

**Aus dem Institut für Ernährungswirtschaft und Verbrauchslehre  
der Christian-Albrechts-Universität zu Kiel**

**Land tenure arrangements, soil conservation measures and productivity in Brong-  
Ahafo Region of Ghana**

Dissertation  
zur Erlangung des Doktorgrades  
der Agrar- und Ernährungswissenschaftlichen Fakultät  
der Christian-Albrechts-Universität zu Kiel

vorgelegt von  
M.Sc. Daniela Lüth  
aus Hagenow

Kiel, 21.02.2019

---

Dekan: Prof. Dr. Dr. Christian Henning

1. Berichterstatter: Prof. Dr. Awudu Abdulai

2. Berichterstatter: Prof. Dr. Jens-Peter Loy

Tag der mündlichen Prüfung: 15.05.2019

Gedruckt mit Genehmigung der Agrar-und Ernährungswissenschaftlichen Fakultät der  
Christian-Albrechts-Universität zu Kiel

## **Danksagung**

Hiermit möchte ich mich ganz herzlich bei allen bedanken, die mich auf dem langen Weg meiner Arbeit begleitet haben. Ich bedanke mich bei Prof. Awudu Abdulai, dass er mir die Möglichkeit gab, zweimal nach Ghana zu reisen. Es war ein wichtiger Beitrag für meine Arbeit und auch eine sehr persönlich prägende Erfahrung.

Für die Übernahme des Zweitgutachtens bedanke ich mich herzlich bei Herrn Prof. Jens-Peter Loy. Ein ganz besonderer Dank geht auch an den Dekan Herr Prof. Christian Henning, der mich in den Endzügen meiner Arbeit begleitet hat. Ein grosses Dankeschön möchte ich an Frau Prof. Silke Thiele ausrichten, die immer ein offenes Ohr für mich hatte. Dank gilt auch der DFG, die einen wesentlichen Teil meiner Arbeit finanziert hat.

Ich möchte auch danke sagen an alle ehemaligen Kollegen und Kolleginnen am Institut für Ernährungswissenschaft und Verbrauchslehre. Ein besonderer Dank gilt meiner Bürokollegin Kai-Brit Bechtold, die mich über all die Jahre mit sehr viel positiver Energie unterstützt hat. Ich bedanke mich sehr bei Yazeed Abdul Mumin, von dem ich unglaublich viel gelernt und Unterstützung erfahren habe. Ein grosser Dank geht auch an alle aktuellen Mitarbeiter des Instituts, die mich herzlich aufgenommen und unterstützt haben, besonders Dr. Sascha Stark und Johanna Scholz.

Über all die Jahre war es nicht zuletzt meine Familie, die mich unglaublich unterstützt und immer an mich geglaubt hat. Ein ganz besonderer Dank gilt dem Lebensgefährten meiner Mutter, Martin Büsch, und meiner Mutter Elfi Lüth, die beide immer für mich da waren. Meine Mutter ist ein grosses Vorbild, wenn es darum geht zu wissen was wichtig ist im Leben, eine starke Frau, die mir immer ganz besonders viel Kraft gegeben hat. Meiner Schwester Annika Neumann bin ich unglaublich dankbar für ihre klaren und mutigen Ratschläge, Du bist ein Fels in der Brandung.

I especially want to thank my fiancée Terry Maher, who has been with me during the final years of my thesis and always by my side, always listening and never doubting. He gave me unbelievable strength and support. I would have not made it without you Terry!

Daniela Lüth

List of figures	10
Appendix tables	10
Appendix figures	11
List of Acronyms	12
Summary	13
Zusammenfassung	13
1 Introduction to the study	17
1.1 Research Questions	18
1.2 Objectives	18
1.3 Problem statement	18
1.4 Outline of thesis	19
2 The study area and farm household survey	21
2.1 Country profile	21
2.2 Sampling procedure	26
2.3 Focus group discussions	28
3 Land tenure arrangements and investments in soil conservation measures	29
3.1 Introduction	29
3.2 Literature review	29
3.2.1 Land tenure in Ghana	29
3.2.2 Investment decisions - theoretical linkages	32
3.2.3 Marshallian inefficiency and Monitoring approach	32
3.2.4 Empirical literature on property rights and soil conservation measures	33
3.2.5 Empirical research: The missing link	37
3.2.6 Tenure arrangements, social capital, and endogeneity	38
3.3 Conceptual framework	40
3.4 Multivariate probit model	53
3.5 Hypotheses of the study	55
3.6 Results and discussions	56

3.6.1	Descriptive results	56
	What needs to change from the farmer's point of view in order to invest	61
	Descriptive comparison of plots under different tenure arrangements	63
3.6.2	Empirical results	65
	<i>Variables included in the model</i>	65
	<i>Variables subject to endogeneity</i>	67
	<i>Results multivariate probit (2SCML)</i>	74
3.7	Summary and conclusions	82
	Annex	84
4	Land tenure arrangements and social networks	85
4.1	Introduction	85
4.2	Literature review	85
4.2.1	Social networks	85
4.2.2	Land tenure arrangements and social networks	87
4.3	Conceptual framework	90
4.4	Hypothesis	91
4.5	Results and discussion	92
4.5.1	Descriptive results	92
4.5.2	Qualitative analysis	94
4.6	Summary and conclusions	101
	Annex	102
5	Land tenure arrangements and productivity	108
5.1	Introduction	108
5.2.	Literature review	108
5.2.1	Land tenure arrangements and productivity	108
5.3	Conceptual framework and empirical specification	110
5.4	Hypothesis	112
5.5	Results and discussion	112
	Variables included in the model	112

Empirical Results	114
5.6 Summary and conclusions	119
Annex	121
6 Impact of investment in soil conservation on productivity	123
6.1. Introduction	123
6.2 Literature review	123
6.3 Conceptual framework and empirical specification	126
Propensity score matching	126
Evaluation framework	126
Implementation of propensity score	130
6.4 Hypothesis	135
6.5 Results and discussion	136
Variables included in the model	136
6.5.1 Descriptive Results	138
6.5.2 Empirical results	140
6.6 Summary and conclusions	146
Annex	147
7 Participation in off-farm activities	151
7.1 Introduction	151
7.2 Literature review	151
7.2.1 Off-farm activities and investment in soil conservation measures	151
7.2.2 Participation in off-farm activities	154
7.3 Conceptual framework	157
7.4 Empirical specification	165
7.5 Hypothesis	166
7.6 Results and discussion	167
7.6.1 Descriptive Results	167
Variables included in the model	168
7.6.2 Empirical Results	170

7.7 Summary and conclusions	173
Annex	175
8 Conclusions from the study	177
8.1 Summary of findings	177
8.2 Conclusions and policy implications	177
8.3 Suggestion for future research	180
References	182
Annex	206

**List of tables**

Table 2-1: Characteristics of Sampled Districts Kintampo North and Techiman.....25

Table 2-2: Sampled villages and number and share of farmers interviewed .....27

Table 3-1: Household characteristics.....56

Table 3-2: Tenure arrangements .....58

Table 3-3: Main crops cultivated on plot .....58

Table 3-4: Plot characteristics .....59

Table 3-5: Erosion control measures .....60

Table 3-6: Agronomic measures.....60

Table 3-7: Soil management measures .....60

Table 3-8: Cultivation measures .....61

Table 3-9: Input use .....61

Table 3-10: Necessary changes from the farmer’s point of view in % .....62

Table 3-11: Differences in key characteristics between tenure arrangements .....63

Table 3-12: Descriptive statistics of variables used in the empirical analysis .....66

Table 3-13: Descriptives social capital variables.....69

Table 3-14: KMO and Bartlett test of sphericity.....70

Table 3-15: Component matrix .....70

Table 3-16: Probit estimates of determinants of land tenure arrangements .....72

Table 3-17: Probit estimates of determinants of off-farm employment .....73

Table 3-18: Multivariate probit regression of investment in soil conservation measures .....75

Table 3-19: Marginal effects on the marginal probability of investment (%) .....81

Table 4-1: Social capital .....92

Table 4-2: Social capital by type of investment.....93

Table 4-3: Constraints on investment .....94

Table 4-4: KMO and Bartlett’s test.....94

Table 4-5: Total variance explained.....95

Table 4-6: Component matrix .....96

Table 4-7: Cronbach’s alpha component 1 .....97



Table 4-8: Cronbach's alpha component 2 .....	97
Table 4-9: Cronbach's alpha component 3 .....	98
Table 4-10: Cronbach's alpha component 4 .....	98
Table 4-11: Cronbach's alpha component 5 .....	98
Table 4-12: Comparison constraints on investment between tenure arrangements .....	99
Table 4-13: Comparison constraints on investment by social capital variables .....	100
Table 5-1: Descriptive statistics of variables used in the empirical analysis .....	114
Table 5-2: Results First stage estimation credit .....	116
Table 5-3: Results 2SLS productivity analysis and household fixed effects. ....	117
Table 6-1: Descriptive statistics for variables used in the empirical analysis .....	136
Table 6-2: Household and plot characteristics of adopters and non-adopters summary statistics .....	138
Table 6-3: Household and plot characteristics of adopters and non-adopters summary statistics .....	138
Table 6-4: Difference in yields on plot between investment and no investment.....	139
Table 6-5: Average treatment effects of investment options and sensitivity analysis .....	143
Table 6-6: Indicators of covariate balancing, before and after matching .....	144
Table 7-1: Cobb-Douglas production function.....	162
Table 7-2: Benjamin test 2SLS .....	163
Table 7-3: Le's Generalized test 2SLS .....	164
Table 7-4: Off-farm activities.....	167
Table 7-5: Cross-tabulation self-employment and incidence of investment.....	168
Table 7-6: Cross-tabulation wage employment and incidence of investment .....	168
Table 7-7: Descriptive statistics for variables used in the empirical analysis .....	170
Table 7-8: Bivariate probit estimates and marginal effects of decision to work off-farm .....	171

## List of figures

Figure 2-1: Map of Ghana .....	21
Figure 2-2: Map of Ghana - Regions .....	25
Figure 2-3: Districts of Brong Ahafo region .....	26
Figure 3-1: The optimal amount of mineral fertilizer .....	47
Figure 3-2: The optimal amount of manure.....	48
Figure 3-3: The optimal amount of multiple cropping .....	51
Figure 3-4: The optimal amount of ditches.....	52
Figure 3-5: Tenure arrangements and instruments .....	68
Figure 4-1: Classification of social capital.....	91
Figure 6-1: Propensity score distribution and common support for propensity score estimation.....	142

