presence of livestock within households.

Following the estimates presented in column (2) and column (3) of the outcome equation (10a) and (10b) respectively of Table 5, the following discussion can be drawn.

First, farm size shows a negative relation with maize output for households that improved soil and for households that did not improve soil. From column 2 and column 3 of Table 5, a hectare increase in farm size given that a household improved soil results in a 22 percent decrease in maize output. On the other hand, the effect of this on maize output given that the household did not improve soil is 26 percent decrease in output. It can be observed that the decrease in maize output for those who improved soil is less compared to those who did not improve soil. Soil improvement therefore mitigated the decrease in maize output and hence the output of households that improved soil were higher than those who did not improve soil. It can be established from this that soil improvement positively impacts on maize output. The observed negative relation between output and farm size is likely to be the result more of an inverse relation between size of farm and other inputs than of scale diseconomies. Factors that may have contributed to this inverse relation may include input constraints, uncertainty involving agriculture production and among other several factors. Consistent with the findings of Vu, Duc and Waibel (2012) in rural Vietnam, farmers with larger farm size recorded significantly lower output compared to their counterparts with smaller farm size. Besides, Lamb (2003) also found an inverse relationship between farm size and agricultural output. Other commentators

whose findings corroborate that of the current study includes Hazell, Poulton, Wiggins and Dorward (2010), Verschelde, Vandamme, D'Haese and Rayp (2011).

Also, farm income proves to have a significant positive impact on maize output for households that improved soil as well as those that did not. From column (2) and column (3) of Table 5, it is observed that a percent increase in farm income for households that improvement soil will increase maize output by 0.2 percent, while those who did not improve soil increases output by 0.1 percent. It is as well evident that there is a maize output gain for households that improve soil against those that did not given a percent increase in farm income. Farm income has shown to be important in influencing maize output and hence its availability would increase maize production in the study region. This finding is consistent with the findings of Koning *et al.*, (1998) who asserted that farm income was essential for raising agricultural production in West Africa.

Furthermore, education level of the household head appear to have different effect on the maize output of household that improve soil and those that did not, it shows not to affect output of some household that did improve soil. For instance, basic education shows to be significant in explaining output of household that did not improve soil, it fails to explain output of households that improve soil. From column 3 of Table 5, given that the household head has basic education compared to no education, maize output will increase by 30.3 percent. However, secondary education rather proved significant in explaining the output of households that improved and those that did not improve soil.

From column (2) of Table 5, compared to a head with no education, a head with secondary education will increase maize output by 31 percent for the case of those who undertook soil improvement and by 43 percent for those who did not undertake soil improvement. However, tertiary education did not explain the variation in output for household that improved soil it did for those that did not improve soil. Generally, education of the household head is significant and positive in explaining maize output of households that improved and those that did not improve soil. Education is said to be important in agricultural production as formal education opens the mind of farmers to knowledge of agricultural practices and innovations and has proven to be effective and output enhancing. This is consistent with the following findings. Okpacha, Okpacha and Obijesi (2013) found that education positively impacted on the agricultural output of smallholder maize farmers in Nigeria. Also, Reimers and Klasen (2013) found that education indeed has a highly significant positive effect on agricultural productivity. In a similar vein, Gille (2011) also found that education spillovers are substantial output enhancing. Finally, Oduro-Ofori, Aboakye and Acquaye (2014) investigated the effect of education on agricultural output in the Offinso Municipality in the Ashanti region of Ghana and found that as the education level increased, output also increased. Education is important because it determines the ability of a farmer to adjust to new innovations. Education catalyses the process of information flow and leads the farmers to explore as wide as possible, the different pathways of getting information about agriculture and technology (Berry, undated). People with more education are likely to be better informed and are likely to interpret information more correctly than the uneducated.

Age of the household head is significant in explaining the variation in maize output of households that improved soil. From column 2 and column 3 of Table 5, given a year increase in the age of the household head, maize output of those who improved soil will increase by 0.95 percent and is significant at one percent. Here it is seen that age of the household head matter in the output of those who did improve soil. This finding collaborate with the finding of Anigbogu *et al.* (2015) who found that age had a significant and positive relationship with farmers' output level. This implies that a year increase in the age of the farmer brings about an increase in the farmers output. However, the positive age- output relationship is not indefinite as exhibited by the non-linearity of the age variable.

Compared to unmarried household head, a married head who improved soil will increase maize output by 5 percent and is significant at one percent, but is not significant for those who did not improve soil. Anigbogu *et al.* (2015) found that marital status is essential in influencing output. They found that married status has a significant positive effect on output level. Thus, the outputs of those who are married were found to be higher compared to those who were not married. The reason for this variation in output between those married and those not married may possibly be among other reasons the sharing of support in terms of productive resources.

Existent literature (Takeshima, Houssou & Diao, 2018; Yang-jie, Ji-kun & Jin-xia, 2014) hold that, asset ownership by farmers significantly affect their agricultural output, thus, the type of asset that the household have greatly influenced the output of the household. As shown on column 2 in Table 5, compared to a household that did not own a tractor, the maize output of

household that owned a tractor will increase by 5 percent for those who improved soil and is statistically significant at one percent. The implication of this finding is that, having an asset like tractor increases maize output more than not having a tractor in the case of those who improved soil. Consistent with this finding, Takeshima *et al.* (2018) found that tractor ownership by maize farmer significantly increased output in maize production in Ghana. Also, Salam (1981) found that yields on tractor farms were significantly higher than those on bullock farms in Pakistan. These studies as well as this study emphasize the importance of tractor ownership by household in increasing maize output.

The coefficient of household size is positive and is statistically significant at the five percent level of significance for household that undertook soil improvement. It is however positive but insignificant for household that did not undertake soil improvement. From Table 5, column 2, a member increase in the size of the household, will result in a 2 percent increase in maize output. This indicates that household size have a positive influence on the output of maize farming households in the study area. A possible explanation to this could be that members of the household contribute significantly to household labour supply which leads to increase in maize output. The significance of household size on the maize output of household that improve soil confirms the positive impact of soil improvement on output. Since household size exerts a positive influence on soil improvement (column 1 of Table 5), a significant positive effect of household size on maize output of households that improve soil is expected. This is in line with the result of the work done by Okorie *et al.* (2011), who noted that farmers with increased

household size obtained higher yield due to family labour supply. This reduces the cost of production since family labour is not paid for.

Chapter Summary

The chapter presented the descriptive statistics of variable of the study, descriptive analysis of the variables as well as regression results for the soil improvement model and the maize output model.

From the descriptive analysis, farm households in the Northern Region of Ghana who had full land right undertook soil improvement in comparison to those with Non-full right. It was found that those with full right were motivated to undertake soil improvement more than their counterparts with Non –full right. Also it was found that in comparison with households whose lands are disputed, household with undisputed lands undertook more soil improvement.

It was also found that households that undertook soil improvement achieved high maize output than those who did not undertake soil improved. It is therefore established that soil improvement by household is important in raising maize output in the Region.

Finally, other variables like education level of the head, farm income, credit, and tractor ownership were all significant and positively affected maize output of households. However, farm size and farm distance showed a negative and significant relationship with maize output. It was also found that gender and household size were significant and positive in explaining maize output.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

This chapter serve as the concluding part of the study. It presents summary of the study, conclusions and recommendations based on the findings of the study. The chapter ends by giving suggestions for future research.

Summary

The study examined land tenure security, soil improvement and maize output in the Northern region of Ghana. Specifically, the study determined the effect of land rights and land disputes as dimensions of tenure security on soil improvement and finally determined the effect of soil improvement on maize output in the region. The study reviewed literature on the neoclassical theory of land tenure security, models of productivity analysis, land tenure security and land improvement investment, land improvement investment and agricultural productivity within African and outside Africa.

The objectives of the study were achieved by testing three hypotheses, thus, land right do not significantly affect soil improvement, land dispute do not significantly affect soil improvement and finally soil improvement do not significantly affect maize output. The study employed the IPA 2011 cross-sectional data for the three districts (Tamale Metropolis Area, Savelugu-Nanton Municipal and West Mamprusi District) of the Northern Region for the analyses. The endogeneous switching regression model was employed to achieve the objectives of the study.

From the descriptive analysis, maize farming households in the Northern region of Ghana reported a high incidence of soil improvement on lands which the household had full right compared to lands that they had non-full right. Also, it was established from the descriptive analysis that households improved soil on lands that their claims were undisputed compared to lands that were disputed. It was further established that variables like credit access by households, education level of head, tropical livestock unit (TLU), marital status of head, and sex of head all had a significant association with household soil improvement. Furthermore, it was established from the descriptive analysis that households that undertook soil improvement recorded higher maize output compared to those who did not improve soil. It was as well established from a t-test analysis that variables such as credit, tractor ownership, and sex proved to have a positive and significant association with maize output.

The probit maximum likelihood estimation of soil improvement on land rights, land dispute and the other independent variables showed that land right and land dispute were statistically significant for explaining soil improvement among maize farming households.

Farm income was shown to be statistically significant in influence soil improvement by maize farming households. It was significant at one percent. Credit was also significant and impacted positively on the dependent variable, soil improvement. Compared to households that did not have credit, households with credit were more likely to improve soil.

Tropical livestock unit was also found to be more likely in making households undertake soil improvement. Livestock owned by maize producing households impacted positively on soil improvement.

Age also explained soil improvement by maize farming households. It was found that age positively influenced soil improvement whilst age squared had a negative association with soil improvement. This portrayed the non-linearity behaviour of the age variable. Thus, as age increases, it positively influence soil improvement up to some point, where age increase does not relate to soil improvement and beyond that point results in an inverse relation between age and soil improvement. Sex of the head was found to be significant in influencing soil improvement. Male headed households were more likely to improve soil compared to their female headed counterparts..

It was found that soil improvement by maize household had a positive effect on maize output. It was established that households that improved soil achieved greater output compared to those who did not improve soil. Farm income was also found to positively and significantly influence household soil improvement as well as maize output.

Conclusions

Compared to previous studies, the present analysis has shed more light on the relationship between dimensions (land rights and land dispute) of land tenure security on soil improvement and hence the effect of soil improvement on maize output under indigenous customary tenure. Soil improvement tends to be more likely with households who had full land rights as well as with households with undisputed lands. Also maize output was high for household who improved soil compared to households who did not improve soil.

Hombrados *et al.* (2015) examined the impact of land tenure security (titling) on agricultural production and land improvement investment in Tanzania and found that land tenure security had no effect on land improvement and output. Tsegaye *et al.* (2012) found that tenure security (land certification) did not incentivize farmers to improve land in Ethiopia. Giri (2011) found that tenure security (titling) did not influence farmers' land improvement and conservation investment and hence farm output in the central Rift Valley of Ethiopia. One may conclude from the work of Hombrados *et al.* (2015), Tsegaye *et al.* (2012) and Giri (2010) that land tenure security has no effect on agricultural land improvement and hence crop output in Africa.

The major flaws in the work of these authors is the conceptualisation of land tenure security as the possession of land titles in the context of customary tenure of Africa where agricultural lands are mostly not registered and land registration is often associated with lands that had been transferred from agricultural use. As Knut and Nohal El-Mikawy (2009) argued that there was the need for a local understanding of indicators of tenure security rather than comparability on global scale (titling), this study adds to literature by measuring tenure security under undeveloped land market economy. Also the absence of tenure security dimensions in the work of Goldstein and Udry (2006) makes it difficult to distinguish the dimension of tenure security that influences land soil improvement and hence maize output.

From this study, it can be concluded that land tenure security positively and significantly influenced soil improvement, and soil improvement as well significantly and positively affected maize output in the Northern region of

Ghana and is contrary to the above findings of no impact of tenure security in Africa. It is also evident from the findings of this study that the dimension of land tenure security that influenced soil improvement and hence maize output in the Northern region of Ghana are, Land rights and Land disputes. The Neo-classical theory (security hypothesis) of land tenure security is supported by the findings of this study.