## Appendix tables

Table 3-1: Eigenvalues.....	84
Table 3-2: Variance inflation factors multivariate investment decision .....	84
Table 4-1: Kaiser-Meyer-Olkin Measure of Sampling Adequacy.....	105
Table 4-2: Component matrix unrotated* .....	105
Table 4-3: Correlation matrix of components .....	106
Table 4-4: Squared Multiple Correlations.....	107
Table 5-1: Variance inflation factors productivity analysis.....	122
Table 6-1: Estimation of propensity score for investment in ditches.....	147
Table 6-2: Estimation of propensity score for investment in fertilizer.....	148
Table 6-3: Estimation of propensity score for investment in manure .....	149
Table 6-4: Estimation of propensity scores for investment in multiple cropping .....	150
Table 7-1: First – stage estimation shadow wage in order to account for possible endogeneity .....	175
Table 7-2: Variance inflation factors bivariate probit .....	176

## Appendix figures

Figure Appendix 1: Screeplot .....	106
Figure Appendix 2: Distribution residuals from productivity analysis .....	121

## List of Acronyms

ATE	Average Treatment Effect
ATT	Average Treatment Effect of the Treated
CIA	Central Intelligence Agency
CIA	Conditional Independence Assumption
CC DARE	Climate Change and Development – Adapting by Reducing Vulnerability
ECA	Economic Commission for Africa
FAO	Food and Agricultural Organization
fbo	Farm based organization
GHS (¢)	Ghanaian Cedis
GPRS I	Ghana Poverty Reduction Strategy I
GPRS II	Growth and Poverty Reduction Strategy II
ha	Hectare
i.e.	id est
IMF	International Monetary Funds
kg	Kilogram
KMO	Kaiser-Meyer-Olkin Measure
LAP	Land Administration Project
LPM	Linear probability model
MDGs	Millennium Development Goals
MMM	Mahalanobis metric matching
NDPC	National Development Planning Commission
NNM	Nearest neighbor matching
OLS	Ordinary least squares
PCA	Principal component analysis
PSM	Propensity score matching
2SCML	Two-Stage Conditional Maximum Likelihood
2SLS	Two-Stage Least Squares
SMC	Squared Multiple Correlations
UN	United Nations
UNDP	United Nations Development Programme
VIF	Variance inflation factor

## Summary

Agricultural productivity has been low in Ghana due to low soil fertility aggravated by soil degradation among other factors. Soil fertility can be increased by investing in soil conservation measures. Tenure arrangements have gained attention as a way to understand investment in soil conservation measures. Secure tenure rights are claimed to increase investment, however, empirical findings concerning the effects of tenure arrangements on investment are ambiguous. Focusing on tenure arrangements alone might not be sufficient; decision-making occurs in the context of its social setting and social networks are therefore a promising source of explanation of investment behavior. Investment decisions might also be influenced by participation in off-farm activities that constitute an important source of income and influence labor allocation. Unravelling the determinants of investment in soil conservation measures helps understanding how to increase agricultural productivity in a sustainable manner.

This study analyzes the impact of land tenure arrangements on farmers' investment decisions in soil conservation measures at plot-level, while also determining the influence of social networks and income diversification of farms using cross-sectional data from 400 farmers in the Brong Ahafo region of Ghana collected in 2010. Four diverse tenure arrangements are employed: ownership with restricted rights, ownership with unrestricted rights, fixed-rentership, and sharecropping. Three soil conservation measures and one productivity-enhancing measure, fertilizer, have been chosen for the analysis. Tenure arrangements' influence on the decision of farmers to invest in these measures is estimated by employing a multivariate probit model, while endogeneity of land tenure arrangements, social capital and off-farm activities are controlled for by 2SCML. The effect of investment on productivity is, unlike tenure arrangements by means of a productivity analysis, examined by propensity score matching which accounts for possible selectivity bias.

A dynamic framework examines the relationship between diverse tenure arrangements, social networks and farmer's investment in productivity enhancing and soil conservation measures. Diverse tenure arrangements lead to different time horizons, and costs of investment differ depending on the type of tenure.

The empirical results show the influence of tenure arrangements, social capital and off-farm activities on farmers' investment decisions. Farmers who rent land are less likely to invest in manure, a soil improving investment with positive long-term effects. Farmers on sharecropping contracts and under fixed-rentership are more likely to invest in fertilizer, a short-term investment option which decreases soil quality over time. The number of years the plot is under use by the cultivator is positively associated with all investment options, supporting the notion of tenure security as an important factor in investment in soil conservation measures.

Investment is driven by social networks. Being part of information networks as well as networks related to other types of assistance is positively related to most investment options. In addition, participation in a farm-based organization increases the likelihood of investment. A descriptive analysis underlines the positive relationship between several types of social networks and investment in soil conservation measures. Investment in soil conservation measures with long-term effects are positively associated with diverse types of social capital covering monetary, practical and knowledge assistance. Underlining the previous analyses, farmers face varying constraints on investment depending on the various tenure arrangements they are confined by and the social networks they have access to.

Results of the productivity analysis uncover no evidence that both tenure arrangements and social capital are significant determinants of productivity. However, results using PSM for the impact of investment on productivity reveal that investment in ditches, fertilizer and multiple cropping significantly increases revenue per acre on plot.

Results of farmers' decisions to participate in self-employment and wage employment show diverse drivers, yet similar entry barriers exist for both types of off-farm activities for households that have very few assets.

## **Zusammenfassung**

Landwirtschaftliche Produktion in Ghana hat wie in anderen afrikanischen Ländern ihr Potential noch nicht ausgeschöpft. Wachstum muss nachhaltig sein, d.h. nachhaltige Bewirtschaftung muss neben produktivitätssteigernden Inputs angewendet werden. Grundbesitzrechte haben in Bezug auf Investition in nachhaltige Bewirtschaftung an Bedeutung gewonnen. Jedoch sind die empirischen Ergebnisse des Einflusses von Grundbesitzrechten auf das Investitionsverhalten des Landwirts nicht eindeutig. Entscheidungen treten in einem sozialen Umfeld auf und soziale Netzwerke können vielversprechend sein um das Investitionsverhalten zu erklären. Allerdings wurde der Einfluss dieser bisher wenig im Zusammenhang mit Grundbesitzrechten untersucht. Nichtlandwirtschaftliche Beschäftigung wird ebenfalls berücksichtigt, da sie eine wichtige Einkommensquelle darstellt und die Arbeitsallokation beeinflusst.

Die Studie analysiert vorwiegend den Einfluss von Grundbesitzrechten auf nachhaltige Bewirtschaftung auf der Grundstücksebene und untersucht gleichzeitig inwiefern soziale Netzwerke und Einkommensdiversifizierung des Landwirts eine Rolle spielen. Mittels einer Befragung, die im Mai 2010 stattfand, wurden Querschnittsdaten von 400 Haushalten in der Brong Ahafo Region in Ghana erhoben. Dabei wurden vier verschiedene Grundbesitzrechte berücksichtigt: Besitz mit beschränkten oder uneingeschränkten Rechten, ein Pachtvertrag mit

monetärer Pacht oder das Entrichten der Pacht als Teil der Ernte. Sozialkapitalvariablen sind angelehnt an ein multidimensionales Konzept. Nicht-landwirtschaftliche Beschäftigung ist unterteilt in selbstständige und nichtselbstständige Beschäftigung. Die Determinanten dieser werden anhand eines bivariaten Probitmodells ermittelt. Zwischen vier verschiedenen Investitionen wird unterschieden: Gräben, Kunstdünger, biologischer Dünger und Mischkultur. Diese werden anhand eines multivariaten Probitmodells untersucht; für Endogenität von Grundbesitzrechten, Sozialkapital und nicht-landwirtschaftlicher Beschäftigung wird mittels der 2SCML kontrolliert. Der Einfluss von Investitionen auf die Produktivität wird, im Gegensatz zu Grundbesitzrechten anhand einer Produktivitätsanalyse, mit Hilfe des Propensity Score Matching erfasst, welches für mögliche Verzerrung durch Selbstselektion kontrolliert.

Der mögliche Einfluss von Grundbesitzrechten und sozialen Netzwerken auf das Investitionsverhalten des Landwirts wird anhand eines dynamisch theoretischen Modells erklärt. Verschiedene Grundbesitzrechte führen zu unterschiedlichen Zeithorizonten, Kosten der Investition sind verschieden und abhängig vom Grundbesitzrecht.

Die Ergebnisse bezüglich des Einflusses von Grundbesitzrechten, Sozialkapital und nicht-landwirtschaftlicher Beschäftigung auf das Investitionsverhalten des Landwirts zeigen, dass das Pachten von Land Investitionen in biologischen Dünger hindert und Pacht als auch Sharecropping Investitionen in Maßnahmen mit privaten Kurzzeiteffekten fördert (chemischer Dünger). Ferner beeinflussen Jahre, die das Land bereits vom Landwirt kultiviert wurde alle Investitionen ebenfalls positiv. Darüber hinaus übt Sozialkapital einen positiven Einfluss auf Investitionen aus. Zusätzliche deskriptive Analysen bestätigen den positiven Einfluss verschiedenster sozialer Netzwerke auf das Investitionsverhalten des Landwirts. Ausserlandwirtschaftliche Beschäftigung fördern Investitionen.

Deskriptive Analysen belegen die Bedeutung von verschiedenen sozialen Netzwerken im Hinblick auf das Investitionsverhalten des Landwirts. Insbesondere Gräben und Mischkultur, Investitionen mit Langzeiteffekten, sind positiv verknüpft mit verschiedensten sozialen Netzwerken. Diese beinhalten sowohl monetäre als auch praktische Hilfe und Zugang zu Informationen. Die fünf Komponenten der Hauptkomponentenanalyse, basierend auf Hindernissen aus Sicht des Landwirts zu investieren, erfassen verschiedene Hindernisse in Bezug auf das Investitionsverhalten: das Fehlen von Kompetenz, Liquidität, praktischer Hilfe, sicheren Grundbesitzrechten und Profitabilität von Investitionen. Diese variieren zwischen den Grundbesitzrechten und je nach sozialen Netzwerken, wobei letzteres weniger offensichtlich ist.

Die Ergebnisse der Produktivitätsanalyse ergeben, dass Grundbesitzrechte und Sozialkapital keine signifikanten Determinanten von Produktivität sind. Allerdings beeinflusst das Besitzen

eines Mobiltelefons Produktivität positiv und deutet auf die Relevanz von Kommunikation hin. Ein Modell mit festen Haushaltseffekten wurde verwendet, um für unbeobachtbare Variablen auf der Haushaltsebene zu kontrollieren, die Produktivität beeinflussen. Grundbesitzrechte sind ebenfalls keine signifikanten Einflussfaktoren von Produktivität.

Ergebnisse bezüglich des Einflusses von Investitionen auf Produktivität zeigen, dass Gräben, Kunstdünger und Mischkultur den Erlös pro Acre signifikant erhöhen. Die Ergebnisse stimmen mit bisherigen Studien überein, die den Einfluss von Investitionen, die in Verbindung zu nachhaltiger Bewirtschaftung stehen, untersuchen.

Die Entscheidung des Landwirts selbstständige und nichtselbstständige Beschäftigung auszuführen wird sehr unterschiedlich determiniert. Jüngere, weibliche und gebildete Landwirte, die Land besitzen und monetär unterstützt werden, gehen eher selbstständiger Beschäftigung nach. Bestimmungsfaktoren von nichtselbstständiger Beschäftigung zeigen auf, dass auch dies heterogene Aktivitäten sind. Eintrittsbarrieren bestehen für beide Arten von Beschäftigung für Haushalte, die mit wenig Besitz ausgestattet sind.

Die aktuelle Studie liefert wichtige Implikationen für die Politik. Die Bereitstellung von sicheren Bodenrechten und die Verlängerung der zeitlich befristeten Rechte würden aufgrund der empirischen Ergebnisse nachhaltige Bewirtschaftung begünstigen. Hinzu kommen Investitionen in Institutionen wie landwirtschaftliche Organisationen und Beratung, die den Informationsaustausch fördern. Damit einhergehend ist es erforderlich, die positiven Effekte von nachhaltiger Bewirtschaftung auf den Erlös zu kommunizieren. Da nicht-landwirtschaftliche Beschäftigung und landwirtschaftliche Produktion zusammenhängen, sind komplementäre Aktivitäten erforderlich, um beides zu fördern. Der Zugang zu nicht-landwirtschaftlicher Beschäftigung muss für die Landwirte verbessert werden, die wenig Besitz haben. Eine Möglichkeit wäre verbesserte Bildung. Der Zugang zu monetären Mitteln ist entscheidend für selbstständige Beschäftigung und verweist auf die große Bedeutung der Förderung des Zugangs zu Kredit.



## 1 Introduction to the study

Agricultural productivity has been low in Ghana due to low soil fertility aggravated by soil degradation among other factors. Soil fertility can be increased by investing in soil conservation measures (Morris *et al.*, 2007; CIA, 2018). Tenure arrangements have gained attention as a way to understand investment in soil conservation measures (Abdulai and Goetz, 2014). Secure tenure rights are claimed to increase investment, however, empirical findings concerning the effects of tenure arrangements on investment are ambiguous. The link between secure land tenure arrangements and investment in soil conservation measures has gained increased attention over time. Tenure arrangements on investment either have been found to exert a positive effect (Abdulai *et al.*, 2011) or only an inconclusive relationship (Besley, 1995). Focusing on tenure arrangements alone might not be sufficient; decision-making occurs in the context of its social setting and social networks are therefore a promising source of explanation of investment behavior (Berry, 2009; 1373). Investment also implies that farmers feel secure enough to invest and are aware of investment possibilities and their effects (Bandiera and Rasul, 2006; Udry, 2008).

A number of studies have separately analyzed the impact of land tenure arrangements and social networks on farmers' investment decisions, however, both have rarely been studied together. A survey of current research concludes that only a few studies have focused on both, and even those miss important aspects. The concept of social capital is simplified, tenure arrangements are not assessed adequately, and investment options are aggregated (see Saint-Macary *et al.*, 2010; Beekman and Bulte, 2012).

Non-farm income accounts for around 50% of rural household income in Africa; in Ghana it is around 40% (Haggblade *et al.*, 2010; Senadza, 2012). Interactions between on-farm and off-farm activities have been analyzed in several developing countries with contradictory results. Off-farm activities are claimed to be beneficial in terms of providing cash, but also to hinder investments by diverting labor away, especially from labor-intensive conservation measures (Killic *et al.*, 2009; Oseni and Winters, 2009). Productivity should be fostered in both the short-term and the long-term. In Ghana, environmental degradation is deemed responsible for productivity not rising sufficiently (CIA; 2018). Therefore, the relationship between tenure arrangements and investment is not all that needs investigation, productivity is also of great importance. Previous studies focus on the effect of tenure arrangements and investment decisions on productivity with ambiguous results (Besley, 1995; Fenske, 2010a; Abdulai *et al.*, 2011).

Increased agricultural productivity in a sustainable manner can be facilitated not only in Ghana but also in other African countries, by making use of these study insights. Conclusions of this study are expected to support sustainable growth in agriculture in Ghana mainly by providing insight into determinants of investment in soil conservation measures. These insights can be used to adjust policy measures in order to enhance investments in both productivity-enhancing as well as soil conservation measures by strengthening security of tenure rights as well as making use of social networks.

### **1.1 Research Questions**

(i) How do different land tenure arrangements influence investment in soil conservation measures? What is the effect of social networks and income diversification on investment behavior?

(ii) What is the influence of tenure arrangements, social networks and investment on productivity?

(iii) What are the determinants to engage in wage employment and self-employment?

### **1.2 Objectives**

The objective of this study is to gain insight into the impact of land tenure arrangements on farmers' investment decisions on soil conservation measures.

Specifically, the study seeks to: (i) examine the relationship between land tenure arrangements, social networks, income diversification and soil conservation measures at plot-level while controlling for possible endogeneity within these concepts, (ii) determine the influence of tenure arrangements, social networks and investment on productivity at plot-level, while controlling for possible self-selection bias concerning the latter, (iii) analyze the farmer's decision to participate in off-farm activities, specifically self-employment and wage employment.

### **1.3 Problem statement**

Agriculture is one of the most important sectors in developing countries. For the past 40 years, agricultural yields and growth rates have remained low in Africa. Any growth that occurred was more due to the use of additional land than to an increase of yields as such. A relatively low and stable use of inputs such as fertilizer can also be observed. Another reason for the insufficient increase in yields is the poor conditions of natural resources which hinder the development of agriculture, along with the reduction of poverty and the increase of food security (Barrett *et al.*, 2002b).

To increase productivity in a sustainable manner, output needs to increase while simultaneously ensuring that natural resources are protected for future use (Udry, 2009). Soil inherits a resource base which, if not replenished, is at risk of giving ever-diminishing returns in the future. The sustainability of agricultural yields requires the maintenance of soil fertility (Agwe *et al.*, 2007).

One means of increasing productivity is to invest in soil conservation measures. But farmers are faced with challenges such as insecure land tenure arrangements, especially for long-term investments (Knox *et al.*, 2002). However, empirical evidence for the positive effect of secure land tenure arrangements on investment decisions in Africa is rather ambiguous and highlights the important role that context plays with regard to investment decisions (Place, 2009).

The decision-making process of farmers is embedded within a social setting, and social networks might provide preconditions of action (Woolcock and Narajan, 2000; Woolcock, 2010). Capacity building of farmers is crucial in that they are endowed with the necessary knowledge and skills (Kothari, 2004) to invest in soil conservation measures. A lack of information concerning investment possibilities and access to inputs and technology may obstruct investment (Place and Otsuka, 2002). Investment decisions might also be influenced by off-farm activities that constitute an important source of income and influence labor allocation (Barrett *et al.*, 2005; Davis *et al.*, 2009; Pfeiffer *et al.*, 2009).

#### **1.4 Outline of thesis**

The remainder of the thesis is organized as follows: In chapter 2, the study area and farm household survey are presented. Information on the country's economic activity and development, in particular, the agricultural sector, is given. The data collection method is outlined and a summary of focus group discussions that took place before executing the survey is given.

Chapter 3 builds the backbone of the thesis. It includes the empirical analysis of the impact of land tenure on farmers' investment decisions in soil conservation measures. The chapter provides a literature overview and an outline of land tenure and its history in Ghana. A review of theoretical linkages and extant empirical literature on property rights and soil conservation measures is presented. A dynamic framework explains the effect of tenure arrangements and social networks on the investment decisions that farmers make. This chapter also covers the methodology employed. A discussion on the empirical results concerning the impact of land tenure arrangements, social networks, and off-farm activities along with controlling for their possible endogeneity, on several investment decisions at plot-level follows.

Chapter 4 presents the concept of social networks in detail. First, a literature overview of the concept and its interlinkages to tenure arrangements in the context of investment behavior is presented, followed by a qualitative analysis complementing the empirical findings in chapter 3. Constraints on investment from the farmer's point of view are analyzed and comparisons are carried out between tenure arrangements and social networks of the farmer.

Chapter 5 presents the influence of land tenure arrangements on plot-level productivity, a literature overview, a conceptual framework and empirical specifications and results.

Chapter 6 focuses on the intermediate effect between tenure arrangements and productivity by using investment options. First, it goes through extant empirical literature analyzing the effect of investment decisions on productivity. Next, the conceptual framework and the empirical specification are presented, followed by the descriptive and empirical results.

Chapter 7 analyzes participation in off-farm activities and gains deeper insight into the relationship between off-farm activities and investment decisions. It presents a review of the extant empirical literature on the interrelations between participation in off-farm activities and investment on the farm and determinants of income diversification. The farmers' decision to participate in self-employment and/or wage employment is determined by a time allocation model based on the tested assumption of separability. This chapter includes the econometric model applied and the descriptive and empirical results analyzing the relationship between participation in off-farm work and investment while discussing participation in self-employment and wage employment.

Finally, chapter 8 closes the thesis with a summary of results along with policy implications and suggestions for future research.

## 2 The study area and farm household survey

This chapter provides an overview of Ghana and, more specifically, of the two regions where the survey was carried out. The sampling procedure is briefly outlined and outcomes of focus group discussions conducted before designing the survey are presented.