Recommendations

Based on the findings, summary and conclusions of the study, the following recommendations and policies are advocated.

Government should strengthen land disputes resolution and arbitration bodies. The government through the Ministry of Land and Natural resources in collaboration with traditional authorities (chiefs) should build the capacity and public trust of the Alternative Dispute Resolution (ADR) bodies to amicably settle land related disputes as they adversely affect the security land tenure of households and hence their willingness to improve soil which has proven to be output enhancing in the study region. The capacity building of ADRs could include the recruitment of highly qualified, objective minded and incorruptible personnel as well as the provision of logistics to aid the smooth operations of ADRs.

Although, security of land tenure (land right) has proved positive in influencing soil improvement by households in the study area, it does not indicate that formal land titling should be recommended. The formalization of land rights in rural areas raises a number of concerns about the land tenure security of the least powerful and least informed. The Ministry of Land and Natural Resources, through the Lands Commission with participation from the

communities and the families within the communities should institute an alternative process of recording and maintenance of records on rights holders within family lands. This approach does not include the issuance of a formal documentary evidence of land rights which makes it compatible with existing norms, rules and contracts and does not also modify expectations. It is also a faster and less expensive because there is no need for a centralized registry and issuance of land titles.

It is established that soil improvement increases households' ability to increase maize output. It is evidenced from the study that variable like farm income boost households' decision to improve soil as well as households maize output. Therefore, government should enhance households' farm income by creating an enabling environment and favourable market for households maize produce. On the enabling environment, government through the Ministry of Roads and Transport should improve the road infrastructure to properly connect the rural household to markets of their produce. On the favourable markets, the National Food and Buffer Stock Company should strengthen their food crop purchase programme and as well include smallholder farm households. This will provide ready market devoid of exploitation as associated with middle men and women who often under-price crop produce to their advantage and to the disadvantage of smallholder farm households which often lead to low farm income by households.

Suggestions for Further Research

The study suggests that future studies can look at a panel analysis of the effect of these dimensions of tenure security on soil improvement and maize output in the Northern Region of Ghana.

Again, a nationwide study can be conducted as this study is limited to the Northern Region.

REFERENCES

- Abdulai, A., Owusu, V., & Goetz, R. (2011). Land tenure differences and investment in land improvement measures: Theoretical and empirical analyses. *Journal of Development Economics*, 96(1), 66-78.
- Abey, A., & Assefa, A. (2004). The role of education on the adoption of chemical fertilizer under different socioeconomic environments in Ethiopia. *Agricultural Economics*, 30(3), 215-228.
- Adal, Y. (2001). Some queries about the debate on Land tenure in Ethiopia. In M. Demeke & T.W. Hana (Eds). *Proceedings of the Tenth Annual Conference on the Ethiopian Economy, EEA*. Nov. 3-5, 2000, Nazareth, Ethiopia
- Adams, M., Sibanda, S., & Turner, S. D. (1999). *Land tenure reform and rural livelihoods in Southern Africa*. London, UK: Overseas Development Institute.
- Adebiyi, S., & Okunlola, J. O. (2013). Factors affecting adoption of cocoa farm rehabilitation techniques in Oyo State of Nigeria. *World Journal of Agricultural Sciences*, 9(3), 258-265.
- Adeniji, O. B., Voh, J. P., Atala, T. K., & Ogungbile, A. O. (2007). Adoption of improved cotton production technologies in Katsina State, Nigeria. *Journal of Applied Sciences*, 7(3), 397-401.
- Afful Jnr., B. (2017). Weedicide adoption, off-farm activities and expected poverty among maize households in the Northern region of Ghana. *PhD Thesis, University of Cape Coast*.
- Alchian, A. A., & Demsetz, H. (1973). The property right paradigm. *The Journal of Economic History*, 33(1), 16-27.

- Alemu, T. (1999). Land tenure and soil conservation: Evidence from Ethiopia. *Journal of Agricultural Economics*, 48(1-3), 250-252.
- Alene, A. D., & Manyong, V. M. (2007). The effects of education on agricultural productivity under traditional and improved technology in northern Nigeria: an endogenous switching regression analysis. *Empirical Economics*, 32(1), 141-159.
- Al-Hassan, R. M., & Diao, X. (2007). Regional disparities in Ghana: Policy options and public investment implications. *The Journal of Modern African Studies*, 28(2), 265-297.
- Alston, L. J., Libecap, G. D., & Schneider, R. (1995). Property rights and the preconditions for markets: the case of the Amazon frontier. *Journal of Institutional and Theoretical Economics (JITE)/Zeitschrift für die gesamte Staatswissenschaft*, 89-107.
- Aluma, J. R. W., Kigula, J., Owor, M. & Place, F. (1995). The Role of Land Tenure and Tree Tenure on the Adoption of Agroforestry Technologies: The case of Uganda. International Centre for Research in Agroforestry (ICRAF), Nairobi, Kenya.
- Amaza, P. S., Bila, Y., & Iheanacho, A. C. (2006). Identification of factors that influence technical efficiency of food crop production in West Africa: Empirical evidence from Borno State, Nigeria. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 107(2), 139-147.

- Anigbogu, T. U., Agbasi, O. E., & Okoli, I. M. (2015). Socioeconomic factors influencing agricultural production among cooperative farmers in Anambra State, Nigeria. *International Journal of Academic Research in Economics and Management Sciences*, 4(3), 43-58.
- Ani, A O., Kanya, HT., & Hassel, UJ. (2012). Impact Study on the Adoption of Improved Agricultural Technology by Groundnut Farmers in Hauwul L.G.A. of Borno State, Nigeria. *Nigeria Journal of Rural Development Cooperation*, 1(7), 19–25.
- Anyanwu, O. S. (2009). Determinants of aggregate agricultural productivity among food crop farmers in Rivers State, Nigeria. *J. Vocational Education and Technology*, 6(1).
- Asfaw, S., Shiferaw, B., Simtowe, F., Leslie, L., (2012). Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy*, 37(3), 283–295.
- Banker, R. D., Conrad, R. F., & Strauss, R. P. (1986). A comparative application of data envelopment analysis and translog methods: an illustrative study of hospital production. *Management Science*, 32(1), 30-44.
- Barrows, R., & Roth, M. (1990). Land tenure and investment in African agriculture: Theory and evidence. *The Journal of Modern African Studies*, 28(2), 265-297.
- Barzel, Y. (1997). *Economic analysis of property rights*. Cambridge: Cambridge University Press.