### 2.1 Country profile

Ghana is part of Sub-Saharan Africa, a group of African countries that, as the name suggests, are countries that lie to the South of the Sahara, constituting its own challenges and circumstances in comparison to the Northern countries of Africa. Ghana is in West Africa. The capital, and largest city is Accra. It is located on the Gulf of Guinea and shares borders with Cote d'Ivoire and Togo to the west and east respectively. To the North, Ghana shares border with Burkina Faso. A map of Ghana and its neighboring countries is shown in figure 2-1.



Figure 2-1: Map of Ghana<sup>1</sup>

Ghana has a population of 28 million, according to the 2012 census, with a population density of around 124 people per km<sup>2</sup> (World Bank, 2016). Ghana's population is rather young, with approximately 57% of the population aged below 25 years. 52% of the total population lives in urban centers (CIA, 2018<sup>2</sup>). Ghana's population is multi-ethnic. Akan is the predominant ethnic group (45%), followed by Mole-Dagbani (17%), the Ewe (14%), Ga and Dangme, and several

<sup>1</sup> Source: [https://www.cia.gov/library/publications/the-world-factbook/maps/maptemplate\\_gh.html](https://www.cia.gov/library/publications/the-world-factbook/maps/maptemplate_gh.html)

<sup>2</sup> Estimate 2017

smaller ones. English is the official language but many other languages are spoken (World Population Review, 2017; Gocking, 2005: 8-10).

Ghana is characterized by a tropical climate with the main seasonal change being between wet and dry season. In the South, one can observe various types of rainforest and experience two rainy seasons whereas, in the North, there is mostly savanna woodland and only the one rainy season (Gocking, 2005: 2). The climate differs from warm and dry along the coast in the Southeast, to hot and humid in the Southwest and dry in the North (CIA, 2018).

Ghana is representative of other African countries since agriculture forms the mainstay of the economy and provides a means of earning a living for a large range of the population, yet with decreasing relevance. In 2010, agriculture accounted for nearly 30% of Ghana's GDP, yet with decreasing importance for the country (World Bank, 2013) accounting for only 20% of GDP in 2016 (World Bank, 2018). Still, farming employs more than half of Ghana's total workforce that are mainly small landholders (CIA; 2018). Farming is mostly practiced on a small scale, 80% of agricultural production coming from an average land holding of below 1.5 hectares (Bennett-Lartey and Oteng-Yeboah, 2008). Previous growth in crop production, like that in other African countries, is mostly due to land expansion and, to a lesser extent, to an improvement in yields. Growth in the future needs sustainable sources of growth (Diao, 2010). Growth that occurred was mostly owing to cocoa production and marketing, whereas sub-sectors such as food crops are not characterized by high improvements (NDPC, 2010, World Bank, 2010).

Of the land available, 70% is agricultural land, 20% is arable and 12% is used for permanent crops, the rest for permanent pasture (CIA, 2018<sup>3</sup>). The most common crops cultivated are maize, cassava, plantain, yam, cocoyam, rice, sorghum, and millet. In the North, sorghum, millet, yam, and rice play a major role, while in the South maize, cassava and plantain are more important crops. Vegetables cultivated are pepper, eggplant, tomatoes, okra, and beans. Cash crops are oil palm, cotton, coconut, tobacco, groundnut, rubber and cocoa.

Exports constitute 41% of the GDP (World Bank, 2018<sup>4</sup>) with a large relevance of agriculture. Cocoa accounts for more than 50% of total exports, followed by manganese ores and concentrates which comprise nearly 10% of exports (Bennett-Lartey and Oteng-Yeboah, 2008; World Bank, 2011a<sup>6</sup>). Other natural resources are oil, gas, gold, diamond, salt, bauxite, limestone, and iron ore that are also exported (Gocking, 2005: 6-8; NDPC, 2010).

---

<sup>3</sup> Estimate 2017

<sup>4</sup> Estimate from 2016

Poor soil constrains the level of agricultural production. One current environmental issue all over the country is soil erosion (CIA, 2018). Environmental degradation and lack of sustainable agriculture are responsible for productivity not rising sufficiently in agriculture (NDPC, 2005). Other environmental concerns, especially with export-oriented agriculture, are land degradation, deforestation and reduced biodiversity (World Bank, 2010; CIA, 2018). Initiatives have had poor success with respect to reversal of degradation of natural resources. This is caused by the rapid depletion of biomass without any replenishing of stocks and generally natural resources being inefficiently managed (UNDP, 2015).

With regard to the Millennium Development Goals, a blueprint for development, the first and the seventh goals are especially related to the study. The first developmental goal of eradicating extreme poverty and hunger has been achieved ahead of target in both urban and regional areas, with Ghana being the first country in Sub-Saharan African (UNDP, 2015). That being the case, the present GDP per capita of \$1.513 is above the average for Sub-Saharan Africa (excluding South Africa) of \$1.464 (World Bank, 2018<sup>5</sup>). Since 1995, Ghana has tried to become a middle-income country. The first national policy development framework developed was 'Vision 2020'. It was followed by the GPRS I and GPRS II (NDPC, 2010), resulting in Ghana's achievement of its goal of becoming a middle-income country (UNDP, 2018).

The share of forested area to total land area is one indicator of the 7<sup>th</sup> millennium development goal of ensuring environmental sustainability and declined from 1990 to 2010 to 22%, a drop of over 10% (World Bank, 2013). Trees that have been lumbered and extension of land used for cultivation led to the loss of large areas of rainforest. Expansion of land is limited and the need for farmland comes at the cost of losing forest area (Gocking, 2005:3). The 7<sup>th</sup> millennium development goal has not been achieved and deforestation is occurring at an alarming rate, despite afforestation efforts since 2010. Part of the challenge is also linked to unsustainable agricultural practices (UNDP, 2015).

Ghana has a market-based economy with relatively few policy barriers to trade and investment. Its economy has been supported by relatively sound management and sustained reductions in poverty, yet has suffered due to loose fiscal policy, high budget deficits along with a depreciating currency (CIA, 2018). There is potential for the private sector to enhancing development and some policy actions address the promotion of the private off-farm sector (NDPC; 2010). For instance, the GPRS II aimed at the promotion of rural off-farm businesses by supporting innovation and entrepreneurship and facilitating access to capital (NDPC, 2005; IMF, 2009). A three-year Poverty Reduction and Growth Facility was signed with the IMF as a

---

<sup>5</sup> Estimate from 2016

follow-up to the GPRS II in 2009 to, among other objectives, enhance competitiveness of the private sector (CIA, 2012). Data from the Ghana Living Standards Survey (GSS 2013) indicate that about 44% of households are engaged in off-farm enterprises, with about 37% in total in rural areas. The main off-farm activities are manufacturing, trading and other economic activities such as mining and construction (GSS, 2013). In 2015, Ghana signed a \$920 million extended credit facility with IMF. Prospects for new oil and gas production and follow through on tighter fiscal management are likely to help Ghana's economy in 2018 (CIA; 2018).

One of Ghana's 10 regions is the Brong Ahafo Region, the 'bread basket', with its capital Sunyani. It covers an area of 39,557 km<sup>2</sup> and has a population of 1,815,408 inhabitants. It was established in 1959 and used to be part of the Ashanti region. 19 administrative districts are part of the region with Kintampo (being separated into Kintampo North and Kintampo South) lying at the center of the country. Agriculture is, like in other regions, the predominant occupation in the Brong Ahafo Region in all districts (Government of Ghana Official Portal, 2013). The region's main endowments are arable land (60%) with nearly half of it under cultivation, followed by forestry, inland fisheries, and clay deposits.





Figure 2-2: Map of Ghana - Regions<sup>6</sup>

The table 2-1 shows main differences between the sampled districts in the Brong Ahafo Region Kintampo North, situated in the North, and Techiman, lying more to the South (Government of Ghana Official Portal, 2013; Embassy of the Republic of Ghana, 2013; Kintampo North Municipal Assembly, 2006; Ministry of Food and Agriculture, 2013).

Table 2-1: Characteristics of Sampled Districts Kintampo North and Techiman

District	Kintampo North	Techiman
<b>Vegetation</b>	- Guinea savannah woodland	- Moist semi-deciduous forest
<b>Climate</b>	- Tropical Continental or interior Savannah type of climate (district lies in the transitional zone between 2 major climatic regions of Ghana)	- Semi-equatorial and tropical conventional or savanna climates, characterized by moderate to heavy annual rainfall - 3 main vegetation zones: Guinea-Savanna woodland (north-west) the semi-deciduous (south) and the Transitional zone (from the south-east and west up to the north of the municipality)
<b>Economy</b>	Agrarian, nearly every citizen is engaged in agricultural and related activities	Agricultural production and agricultural marketing

<sup>6</sup> Source: <http://www.feedthefuture.gov/sites/default/files/countries/images/map-ghana.png>

<b>Soil</b>	Groundwater lateral soils which cover nearly 3/5 of the area (poor in organic matter and nutrients)  Savanna Ochrosols covering the remaining 2/5 of the area (more organic matter and nutrients)	Forest and Savanna Ochrosols
<b>Land Use</b>	Crop production (mainly yam, maize, cowpea, cassava, rice, plantain)  livestock production (cattle, sheep, goats, local poultry)	Crop production (mainly maize, yam, cassava, plantain), livestock production (poultry, sheep, goats, cattle, pigs)
<b>Land area</b>	5,108km <sup>2</sup>	1,119 km <sup>2</sup>

## 2.2 Sampling procedure

In Figure 2-3, the districts of the Brong Ahafo region are plotted. The survey was carried out in the two districts of Techiman and Kintampo North (marked by a dashed circle). Three villages in the Techiman and three villages in the Kintampo district were selected, Twimea, Aworopat and Fiaso, Kintampo, Kunso and Badukrom respectively. The total sample size is 400 households with 200 households from each district.

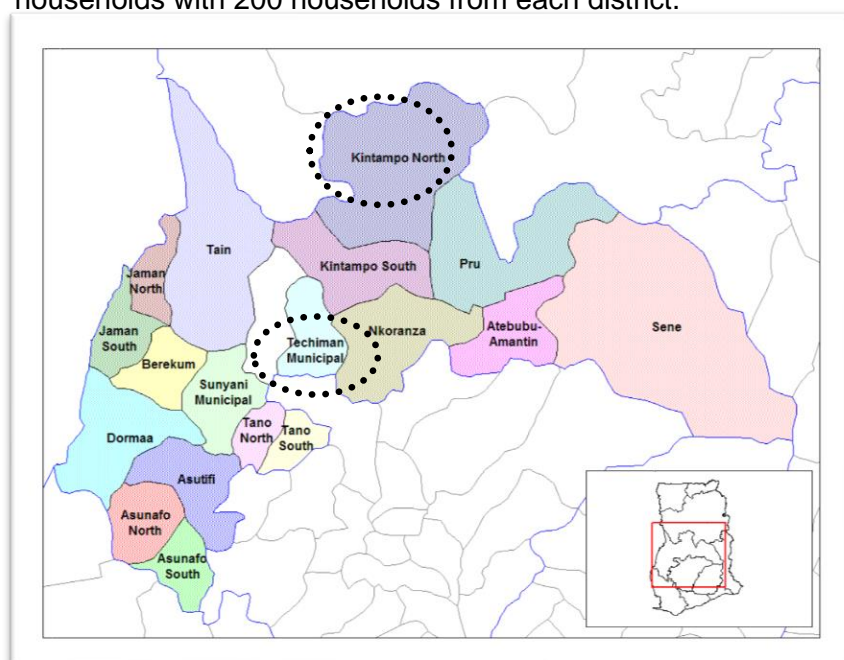


Figure 2-3: Districts of Brong Ahafo region<sup>7</sup>

<sup>7</sup> Source: [http://ghana-net.com/Documents/776px-Brong\\_Ahafo\\_districts.png](http://ghana-net.com/Documents/776px-Brong_Ahafo_districts.png)

The Brong-Ahafo Region was chosen due to the plenty land tenure rights observed in this region, allowing a comparison between those in terms of investment behavior of farmers. A two-stage stratified random sampling technique was employed in order to select farmers within each district. First, two districts were selected out of the 19 districts in the Brong Ahafo region, and then three villages within each district. The two districts have been selected due to one being in the South and one being in the North, where we could obtain variance in the data with regards to soil characteristics, as shown in the table above. The three villages out of each district have been chosen based on knowing that there are enough farmers with different land tenure arrangements and different distances to the next town, which might influence results. Second, a stratified random sampling was applied for each district to select farmers out of the three villages.

The following equation presents the procedure for each district:

$$S_i = \frac{x_i}{X} N \quad (2-1)$$

Where  $S_i$  is the stratified random sampling to be drawn from each village (stratum)  $i$ ,  $x_i$  is the population within each village,  $X$  is the total population of each district and  $N$  is the total sample size to be drawn from each district. In total, we obtained a sample size of 400 households, 200 out of each district. Within the villages, the selection of farmers was random. The farmers partaking represented the various land tenure arrangements in the region. Table 2-2 indicates the sampled villages and the number and share of farmers interviewed based on the sampling strategy. The survey was conducted by means of questionnaire interviews which took place between April and May 2010.

Table 2-2: Sampled villages and number and share of farmers interviewed

Villages	Number of farmers	Percentage
<i>District Techiman</i>		
Twimea	46	0.12
Awaropat	98	0.25
Fiaso	56	0.14
<i>District Kintampo North</i>		
Kintampo	93	0.23
Kunso	45	0.11
Badukrom	62	0.15

Source: Survey data

### **2.3 Focus group discussions**

Before the survey was carried out, we executed focus group discussions in two villages. In each village, most of the village inhabitants came together. We informed them beforehand by extension services about our visit and that we would conduct a research with regards to investments on their land. During the meeting, we explained that the purpose of our visit was to perform a survey in six villages in the area and that we wanted to get some more information about their cultivation and conservation measures.

The main intention of the focus group discussions was to gain information about their cultivation and conservation measures, their land tenure rights and social networks from their point of view. Through this, we obtained valuable information we used for designing the questionnaire. First, we wanted to get to know their most common practices applied in order for the survey to not miss any important data.

We discussed the types of land tenure arrangement. The farmers informed us about *taungya* – a type of restricted landownership – where use rights are given to farmers for a couple of years until trees were planted by the government making farming impossible. Consequently, we included this type of tenure rights in the questionnaire.

In addition, we asked for reasons not to apply specific practices. They named several aspects such as monetary constraints, lack of practical assistance and information. These aspects have been added to the questionnaire by ranking constraints of investment in order to enrich the quantitative analysis with qualitative information. In line with constraints of investment, we also asked about information sources they used and social networks they are part of and address for help. This knowledge improved social network analysis to a great extent by asking farmers questions related to their real-life experiences.

They also showed us a couple of fields. In particular, they pointed out some practices, like building ditches, and showed some plants being cultivated during the time of the visit. In summary, the focus group discussions helped to design an enriched questionnaire and to focus on important aspects from the farmers' point of view.

### **3 Land tenure arrangements and investments in soil conservation measures**

#### **3.1 Introduction**

In this chapter, we analyze the influence of tenure arrangements on investment decisions of farmers. The analysis will shed further light on the relevance of tenure arrangements on investment behavior. The effect of land tenure arrangements on investment in soil conservation measures is ambiguous in extant empirical literature and needs further empirical attention in order to foster sustainability in agriculture. We also include the effect of social networks and income diversification of farmers in order to provide a holistic picture of the determinants influencing investment behavior of farmers. The following chapters will focus more deeply on social networks and income diversification. Productivity analysis focuses on the measurable effect for farmers. This chapter is divided as follows: First, an overview of land tenure in Ghana and theoretical linkages between land tenure and investment decisions are provided. Next, empirical literature on land tenure arrangements and soil conservation measures is presented and the missing link to social networks is briefly outlined. A conceptual framework is presented, which mainly addresses the impact of diverse tenure arrangements on the investment decisions of farmers. The empirical model employed is outlined and necessary changes for farmers to invest in soil conservation measures are presented. Lastly, the investment specification is presented and the empirical results are discussed.

#### **3.2 Literature review**

##### **3.2.1 Land tenure in Ghana**

Land in rural areas serves several crucial functions. It is a means of earning a living and it can also serve as an asset that can be traded, in some cases, for a home. Agricultural production in Sub-Saharan Africa like Ghana (except South Africa) is mainly carried out by farmers on small plots. Land is linked to property rights. A property right includes the capacity of the right's holder to induce the system of authority to come to his or her defense in case of need. It can also be linked to utility of the holder over time due to extracting resources and consuming them. In Ghana, we observe a customary tenure system and an increasing amount of land is now being cultivated under commercial land tenure arrangements such as sharecropping and fixed-renting (Arnot *et al.*, 2011; Udry, 2012).

Land tenure is the relationship, both legally and customarily, among people, with regards to land (FAO; 2002). Arrangements around land tenure are complex because they contain several concepts. The most challenging term is “tenure security” and mostly linked to people’s perception (FAO; 2012). A common definition of tenure security is provided by Roth and Haas

(1998: 1-2) 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 gain the benefits of labor or capital invested in the land, either in use or alienation.” Tenure arrangements’ security is also influenced by the length of duration, and the assurance that tenants are not being dispossessed or evicted (Place and Swallow, 2002; Place, 2009). The exclusivity of rights and their transferability are also addressed along with security where the importance of transferability depends to a large extent on the situation of the land market (Place and Swallow, 2002).

In Ghana, land law has evolved from a complex combination of several sources drawing from religion, customs, legislation, and executive. Two main types of land tenure can be distinguished, namely, customary land tenure and public land tenure. The latter is linked to the right of the government to acquire land for the greater public good (Sarpong, 2006). Customary law implies land to be a common asset where the individual farmer owns the crops but not the soil. Deeds on land are subject to lineage and the access that individuals are afforded is based on membership of these groups and previous land transactions. Non-members must seek the permission of the chief to stay in the area and can obtain land as a sharecropper from a landowner or the chief (Pande and Udry, 2007; Berry, 2009).

Most of the land tenure arrangements across the country are governed by a combination of customary rules or convention and legislation. However, the laws and conventions governing inheritance vary in their application within the country. In the Akan-speaking region, matrilineal rules are predominant. Should a male die leaving no last will and testament, his belongings are distributed among his maternal family members in accordance with customary law. The deceased’s wife and children are excluded from any gain. In the North, among the Volta and the Ga, rules are patrilineal whereby the deceased’s property is divided up among his children which has led to plots becoming ever smaller and thus more difficult to cultivate economically viable (Sarpong, 2006; Pande and Udry, 2007).

Generally, commercial land transactions such as sales, fixed-renting, and sharecropping have become more prevalent in the recent past in Ghana (Goldstein and Udry, 2008). Most land transactions are, by definition, informal, since there is no official registration and they are not characterized by individual property rights as in western cultural understanding (Amanor, 1999; Pande and Udry, 2007). Since the traditional system implies that full ownership still belongs to the community and individuals are faced with restricted rights, use and transfer rights are more important (Place and Hazell, 1993). Ghana’s tenure system is very complex. Rights are mostly secure as long as the plot is cultivated, rights over a plot are rarely lost while being cultivated. However, rights become insecure for the farmer once the land is left fallow (Pande and Udry, 2007; Goldstein and Udry, 2008).

In pre-colonial times there was no land market since land was not a scarce resource (Austin, 2005: 105). The emerging palm oil, and then cocoa industries gave way to commercial land transactions (Berry, 1993: 104). Cocoa trees are a long-term investment and ensured farmers the right to cultivate for extended periods. They even afforded farmers the right to rent out the plot or use it as collateral. However, over the 20<sup>th</sup> century due to population, migration and industrialization land was no longer abundant (Pande and Udry, 2005). The number of land rights claimants increased which increased competition for land. Payments for land rights rose and agricultural intensification became more common (Berry, 1993: 110).

Colonial land administration forms took shape and emerged with the local chiefs being an inherent and supervisory part of the system. Four categories constituted land rights in the colonial land administration: lineage land secured access to 'use-rights' within the lineage (however, 'use-rights' via sharecropping could be provided to migrants by the lineage head); virgin land that could be sold or leased via sharecropping to migrants; concessions of mineral and timber rights given by the chief as a form of land usage; and individual land plots purchased by individual farmers from the chief. However, with respect to the last category, help from several members of lineage was often needed on the plot, resulting in the plot becoming lineage land again after the death of the farmer (Amanor, 1999).