- Battese, G. E. (1997). A note on the estimation of Cobb-Douglas production functions when some explanatory variables have zero values. *Journal of Agricultural Economics*, 48(1-3), 250-252.
- Battese, G. E., & Broca, S. S. (1997). Functional forms of stochastic frontier production functions and models for technical inefficiency effects: a comparative study for wheat farmers in Pakistan. *Journal of Productivity Analysis*, 8(4), 395-414.
- Bekele, W., & Drake, L. (2003). Soil and water conservation decision behavior of subsistence farmers in the Eastern Highlands of Ethiopia: a case study of the Hunde-Lafto area. *Ecological Economics*, 46(3), 437-451.
- Belay, K., & Manig, W. (2004). Access to rural land in Eastern Ethiopia: Mismatch between policy and reality. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 105(2), 123-138.
- Besley, T. (1995). Property rights and investment incentives: Theory and evidence from Ghana. *Journal of Political Economy*, 103(5), 903-937.
- Bindlish, V., & Evenson, R. E. (1993). *Evaluation of the Performance of T & V Extension in Kenya* (Vol. 23). Washington, D.C: World Bank.
- Blench, R. & Dendo, M. (2004). *Cultural and biological interactions in the savanna woodlands of Northern Ghana*. Presented at the Conference on Trees, Rainfall and Politics in Africa, Oxford, September 29-October 1, 2014.
- Bromley, D. W. (1991). *Environment and economy: Property rights and public policy*. Cambridge: Blackwell Ltd.

- Bruce, J. W. (1998). *Review of tenure terminology*. Madison: University of Wisconsin
- Bruce, J. W., Migot-Adholla, S. E., & Atherton, J. (1994). The findings and their policy implications: Institutional adaptation or replacement. *Searching for Land Tenure Security in Africa*, 1(1), 251-265.
- Burgess, R. (2001). Land and welfare: Theory and evidence from China. *London School of Economics Working Paper*.
- Byiringiro, F., & Reardon, T. (1996). Farm productivity in Rwanda: effects of farm size, erosion, and soil conservation investments. *Agricultural Economics*, 15(2), 127-136.
- Campbell, D. T., & Russo, M. J. (1999). *Social experimentation* (Vol. 1). London, UK: Sage Publications Inc.
- Carter, M. R. & Olinto, P. (2003). Getting Institutions Right for Whom? Credit Constraints and the Impact of Property Rights on the Quantity and Composition of Investment. *American Journal of Agricultural Economics*, 85, 173-186.
- Carter, M. R., Wiebe, K. & Blarel, B. (1994). Tenure Security for Whom? Differential Effects of land Policy in Kenya. *World Bank Economic Review*, 5 (1), 120-135.
- Carter, M. R., Wiebe, K. D., & Blarel, B. (1989). *Tenure Security for Whom?: An Econometric Analysis of the Differential Impacts of Land Policy in Kenya*. Land Tenure Center, University of Wisconsin-Madison.
- Coelli, T. J. (1995). Recent development in frontier modeling and efficiency measurement. *The Australian Journal of Agricultural Economics*, 39(3), 219-245.

- Coelli, T. J., & Battese, G. E. (1996). Identification of factors which influence the technical inefficiency of Indian farmers. *Australian Journal of Agricultural Economics*, 40(2), 103-128.
- Chand, S., & Yala, C. (2009). Land tenure and productivity: farm-level evidence from Papua New Guinea. *Land Economics*, 85(3), 442-453.
- Chapoto, A., Sabasi, D., & Asante-Addo, C. (2015). Fertilizer intensification and soil fertility impact on maize yield response in northern Ghana. *Agricultural and Applied Economics Association (AAEA)*. July 26-28, San Francisco, California.
- Cheng'ole, J. M., Kimenyi, L. N., & Mbogoh, S. G. (2003). Engendered Analysis of the Socioeconomic Factors Affecting Smallholder Dairy Productivity: Experience from Kenya. *Journal of Sustainable Agriculture*, 22(4), 111-123.
- Chilonda, P., & Otte, J. (2006). Indicators to monitor trends in livestock production at national, regional and international levels. *Livestock Research for Rural Development*, 18(8), 117.
- Coase, R. H. (2013). The problem of social cost. *The Journal of Law and Economics*, 56(4), 837-877.
- Danso-Abbeam, G., Setsoafia, E. D., & Ansah, I. G. K. (2014). Modelling farmers investment in agrochemicals: the experience of smallholder cocoa farmers in Ghana. *Research in Applied Economics*, 6(4), 1-16.
- Das, A., Senapati, M., & John, J. (2009). Impact of agricultural credit on agriculture production: an empirical analysis in India. *Reserve Bank of India Occasional Papers*, 30(2), 75-107.

- Davidson, C. & Tolich, M. (2003). *Social science research in New Zealand. Many paths to understanding (2nd ed.)*. Auckland, New Zealand: Prentice Hall.
- Debertin, D. L. (2012). *Agricultural Production Economics, Second Edition*. New Jersey: Macmillan Publishing Company.
- Deininger, K., & Jin, S. (2006). Tenure security and land-related investment: Evidence from Ethiopia. *European Economic Review*, 50(5), 1245-1277.
- Deininger, K. W. (2003). *Land policies for growth and poverty reduction*. Washington D.C, World Bank Publications.
- Deininger, K., & Castagnini, R. (2006). Incidence and impact of land conflict in Uganda. *Journal of Economic Behavior & Organization*, 60(3), 321-345.
- Deininger, K., & Chamorro, J. S. (2004). Investment and equity effects of land regularisation: the case of Nicaragua. *Agricultural Economics*, 30(2), 101-116.
- Deininger, K., Ali, D. A., & Yamano, T. (2008). Legal knowledge and economic development: The case of land rights in Uganda. *Land Economics*, 84(4), 593-619.
- De Laiglesia, J. R. (2004). Investment and credit effects of land titling and registration: Evidence from Nicaragua. *London School of Economics*.
- Demsetz, H. (1967). Towards a theory of property rights. *American Economic Review*, 57(2), 347-359.
- Dey, J. (1994). Women in rice farming system. *Science and Public Policy*, 11(4), 201-218.