Following independence in 1957, the country's national government adopted land tenure policies in order to change the laws on property rights and land transactions under its flagship of economic development. The government nationalized control over land resulting in access to land being mainly determined by political connections being dramatically different from customary tenure before (Berry, 1993: 124-125). A National Land Policy was published in 1999, with the main objective to develop an efficient and transparent land management system. Customary land tenure has again been recognized by the government since independence (Berry, 2009; World Bank, 2011b). Yet, there is still no independent customary land tenure system; it is linked with other political and land administration systems (Amanor, 1999).

Several other national policies addressed land tenure arrangements in Ghana. Enhancing access to land and equity for all farmers has been one of the objectives of the Growth and Poverty Reduction Strategy (GPRS II) that has been set up for a period of three years between 2006 and 2009 in order to accelerate growth and achieve becoming a middle-income country. In addition, enforcement of the Land Administration Law from 1985 (Intestate Succession Law: PNDCL 111) aimed at ensuring tenure security for holders of especially small plots of land (NDPC, 2005). The Land Title Registration Law from 1986 (PNDCL 152) complements the PNDCL 111 and hopes to achieve an increase in the registration of land and enhance the security of tenure. However, it only applies in urban areas around larger cities such as Accra

and Kumasi and is not applicable to peasants (Pande and Udry, 2007). A Land Administration Project (LAP) was initiated in 2003 in order to implement the National Land Policy and, amongst other things, to build up a decentralized land administration system that increases land tenure security, and is characterized by fairness, efficiency, and cost-effectiveness (Sarpong, 2006, World Bank, 2011b). Three main benefits have been attributed to the LAP: an improvement in security of land tenure, a reduction in time to register deeds and titles and easier access to land information (World Bank, 2011b).

### **3.2.2 Investment decisions - theoretical linkages**

Two main schools of thought regarding the impact of land tenure arrangements on investment have evolved in research circles. One argues that the form of land tenure barely influences performance of agriculture in Africa. Other social, political and local constraints are claimed to be responsible, whereas customary tenure is flexible and adapts if needed in cases of changing circumstances. The other school of thought states that indigenous land tenure arrangements are not secure enough to foster agricultural investment or to provide incentives to use land productively. In particular, informal contractual tenure arrangements fail to promote investment. Accordingly, individual property rights that are secure are a key element of facilitating investment (Amanor, 1999; Peters, 2004).

Several theoretical links exist between land tenure arrangements and investment, in that more secure and transferable rights increase the incentive to invest (Arnot *et al.*, 2011). Three arguments support this link. The first, and the most apparent, is the 'assurance effect' which means that individuals can be sure of reaping the benefits of their investment in future. Hence, the incentive to invest, especially in measures with long-term effects such as soil conservation measures, becomes greater with decreasing uncertainty, since there is no fear of being expropriated (Feder *et al.*, 1988: 5; Brasselle *et al.*, 2002; Abdulai *et al.*, 2011). The second is the 'realizability effect' and is the right to transfer land. Improved rights decrease the costs of exchange by selling or renting it. Thus, the incentive to invest increases which in turn leads to higher expected returns in cases of exchange (Besley, 1995; Brasselle *et al.*, 2002). The last is the so-called 'collateralization effect', enhancing access to credit, fostering investments (Brasselle *et al.*, 2002). Yet the last effect assumes the existence of formal credit markets where land can be used as collateral with respect to agricultural investment, which is most often not the case in Sub-Saharan Africa (Jacoby and Minten, 2007). Hence, the empirical significance mainly relies on the first two effects (Fenske, 2010a).

### **3.2.3 Marshallian inefficiency and Monitoring approach**

With respect to productivity (efficiency) under different tenure regimes, two contradictory streams of theory emerged that shall be discussed below, since they are closely related to investment behavior of the farmer. The Marshallian inefficiency states that the farmer applies



fewer inputs on a sharecropped plot compared to a plot he owns, due to the sharecropper not receiving the full benefit of his investment, and high transaction costs of monitoring, an opportunity to overcome the lack of incentives, leading to lower outputs (Shaban, 1987). Shaban (1987) also provides empirical findings from eight villages in India. However, a study by Arcand *et al.* (2007) on Tunisia concludes that there is no Marshallian inefficiency for sharecroppers with respect to irrigation and transportation and no effects are found with respect to output per hectare.

The other theory is the Monitoring approach. This one argues that the landlord has the means to monitor the sharecropper effectively and that the farmer increases input, and by this, output (Shaban, 1987). Jacoby and Mansuri (2009) construct a tenancy model with supervision which explains that the sharecropper, when supervised (around once a month as a threshold), reaches outputs similar to owned and rented plots, compared to unsupervised sharecropped plots with lower outputs. Pender and Fafchamps (2006) also relate transaction costs of monitoring to fixed-rent tenants in Ethiopia. On one hand, it is not necessary to monitor the tenant since the rent paid is not dependent on the tenant's effort. However, on the other hand, it still might be necessary to monitor the fixed-rent tenant in order to avoid depleting soil fertility.

Another concept is the threat of eviction. Kassie and Holden (2007) argue in their study on Ethiopia that the threat of eviction is reduced by increased output on plot, which involves more input on the plot in order to increase payoff. Their comparison is based on the same households, and they differentiate according to the relationship the tenant has in relation to his landlord. In a theoretical study, Banerjee and Ghatak (2004) state that a fixed-rent contract is beneficial for outputs. However, due to incomplete accountability, the rent the landlord can charge is typically low. One possibility to extract more rents is the sharecropping contract, but it might reduce output due to reduced incentives by the sharecropper. One possibility to increase incentives is eviction threats, which is in line with the argument by Kassie and Holden (2007). Banerjee and Ghatak (2004) even go further in their argumentation. Beyond the positive effect of eviction threats of increasing (unobservable) investment effort is another dynamic one. Investment in the present period also enhances output in the following periods.

### **3.2.4 Empirical literature on property rights and soil conservation measures**

Tenure security is defined in various ways in empirical studies analyzing investment decisions. A common proxy for tenure security is duration of tenure and a legal title. Both proxies have its drawbacks. The first can be reasoned also by a short duration of tenure hindering investment. The latter, legal title, does not always coincide with tenure security (Arnot *et al.*, 2011). Land titles do not play a crucial role in West Africa, with either no widespread registration program or if so, then they have failed (Fenske, 2010a). A perceived measure of security from farmers' point of view can be added (see Beekman and Bulte, 2012).

Research has determined the extent of use and transfer rights in empirical analysis very different. In one of the early studies analyzing the relationship between land tenure arrangements and investment in Ghana, Besley (1995) distinguishes between six diverse types of rights. These rights are being able to change the user or even owner of the land by renting, selling or simply giving it away or passing it onto someone and using it as collateral. The quantitative analysis condensed these six rights into two categories. Brasselle *et al.* (2002) in their analysis on Burkina Faso, distinguish between five categories that are a combination of use and transfer rights and account for a hierarchy in transfer rights.

A slightly different approach is to distinguish between the tenure type such as mailo owner, long-term tenants and holders, either public or customary, combined with the extent farmers can actually carry out these rights (see Place and Otsuka, 2002). Smith (2004), in his analysis on Zambia, only bases the distinction of land tenure arrangements on the sort of land documentation, including those who have none as one category. Other aspects taken into account in previous research are perceived rights or the mode of acquisition (see Deininger and Jin, 2006; Deininger *et al.*, 2008; Ali *et al.*, 2011).

The mapping of diverse land tenure arrangements in one study area shall best capture the differences. Abdulai *et al.* (2011), in their analysis on the effect of land tenure arrangements on investment and productivity in Ghana, collected information about individual rights to use and transfer land at the plot-level. The respective arrangements are owner-operated with full property rights and owner-operated with restricted property rights, sharecropping, and fixed-rentership. The main difference between ownership with full and restricted property rights is that, in case of the latter, land cannot be transferred or inherited, only renting out is feasible. The study by Ali *et al.* (2012) on Pakistan applies similar categories of tenure arrangements in analyzing farmers' decision to invest in several investment options. Sharecropping implies providing part of the output to the landlord as compensation for using the land. The share of compensation is most often either half of the output (*abunu*) or two-thirds (*abusa*) (see Todardo and Smith, 2009: 457 et seq.).

A sizeable body of empirical research exists that has examined the effects of land tenure on investment and has employed diverse econometric models. Mostly, the decision whether to invest or not has been analyzed by means of binary response models (e.g. Brasselle *et al.*, 2002; Deininger and Jin, 2006; Deininger and Ali, 2008; Abdulai *et al.*, 2011). Some studies determine the extent of investment and make use of tobit models due to the censoring nature of the investment variable (Place and Otsuka, 2002; Smith, 2004; Fenske, 2010b; Ali *et al.*, 2011; Ali *et al.*, 2012).

Evidence for the theoretical linkages concerning land tenure and investment mentioned previously, is predominantly weak and incomplete (Udry, 2012). In particular, empirical results on Africa with regard to the relationship between tenure arrangements and investment appear to be ambiguous (Fenske, 2010a). Still, several recent studies confirm a positive effect of tenure security, in this instance defined as plot ownership, upon investment in Africa (e.g. Deininger and Ali, 2008; Abdulai *et al.*, 2011). However, OLS regressions by Place and Hazell (1993) on data from several African countries do not reveal a significant positive relationship between higher tenure security and input use on the plot. The results concerning land improvements analyzed by logit and multinomial logit models are mixed. The study by Holden and Yohannes (2002) on Ethiopia also shows that tenure security does not influence both the decision whether or not to purchase farm inputs and the number of purchased farm inputs. Using survey data from Ethiopia, Pender and Fafchamps (2006) also reveal that the extent of input use is not influenced by the type of tenure arrangement, that is, fixed-rentership, sharecropping and ownership, determined by an OLS regression.

Some reasons for poor empirical results pointed out are: difficulty to measure tenure security, causality going in two directions, missing importance of credit markets and other factors influencing investment (Fenske, 2010a; Udry, 2012). In addition, studies that only include one investment option (see Goldstein and Udry, 2008; Fenske, 2010b) and studies that merge a number of investments (see Smith, 2004) failed to gain insight into the concrete mechanisms of how tenure rights might influence investment decisions. The influence of tenure security might be different depending on the type of investment (Deininger and Jin, 2006).