- Dlamini, J. C. (2015). *Maize growth and yield as affected by different soil fertility regimes in a long term trial*. Master of Science dissertation, University of Pretoria.
- Dhliwayo, T., Pixley, K., Menkir, A., & Warburton, M. (2009). Combining ability, genetic distances, and heterosis among elite CIMMYT and IITA tropical maize inbred lines. *Crop Science*, 49(4), 1201-1210.
- Di Falco, S., Veronesi, M., & Yesuf, M. (2011). Does adaptation to climate change provide food security? A micro-perspective from Ethiopia. *American Journal of Agricultural Economics*, 93(3), 829-846.
- Do, Q. T., & Iyer, L. (2008). Land titling and rural transition in Vietnam. *Economic Development and Cultural Change*, 56(3), 531-579.
- Douglas, P. H. (1976). The Cobb-Douglas production function once again: its history, its testing, and some new empirical values. *Journal of Political Economy*, 84(5), 903-915.
- Edewor, J. R. & Olufemi, R. D. (2013). Effect of property rights on agriculture production in Nigeria. *African Journal of Estate and Property Management*, 1(1), 18-24.
- Eggertsson, T., Eggertsson, T., & Eggertsson, P. (1990). *Economic behavior and institutions: Principles of Neoinstitutional Economics*. Cambridge: Cambridge University Press.
- Feder, G. & Nisho, A. (1999). The Benefits of Land Registration and Titling: Economic and Social Perspectives, *Land Use Policy*, 15(1), 25-43.
- Feder, G., & Feeny, D. (1991). Land tenure and property rights: Theory and implications for development policy. *The World Bank Economic Review*, 5(1), 135-153.

- Feder, G., & Onchan, T. (1987). Land ownership security and farm investment in Thailand. *American Journal of Agricultural Economics*, 69(2), 311-320.
- Feder, G. (1988). *Land policies and farm productivity in Thailand*. Johns Hopkins University Press. Baltimore, USA
- Feder, G., Onchan, T., & Chalamwong, Y. (1988). Land policies and farm performance in Thailand's forest reserve areas. *Economic Development and Cultural Change*, 36(3), 483-501.
- Food and Agricultural Organization. (2002). Agriculture Data. Retrieved from <http://apps.fao.org/page/collections>.on 25 May, 2018..
- Fort, R. (2008). The homogenization effect of land titling on investment incentives: evidence from Peru. *NJAS-Wageningen Journal of Life Sciences*, 55(4), 325-343.
- Galliers, R. D. (1991). Choosing Appropriate Information Systems Research Approaches: A revised Taxonomy. *Information Systems Research: Contemporary Approaches & Emergent Traditions*, 69(2), 327-346.
- García Hombrados, J., Devisscher, M., & Herreros Martínez, M. (2015). The Impact of land titling on agricultural production and agricultural investments in Tanzania: a theory-based approach. *Journal of Development Effectiveness*, 7(4), 530-544.
- Gavian, S., & Ehui, S. (1999). Measuring the production efficiency of alternative land tenure contracts in a mixed crop-livestock system in Ethiopia. *Agricultural Economics*, 20(1), 37-49.

- Gille, V. (2011). Education spillovers in farm productivity: empirical evidence in rural India. *American Journal of Agricultural Economics*, 16(6), 81-102.
- Giri, S. (2010). The Effect of Rural Land Registration and Certification Programme on Farmers' Investments in Soil Conservation and Land Management in the Central Rift Valley of Ethiopia. *Master of Science Thesis, Wageningen University*
- Goldstein, M., & Udry, C. (2008). The profits of power: Land rights and agricultural investment in Ghana. *Journal of Political Economy*, 116(6), 981-1022.
- Greene, W. H. (2000). *Econometric analysis*. Upper Saddle Rivers, New Jersey: Prentice – Hall Inc.
- Ghana Statistical Service (2012). 2010 Population and Housing Census (PHC) Final Results. www.statsghana.gov.gh/2010phc (accessed on 15 March, 2018).
- Ghana Statistical Service (2010). *Ghana Living Standard Survey*. Accra, Ghana: Ghana Statistical Service.
- Gujarati, D. (1992). *Essentials of Econometrics*. New York: MacGraw–Hill,
- Harrison, P. (1987). *The greening of Africa. Breaking through in the battle for land and food*. Paladin, for International Institute for Environment and Development-Earthscan. London, UK.
- Hasselberg, J. (2013). Small Scale Farming and Rural Development in Northern Ghana. In Yaro, (Ed): *Rural Development in Northern Ghana*. New York: Nova Publication,

- Hayes, J., Roth, M., & Zepeda, L. (1997). Tenure security, investment and productivity in Gambian agriculture: A generalized probit analysis. *American Journal of Agricultural Economics*, 79(2), 369-382.
- Holden, S., & Yohannes, H. (2002). Land redistribution, tenure insecurity, and intensity of production: A study of farm households in Southern Ethiopia. *Land Economics*, 78(4), 573-590.
- Hunt, D. (2003). The debate on land privatisation in sub-Saharan Africa: Some Outstanding Issues. *University of Sussex, Discussion Papers in Economics*, (96).
- International Fund for Agricultural Development. (2012). Ghana country programme evaluation. IFAD Publ. No. 84, May 2012. http://www.ifad.org/evaluation/public_html/eksyst/doc/profile/pa/gha2012.htm (retrieved 23 May, 2018).
- Jacoby, H. G., & Minten, B. (2007). Is land titling in Sub-Saharan Africa cost-effective? Evidence from Madagascar. *The World Bank Economic Review*, 21(3), 461-485.
- Jansen, K., & Roquas, E. (1998). Modernizing insecurity: The land titling project in Honduras. *Development and Change*, 29(1), 81-106.
- Jongwook, K., & Mahoney, J. T. (2005). Property rights theory, transaction costs theory, and agency theory: an organizational economics approach to strategic management. *Managerial and Decision Economics*, 26(4), 223-242.
- Kabubo-Mariara, J., Linderhof, V., & Kruseman, G. (2010). Does land tenure security matter for investment in soil and water conservation?

- Evidence from Kenya. *African Journal of Agricultural and Resource Economics*, 4(2), 123-139.
- Karlan, D., Osei, R., Osei-Akoto, I., & Udry, C. (2014). Agricultural decisions after relaxing credit and risk constraints. *The Quarterly Journal of Economics*, 129(2), 597-652.
- Kibaara, B., Ariga, J., Olwande, J., & Jayne, T. S. (2008). *Trends in Kenyan agricultural productivity: 1997-2007* (No. 1093-2016-88047). Nairobi, Kenya: Tegemeo Institute of Agricultural Policy & Development
- Kille, G. S. (1993). Property rights to land, on-farm investment and farm productivity: a study in the Madadeni district of KwaZulu. *Journal of Agricultural Economics*, 39, 219-245.
- Kim, J., & Mahoney, J. T. (2005). Property rights theory, transaction costs theory, and agency theory: an organizational economics approach to strategic management. *Managerial and Decision Economics*, 26(4), 223-242.
- Kohansal, M. R., Ghorbani, M., & Mansoori, H. (2008). Effect of Credit Accessibility of Farmers on Agricultural Investment and Investigation of Policy Options in Khorasan Razavi Province of Iran. *Journal of Applied Sciences*, 8(23), 4455-4459.
- Kombiok, J. M., Buah, S. S. J., & Sogbedji, J. M. (2012). Enhancing soil fertility for cereal crop production through biological practices and the integration of organic and in-organic fertilizers in northern savanna zone of Ghana. In *Soil Fertility*. InTech.

- Koning, N., Heerink, N., & Kauffman, S. (1998). *Integrated soil improvement and agricultural development in West Africa: why current policy approaches fail* (No. 9-98). Wageningen Agricultural University.
- Kranjac-Berisavljevic, G., Bayorbor, T. B., Abdulai, A. S., Obeng, F., Blench, R. M., Turton, C. N. & Drake, E. (1999). Rethinking natural resource degradation in semi-arid Sub-Saharan Africa: the case of semi-arid Ghana. *University for Development Studies*.
- Kumbhakar, S. C. (1997). Modeling allocative inefficiency in a translog cost function and cost share equations: an exact relationship. *Journal of Econometrics*, 76(1-2), 351-356.
- Kumbhakar, S. C., Heshmati, A., & Hjalmarsson, L. (1997). Temporal patterns of technical efficiency: Results from competing models. *International Journal of Industrial Organization*, 15(5), 597-616.
- Laksa, K., & El-Mikawy, N. (2009). Reflections of land tenure security indicators. *UNDP Oslo Governance Centre (OGC) DISCUSSION PAPER, 11*.
- Li, G., Rozelle, S., & Huang, J. (2000). Land rights, farmer investment incentives, and agricultural production in China. University of California Davis Working Paper No. 00-024
- Libecap, G. D. (1993). *Contracting for property rights*. Cambridge: Cambridge University Press.
- Lichtenberg, E. (2001). Adoption of soil conservation practices: a revealed preference approach. *College Park, MD, USA, University of Maryland*.
- Long, J. (1997). Regression models for categorical and limited dependent variables. *Advanced Quantitative Techniques in the Social Sciences*.

- Lokshin, M., & Sajaia, Z. (2004). Maximum likelihood estimation of endogenous switching regression models. *The Stata Journal*, 4(3), 282-289.
- Long, L. M. (2003). *Conservation practices adoption by agricultural landowners*. Master of Science Dissertation, Northern Illinois University.
- Louwaars, N. P. & de Boef, W. S. (2012). Integrated seed sector development in Africa: a conceptual framework for creating coherence between practices, programs, and policies. *Journal of Crop Improvement*, 26(1), 39-59.
- Maddala, G.S.(1983). *Limited-Dependent and Qualitative Variables in Econometrics*. Cambridge: Cambridge University Press.
- Maddala, G. S., & Nelson, F. D. (1975). Switching regression models with exogenous and endogenous switching. *Proceedings of the American Statistical Association*, 1(5), 423-426.
- Mahoney, J.T. (2004). Property rights theory. *Economic Foundations of Strategy*, 3, 109-137.
- Marinda, P., Bangura, A., & Heidhues, F. (2006). Technical efficiency analysis in male and female-managed farms: A study of maize production in West Pokot District, Kenya. In *Poster paper prepared for Presentation at the International Association of Agricultural Economists Conference. Gold Coast, Australia*.
- Masterson, T. (2007). Productivity, technical efficiency, and farm size in Paraguayan agriculture. The Levy Economics Institute, Working Papers No. 490

- Matchaya, G. (2009). Land ownership security in Malawi. *African Journal of Agricultural Research*, 4(1), 001-013.
- McArthur, J. W., & McCord, G. C. (2017). Fertilizing growth: Agricultural inputs and their effects in economic development. *Journal of Development Economics*, 1(127), 133-152.
- Migot-Adholla, S., Hazell, P., Blarel, B., & Place, F. (1991). Indigenous land rights systems in sub-Saharan Africa: a constraint on productivity?. *The World Bank Economic Review*, 5(1), 155-175.
- Ministry of Food and Agriculture (2011). Agriculture in Ghana: Facts and Figures, Accra, Ghana: Ministry of Food and Agriculture.
- Morris, M. L., Tripp, R. B., & Dankyi, A. A. (1999). Adoption and impacts of improved maize production technology: *A case study of the Ghana Grains Development Project*. Economics Program Paper 99-01
- Moor, G. M. (2015). *Tenure security and productivity in the Zimbabwean small farm sector: implications for South Africa*. Master of Science dissertation, University of Natal Pietermaritzburg.
- Musafiri, I., & Mirzabaev, A. (2014, May). Long-Term Determinants of Agricultural Output in Smallholder Farmers in Rwanda. *Paper presented at the Annual Meeting of Agricultural and Applied Economics Association*. 27th -29th July, 2014. Minneapolis, Minnesota
- Muyanga, M., & Gitau, R. (2014). Do land disputes affect smallholder agricultural productivity? Evidence from Kenya. *Journal of Economics and Sustainable Development*, 4(14), 112-122.