Investment can be categorized into different types. The investment decisions analyzed in the study by Abdulai *et al.* (2011) on Ghana are the use of mineral fertilizer, the use of organic fertilizer (i.e. mulch and organic manure) and the planting of trees. Diverse investment decisions are estimated jointly, accounting for unobservables that influence investment decisions being significantly related, by means of a multivariate probit model. A household fixed-effects model accounts for unobservables at the household-level with an influence on investment. In both specifications, ownership of the plot is positively and significantly associated with all investment options. Another study on Ghana by Abdulai and Goetz (2014) reveals negative and significant effects of leasing variables, fixed-rent tenancy, and sharecropping on the extent of soil-conservation measures, specifically, investment in ditches and manure. Interaction terms for leasing variables with number of contract renewals show that fixed-rent tenants become more likely to invest in soil conservation measures due to increased tenure security. Sharecroppers still invest less, even when accounting for tenure security in line with the Marshallian inefficiency hypothesis, due to outputs shared with the landlord. In addition, fixed-rent contracts are positively associated with investment in mineral

fertilizer, a short-term investment. This effect declines with increasing tenure security. Besley (1995), however, in the analysis of investment options such as tree planting, manuring, land excavation, irrigation, mulching and making shallot beds in Ghana reported mixed results. Enhanced tenure security facilitates investment, i.e. tree planting, in one area of research, whereas in another, similar findings were not robust in relation to the other investments by using linear probability models.

In their study on Pakistan, Ali *et al.* (2012) also show that owners are more likely to invest in manure, fertilizer and leguminous crops compared to sharecroppers by employing a multivariate tobit model. The decision to construct terraces, itself a soil conservation measure, has been analyzed in other recent studies and is positively linked to ownership of land (Deininger and Ali, 2008) in Uganda and tenure security and transferability of land (Deininger and Jin, 2006) in Ethiopia, depending on how the effect of land tenure has been assessed. However, Hagos and Holden (2006), in their study on Ethiopia, have found poor effects of perceived tenure security, type of rental contract and duration of tenure on the decision whether to invest or not in soil bunds and stone terraces, and also the extent of investment measured by area used. One important determinant of investment has been public conservation programs overcoming market failures. Jacoby and Mansuri (2008) focus on the relationship between land tenancy and non-contractible investment across plots within the same household in Pakistan by using a tobit model and also estimating household fixed effects. Farmyard manure is used more extensively on owned plots than on leased ones. Additionally, tenure duration is also positively and significantly related to the respective investment. Fallowing has been analyzed with tenure security, being a significant predictor for the incidence of fallowing (Otsuka *et al.*, 2003), the proportion of land left fallow (Fenske, 2010b) and duration of fallowing (Goldstein and Udry, 2008).

The influence of titles as one indication of tenure security has been analyzed. Deininger and Chamorro (2004), in their analysis on Nicaragua, reveal that full registration of a plot increases both the propensity and the extent of land-attached investments, like irrigation-facilities. Wannasai and Shrestha (2008) show that land titles in Thailand exert a positive and significant effect on the extent of investment in perennial crops due to obtaining institutional credit. However, other farm resources like labor have also been pointed out to be crucial for investment decisions.

Short-term investments appear to be less affected by security of tenure. A review of several studies examining the effect of tenure security on investment in Western Africa leads to the conclusion that, generally, short-term investments are not influenced by land tenure. Additionally, it is argued that with agriculture becoming more input-intensive, the effect of

tenure security might even decline (Fenske, 2010a). However, soil conservation measures that entail long-term effects are an essential element of making agricultural intensification more sustainable (Beekman and Bulte, 2012).

### **3.2.5 Empirical research: The missing link**

Some research indicates a link between social networks and land tenure arrangements (see Brasselle *et al.*, 2002). Pender and Fafchamps (2006) argue that sharecroppers and fixed-rent tenants in Ethiopia are characterized by diverse social networks, as sharecroppers are not recent immigrants. The type of tenure differs by transaction costs of screening and monitoring, and is determined by how well the landlord knows the tenant. The connection between land tenure arrangements and social networks in Ghana is pointed out by Berry (2009: 1373): “Whether or not investments are individually owned, decisions about investment and the disposition of property are shaped by social relations and concerns”. The study by Goldstein and Udry (2008) on land tenure arrangements and fallowing in Ghana reveals that farmers who are not subject to networks of ‘social and political power’ are faced with less tenure security, i.e. with a higher risk of expropriation during fallowing. Hence, they leave their land fallow for shorter periods than might otherwise be optimal. Accordingly, participation in social groups such as the family or the village determines access to land rights (Udry, 2012).

Both concepts have mostly been applied separately in previous empirical analyses in order to explain decision-making of farmers. Research combining the two concepts is still in its infancy since few economic studies have given attention to both tenure arrangements and social networks, in terms of analyzing investment decisions. Saint-Macary *et al.* (2010) analyze knowledge and adoption of a soil conservation technology, agro-forestry, in Vietnam. The variables representing tenure security are only based on titled land and expectations about reallocation. Both are significant determinants of adoption. Formal social networks are categorized as horizontal (farmer union) and vertical (extension service) social capital and influence knowledge about agro-forestry positively. However, social networks have not been used for explaining adoption. Beekman and Bulte (2012) study the effect of social norms and tenure security on fertilizer use and erosion management in Burundi. They show that tenure security influences investment in erosion managements positively, but not fertilizer use. They apply similar proxies as Saint-Macary *et al.* (2010) for tenure security. Investments are aggregated in that planting trees and building ditches or terraces are one category, and fertilizer implies both mineral and organic fertilizer, neglecting that the latter has long-term effects. In addition, the decision whether to invest or not in both types of investment is estimated independently by two probit models. Various social norms influence soil erosion measures positively when estimated at the community level. Social norms do not comprise

social networks in detail; merely the perception of cooperative behavior is assessed. In addition, altruism, trust and voting behavior account for social capital (Sobel, 2002).

The question arises, why put effort into the concept of social networks and not only focus on the provision of legal needs in order to enhance tenure security and diminish market failures. One reason is the intrinsic value of social capital (Sobel, 2002). Individuals like to be in contact with others and value the interaction in social networks. From this, other non-intended improvements can emerge. Uphoff (2000) studies the formation of farmer organizations with respect to water management in Sri Lanka, and points to progress in terms of qualitative aspects of life, as individuals value the corporate feeling in the community. He observes that various actions have been initiated by the group due to organizational skills, for instance, the provision of loans.

### **3.2.6 Tenure arrangements, social capital, and endogeneity**

Generally, endogeneity arises due to simultaneity, measurement error, and omitted variables, and results in biased and inconsistent estimates (Jackson, 2008: 437; Wooldridge, 2010: 54-55), and has been discussed with respect to both concepts; tenure arrangements and social networks respectively.

Investment also serves different purposes than increasing yields in the short and long term. Farmers may undertake investments in order to increase tenure security, especially planting trees, since this is a legitimate procedure in claiming more secure rights (Sjaastad and Bromley, 1998; Place, 2009) that leads to endogeneity of tenure in estimating the effect of tenure rights on investment (Abdulai *et al.*, 2011). Woodhouse (2003), in his review of four case studies in Africa, concludes that increasing tenure security is one of the fundamental factors of increasing investment. Generally, tenure arrangements and the decision to invest may be determined together (Ali *et al.*, 2012). Unobservable factors such as ability or entrepreneurial skills of farmers linked to the type of tenure and investment are another cause of endogeneity (Jacoby and Mansuri, 2008).

Few empirical studies have taken endogeneity of tenure into account in analyzing the relationship between land tenure and investment (Arnold *et al.*, 2011). The possibility of land tenure arrangements and investment decisions to be determined jointly has been addressed, for example, by Brasselle *et al.* (2002), Abdulai *et al.* (2011) and Ali *et al.* (2012) through the Two-Stage Conditional Maximum Likelihood (2SCML) approach accounting for the nonlinearity of the investment specification.

Even if few studies have accounted for endogeneity of tenure, a wide range of instruments have been applied. For instance, Brasselle *et al.* (2002) make use of the initial land endowment of farmers and two interaction terms with the first instrument, one whether the farmer is a

migrant and the other whether the farmer resides in a recently settled village for explaining five diverse categories of land rights. Abdulai *et al.* (2011) deal with the endogeneity of three types of tenure arrangements out of four analyzed, since one serves as a base category. For owners, they apply mode of acquisition of plot, namely if the plot was inherited, if the owner cultivating the plot also resides in the same village where the plot is located and the distance to the plot. For sharecroppers and fixed-rent tenants, they make use of the distance of the plot to the landlord's home and whether this landlord resides in the same village where the plot is located. Ali *et al.* (2012) apply similar instruments for owners and fixed-rent tenants in Pakistan with sharecropping serving as the base category. Jacoby and Mansuri (2008) apply a quite different approach in that they are also restricting information to those owners of plots who are not cultivating any of them in that there arises no selection in leasing out the plots. In a second strategy of approaching endogeneity, they instrument leasing by the distance of the plot to the owner's home and accordingly apply an instrumental variable approach.

The question why those belonging to one social network behave in the same way has also attracted the attention of many researchers. There are several determinants of behavior: observable and unobservable characteristics of both the individual and the network and lastly, the subjective expectation of the individual within the network of the average decision of the network members. The last implies that behavior of other network members influences individual decision-making (Brock and Durlauf, 2007). Unobservable network effects are leadership and institutions, whereas an unobserved individual effect is self-selection (Fafchamps, 2006). The issue at stake is that in case of full information the obstacles mentioned above can be solved. Thus, all these relate to omitted variable bias. Social capital might also be subject to reverse causality since it is affected by the factors it is assumed to exert influence on (Jackson, 2008: 437).