- Mozumdar, L. (2012). Agricultural productivity and food security in the developing world. *Bangladesh Journal of Agricultural Economics*, XXXV, 1, 53-69.
- Mwakubo, S. M., & Njoro, K. (2002, May). Land tenure and natural resource management in semi-arid areas, Kenya. In *Agriculture economics department, Egerton University. Paper prepared for the Beijer Research workshop on Property rights, Durban, South Africa* 28-30.
- Myyrä, S., Pietola, K., & Yli-Halla, M. (2007). Exploring long-term land improvements under land tenure insecurity. *Agricultural Systems*, 92(1-3), 63-75.
- Naab, F. Z., Dinye, R. D., & Kasanga, R. K. (2013). Urbanisation and its impact on agricultural lands in growing cities in developing countries: a case study of Tamale, Ghana. *Modern Social Science Journal*, 2(2), 256-287
- Nwaru, J. C., & Iwuji, O. (2005). Marketing margins and their determinants in plantain marketing in Owerri agricultural zone of Imo State, Nigeria. In: A.M. Orheruata, S.O. Nwokoro, M.T Ajayi, A.T. Adekunle, & G.N. Asumugha, *Agricultural Rebirth for Improved Production in Nigeria (Eds.). Proceedings of the 39th Annual Conference of the Agricultural Society of Nigeria, University of Benin, Benin City, Nigeria*, pp. 385-387. Ibadan, Nigeria: Agricultural Society of Nigeria.
- Nyari, B. (2008). Biofuel land grabbing in Northern Ghana. ODI (2005). Overseas Development Institute (2005). *Economic Growth in Northern Ghana Revised Report for DfiD, Accra, Ghana*.

- Oduro-Ofori, E., Aboagye, A. P., & Acquaye, N. A. E. (2014). Effects of education on the agricultural productivity of farmers in the Offinso municipality. *International Journal of Development Research* 4(9), 1951 -1960.
- Okorie, K. C., Nkwocha, G. A., & Ndubuisi, E. C. (2011). Implications of feeding varying dietary levels of cassava leaf meal on finisher broilers: Performance, carcass haematology and serological profiles. *Global Research Journal of Science* 1(1): 58-66.
- Okpachu, A. S., Okpachu, O. G., & Obijesi, I. K. (2013). The Impact of education on agricultural productivity of small scale rural female maize farmers in Potiskum Local Government, Yobe State: A Panacea for Rural Economic Development in Nigeria. *International Journal of Research in Agriculture and Food Sciences*, 2(4), 26-33.
- Overseas Development Institute (2005). *Economic Growth in northern Ghana Revised Report for DfID. Accra, Ghana: ODI*
- Owusu, S. (2017) Effect of Access to Credit on Agricultural Productivity: Evidence from Cassava Farmers in the Afigya-Kwabre District of Ghana. *International Journal of Innovative Research in Social Sciences & Strategic Management Techniques* 4(2), 2467-8155
- Parikh, A., Ali, F., & Shah, M. K. (1995). Measurement of economic efficiency in Pakistani agriculture. *American Journal of agricultural economics*, 77(3), 675-685.
- Patel, S., Pinckney, T. & Jacger, W. (1995). "Smallholder Wood Production and population Pressure in East Africa: Evidence on Environmental Kuznet Curve? *Land Economics*, 71(4), 516-530.

- Patton, M. Q. (2002). *Qualitative Research and Evaluation Methods*. (3rd eds), London, UK: Sage Publication..
- Pender J, Nkonya E, Jagger P, Sserunkuma D & Ssali H, (2004). Strategies to increase agricultural productivity and reduce land degradation: Evidence from Uganda. *Agricultural Economics* 31(2-3), 181–95.
- Pender, J., & Fafchamps, M. (2006). Land Lease Markets and Agricultural Efficiency in Ethiopia. *Journal of African Economies*, 15(2), 251–284.
- Place, F. and Otsuka, K. (2002). "Land Tenure Systems and their Impacts on Agricultural Investments and Productivity in Uganda". *Journal of Development Studies*, 38(6), 105-128.
- Place, F., & Hazell, P. (1993). Productivity effects of indigenous land tenure systems in sub Saharan Africa. *American Journal of Agricultural Economics*, 75(1), 10-19.
- Place, F., Roth, M., & Hazell, P. (1994). Land tenure security and agricultural performance in Africa: Overview of research methodology. *Searching for land tenure security in Africa*, 15-39.
- Platteau, J. P. (2000). Does Africa need land reform?. *Evolving land rights, policy and tenure in Africa.*, 51-74.
- Platteau, J. P. (1995). Reforming Land Rights in Sub-Saharan Africa: Issues of Efficiency and Equity. *UNRISD Discussion Paper No. 60*. Geneva.
- Quisumbing, A. R. (1996). Male-female differences in agricultural productivity: Methodological issues and empirical evidence. *World Development*, 24(10), 1579-1595.
- Ragasa, C., Chapoto, A., & Kolavalli, S. (2014). *Maize productivity in Ghana* (Vol. 5). International Food Policy Research Institute.

- Reimers, M., & Klasen, S. (2013). Revisiting the role of education for agricultural productivity. *American Journal of Agricultural Economics*, 95(1), 131-152.
- Roth, M. & Haase, D. (1998). Land Tenure Security and Agricultural Performance in Southern Africa, LTC Paper, Madison, WI, University of Wisconsin-Madison, Land Tenure Centre.
- Roy, D. R., Islam, M. S., Sarker, B. C., Tusher, T. R., Kabir, M. H., Muliadi, M., & Al Mamun, S. (2016). Impacts of fertilizer application on soil properties at kaharole upazila of Dinajpur district in Bangladesh. *AGRIVITA, Journal of Agricultural Science*, 38(2), 116-125.
- Salam, A. (1981). Farm tractorization, fertilizer use and productivity of Mexican wheat in Pakistan. *The Pakistan Development Review*, 20(3), 323-345.
- Salas, O., Knight, F., & Saenz, C. (1970). Land Titling in Costa Rica. *A Legal Economic Survey. USAID Contracts*, 515-175.
- Sedem, E. D., William, A., & Gideon, D. A. (2016). Effect of access to agriculture credit on farm income in the Talensi district of northern Ghana. *Russian Journal of Agricultural and Socio-Economic Sciences*, 55(7).
- Shepherd, A., Jebuni, C., Al-Hassan, R., McKay, A., Poulton, C., Whitehead, A., & Kydd, J. (2005). Economic growth in Northern Ghana, Revised Report for DFID Ghana. *Prepared by Overseas Development Institute and Centre for Policy Analysis*, London/Accra.
- Shumet, A. (2011). Analysis of technical efficiency of crop producing smallholder farmers in Tigray, Ethiopia. MPRA Paper No.40461

- Sibanda, M (2012). Market Potential and Profitability of Improved Open Pollinated Varieties in the Eastern Cape, South Africa. Master of Science Dissertation, University of Fort Hare, Alice.
- Smaling, E. M., Lynam, J. K., & Nandwa, S. M. (1998). Nutrient balances as indicators of productivity and sustainability in Sub-Saharan African agriculture: Papers Presented during the conference "Soil Fertility Management in Sub-Saharan Africa" held in Nairobi, February 1997. *Agriculture, Ecosystems and Environment*, 71(1), 1-3.
- Solís, D., Bravo-Ureta, B. E., & Quiroga, R. E. (2007). Soil conservation and technical efficiency among hillside farmers in Central America: a switching regression model. *Australian Journal of Agricultural and Resource Economics*, 51(4), 491-510
- Sulemana, M. (2009). Understanding the causes and impacts of conflicts in the northern region of Ghana.
- Tabachnick, B. G., & Fidell, L. S (1998). *Using multivariate statistics*. New York: Harper Collins College Publishers.
- Takehima, H., Houssou, N., & Diao, X. (2018). Effects of tractor ownership on returns-to-scale in agriculture: Evidence from maize in Ghana. *Food Policy*, 77(1), 33-49.
- Tenaw, S., Islam, K. Z., & Parviainen, T. (2009). Effects of land tenure and property rights on agricultural productivity in Ethiopia, Namibia and Bangladesh. *University of Helsinki Discussion Papers No.33*.
- Tengan, K. M., Obeng-Antwi, K., Ewool, M. B., & Danso, C. F. (2011). CSIR-Crops Research Institute: maize improvement programme. Fact sheet.

- Theodoridis, A. M., Psychoudakis, A., & Christofi, A. (2006). Data envelopment analysis as a complement to marginal analysis. *Agricultural Economics Review*, 7(2), 55-65.
- Toulmin, C. (2009). Securing land and property rights in sub-Saharan Africa: the role of local institutions. *Land Use Policy*, 26(1), 10-19.
- Tsegaye, A., Adgo, E., & Selassie, Y. G. (2012). Impact of land certification on sustainable land resource management in Dryland Areas of Eastern Amhara Region, Ethiopia. *Journal of Agricultural Science*, 4(12), 261.
- Twerefou, D. K., Osei-Assibey, E., & Agyire-Tettey, F. (2011). Land tenure security, investments and the environment in Ghana. *Journal of Development and Agricultural Economics*, 3(6), 261-273.
- Udry, C., Hoddinott, J., Alderman, H., & Haddad, L. (1995). Gender differentials in farm productivity: Implications for household efficiency and agricultural policy. *Food Policy*, 20(5), 407-423.
- UN (2004). Ghana country profile. *United Nations Convention to combat Desertification*, www.un.org/esa/agenda21/natlinfo/wssd/ghana.pdf (accessed on May, 2018)
- USAID. (2017). Agriculture and food security. <https://www.usaid.gov/ghana/agriculture-and-food-security> (retrieved on 23 May, 2018.)
- Van den Broeck, K., Newman, C., & Tarp, F. (2007). Land titles and rice production in vietnam, Trinity Economic Papers. *Working Paper No. 1207*.
- Vershelde, M., D'Haese, M., Rayp, G., & Vandamme, E. (2013). Challenging Small-Scale Farming: A Non-Parametric Analysis of the

- (Inverse) Relationship between Farm Productivity and Farm Size in Burundi. *Journal of Agricultural Economics*, 64(2), 319-342.
- Vigneri, M. (2008). Drivers of Change in Ghana's Cocoa Sector. *Ghana Strategy Support Programme, Paper No. 13*, International Food Policy Research Institute, Washington DC, USA.
- Villamizar, F. (1984, August). IBD Financing in Land Administration Programs. *International Workshop on Land Tenure Administration, Salvador, Brazil, August* (pp. 20-24).
- Vu, T. H., Duc, T. P., & Waibel, H. (2012, September). Farm size and Productivity: Empirical Evidence from Rural Vietnam. In *Conference on International Research on Food Security, Natural Resource Management and Rural Development*.
- World Bank (2007). Agriculture for Development. Washington, DC: The International Bank for Reconstruction and Development / The World Bank. http://siteresources.worldbank.org/Resources/WDR_00_book.pdf
- World Bank (2011). Republic of Ghana. Tackling Poverty in Northern Ghana, *Report No.53991 GH.PREM4/AFTAR*, Africa Region 97
- Youn, H. K. (1992). The translog production function and variable returns to scale. *The Review of Economics and Statistics*, 74, 546-552.