In particular, three hypotheses around social interaction exist. One is endogenous interaction, meaning that the behavior of an individual depends on the action of the network, and the second is contextual interaction, where characteristics of the network members influence behavior of the individual. Third, there are correlated effects, not being a social event, only implying that individuals in one network act similarly due to their similar characteristics and institutional surroundings (Manski, 2000). Those lead to the identification problem. Manski (1993) refers to it as the reflection problem<sup>8</sup>. It might be possible to differentiate between the first two effects and the latter. However, to determine if network behavior influences individual

---

<sup>8</sup>The term reflection refers to the movement of an individual in a mirror and his reflection. One cannot tell from only watching if the motion of the individual causes the motion in the mirror or the other way around (Manski, 2000)

actions or if the behavior of the network is merely an aggregation of individual actions remains a challenge (Manski, 1993). Specifically, the reflection problem is concerned with the differentiation between factors relating to behavior and factors relating to the context. The reflection problem is due to the fact that the individuals within the network are not assessed directly (Jackson, 2008: 439).

The reflection problem can be overcome by having information about the others in the network with varying characteristics from the individual and with an asymmetric relationship. However, even if identification issues are less likely, they still can be present (Jackson, 2008: 440-441). A suitable approach is again to make use of instrumental variables since part of the problem is resulting from endogeneity (Manski, 2000; Jackson, 2008: 439). For instance, Beekman and Bulte (2012) address endogeneity of social capital analyzing investment decisions by two strategies. First, social capital is measured at community level based on the argument that community level social capital is not influenced by individual investment decisions. The second employs instrumental variables, however, it is limited in their use due to not finding suitable instruments for all social capital proxies. The instruments used for altruism are historical measures of conflict intensity in Burundi. Fafchamps and Minten (2002), when determining firm performance of traders in Madagascar, apply various instruments for their social capital variable, number of traders known, such as age, place of birth, religion, and characteristics related to the family. Krishnan and Sciubba (2009) use instrumental variables that are related to how connected a farmer is within the village, such as years of residence in the village in order to analyze the effect of social networks on farm performance in India. Endogeneity of social capital can also be approached by using latent social networks that are part of social capital and are not subject to endogeneity. A principal component analysis (PCA) can be applied in order to make use of observable factors of the social environment to generate these latent social capital variables as has been used by Genius *et al.*, (2013) in Greece as well as in a similar approach by Willy and Holm-Müller (2013) on Kenya and Hunecke *et al.* (2017) in Chile. We follow a similar approach described in detail in section 3.6.2.

### **3.3 Conceptual framework**

We analyze the link between tenure arrangements and investment decisions of farmers within a dynamic framework which provides an extension of the theoretical framework by Abdulai *et al.* (2011) and Abdulai and Goetz (2014). Within this framework, we model soil capital as a renewable resource of farmers, which is subject to change over time, and examine their interactions with agricultural production. Time is indicated by calendar time  $t$ .



### ***Investment in soil conservation measures***

Farmers can invest in four investment options: in mineral fertilizer  $X_M(t)$ , in organic fertilizer manure  $X_O(t)$ , in ditches  $L_D(t)$  and in multiple cropping  $M(t)$ .

Mineral fertilizer increases soil capital in the short-run since nutrients are made accessible for crops without a time lag and as a result, yields increase. Yet, as Abdulai *et al.* (2011) have rightly noted; applying only mineral fertilizer will degrade soil capital physically and chemically. Organic fertilizer has to be added to improve the soil structure again; it is a productive input that ensures higher soil organic matter and leads to yield increases (IRRI, 2003).

We define the agricultural production function per hectare as follows:

$$f(S(t), X_M(t), X_O(t)) \tag{3-1}$$

the function  $f(\cdot)$  indicates agricultural production of crops with  $S(t)$  being soil capital and  $X_M(t)$  and  $X_O(t)$  are as defined previously.

Following the standard convention, we assume the function  $f(\cdot)$  to be strictly concave in its arguments. Since mineral fertilizer and manure are close substitutes in the short-run since both enhance yields by increasing fertility of the soil, we assume  $f(\cdot)$  to be additive separable in  $X_M(t)$  and  $X_O(t)$ , which results in the cross derivations with respect to these variables being zero. However, manure exerts positive effects on soil capital in the mid-term and long-term and it increases soil productivity, whereas an increase in  $S(t)$  decreases the marginal productivity of the investments  $X_O(t)$  and  $X_M(t)$ . Consequently, we assume  $f_{X_O S}$  and  $f_{X_M S}$  to be  $f_{X_O S} < 0$  and  $f_{X_M S} < 0$ .

As an erosion control practice, ditches hinder the negative effects of erosion. Erosion leads to an increase in water runoff so that consequently less water remains in the soil. Furthermore, erosion results in a lack of soil nutrients necessary for crop production (Pimentel *et al.*, 1995). As such, ditches as a physical method of soil conservation enhance the uptake of nutrients and the retention of water (Ruben *et al.*, 2006). Land is restricted, the size of the entire land cultivated by farmers is normalized to one, and it will be used for crop cultivation  $L_{CR}(t)$  and investment in ditches  $L_D(t)$ <sup>9</sup>. Thus, ditches decrease the amount of land that can be used for agricultural production.

The restriction for land is defined as follows:

$$0 \leq L_{CR}(t) = 1 - L_D(t). \tag{3-2}$$

---

<sup>9</sup> Area used for trees is due to simplicity not considered here.

It is assumed that farmers cultivate various crops on their plots. However, this is not necessarily equated with multiple cropping which is described as the “intensification of cropping in time and space such as growing two or more crops on the same field in a year” (Sumner *et al.*, 1981: 168), that is intercropping and crop rotation (Knörzer *et al.*, 2009). Crops described as being intercropped are planted at the same time, whilst crop rotation describes multiple cropping with a time lag. However, for simplification, we have restricted our attention on sequential cropping systems where two or more crops are grown in sequence on the same plot within one year involving two growing seasons.

Crop rotation and intercropping display a range of similarly positive effects and increase soil capital (FAO, 2012: 58). Crop rotation maintains soil fertility despite continuous crop cultivation by maintaining the soil’s organic matter, conserving topsoil and suppressing higher weeds and pests (Liebman and Dyck, 1993). In addition, it also controls soil erosion, makes use of the available nutrients and water in an optimal fashion due to the differing roots of diverse crops and, in cases of crop rotation with legumes, enhances nitrogen fixation (AgrilInfo, 2011; Infonet-Biovision, 2011). Intercropping leads to a decrease in weed growth and positively affects soil erosion (Olasantan *et al.*, 1996). Physical resources like mineral nutrients are used more optimal (Mutsaers *et al.*, 1993).

Soil capital changes over time and is defined in equation (3-3), the dot over the variable indicates  $\frac{d}{dt}$  and is augmented by investment in manure used in combination with crop cultivation, thus it enriches soil capital by  $h(X_O(t))$  with  $h'(\cdot) > 0$ . In addition, the amount of area used for ditches augments soil capital, determined by the function  $l(L_D(t))$  with  $l'(\cdot) > 0$ . Multiple cropping also increases soil capital over time according to  $m(M(t))$  with  $m'(\cdot) > 0$ . Cultivation of crops  $f(S(t), X_M(t), X_O(t))$  decreases soil capital due to nutrients extracted, indicated by the factor  $\delta$  stating degradation of soil capital in proportion to the output.

The state variable soil capital is defined as:

$$\dot{S}(t) = h(X_O(t))L_{CR}(t) + l(L_D(t)) + m(M(t))L_{CR}(t) - \delta f(S(t), X_M(t), X_O(t))L_{CR}(t). \quad (3-3)$$

### **Social networks and transaction costs**

Social networks are assumed to foster investment in productivity-enhancing and especially in soil-conserving measures through means of better information and easier access to practical and monetary assistance. These effects can be operationalized by linking social networks to transaction costs of investment that are mainly unobservable (see e.g. Rudd, 2000; Combes *et al.*, 2005; Wollni *et al.*, 2010; Zanello, 2012).

Farmers are constrained in multiple ways concerning investment in soil conservation measures that is, among other things, limited information (Wollni *et al.*, 2010). Place and Otsuka (2002), in their analysis on tenure security and investments in Uganda, conclude that the lack of information is crucial, that begins with being aware of investment possibilities and of the access to inputs and technology. Information gathering on how to apply measures and how to combine them also take place in the context of learning about biophysical processes which determine soil capital and yields (Wollni *et al.*, 2010). For example, knowledge associated with multiple cropping is related to the management of the complex systems of various crops with individual nutritional and water needs and possible allelopathic consequences (FAO, 2012: 62).

Social networks are assumed to reduce transaction costs and consequently to exert positive effects on various outcomes (Rijn *et al.*, 2012). Gathering information has its costs and social networks can be one way of obtaining information at a lower level of cost and thus improving the possibility of action (Coleman, 1988). For example, fbos have the potential to reduce information search costs concerning investment (Wollni *et al.*, 2010). Open ended questions posed to farmers in the survey elicit the type of assistance through social networks. Advice on the farm business from various sources that involve social networks, such as having friends includes, apart from market information, specific advice linked to investment, such as how to apply chemicals, how to diversify crops and when to cultivate them and control of erosion on the farm. Similarly, an fbo is indicated to provide inputs, loans, labor, and advice.

Various forms of social networks assessed in the empirical analysis are represented by connectivity of the farmer  $C$  which indicates to what extent a farmer is connected with others<sup>10</sup>, it follows that  $C \geq 0$ . The influence of connectivity on transaction costs is given by  $(1 + C)^{-\alpha}$ . In case a farmer is not connected with others ( $C = 0$ ) transaction costs are as given. However, in case a farmer is highly connected, transaction costs decrease. Consequently, the parameter  $\alpha$  is positive (see Combes *et al.*, 2005) and indicates the extent to which connectivity makes an influence on transaction costs. The extent is determined empirically.

Transaction costs can be distinguished between fixed and variable (proportional) transaction costs. The first does not depend on the amount invested in relation to search and negotiation costs, and costs associated with screening the quality of inputs and monitoring of labor in case labor is hired for investment. Accordingly, fixed transaction costs of investment  $m\ tc_m^f$  influence the decision whether to invest or not. Variable transaction costs increase the price for investment and they are calculated per cost of investment unit linked with transportation of

---

<sup>10</sup> A farmer being part of many social networks requires him to be highly connected. In so doing, we do not distinguish between various effects of diverse types of social networks. This is only determined empirically.

inputs and imprecise information. The price paid will be higher than the market price  $p_m$  for the respective investment by the amount  $tc_m^v$  (Key *et al.*, 2000).

### **The farmers' decision problem**

The dynamic context of the analysis involves the consideration of the fact that current investment decisions influence soil capital over time. We assume the farm household maximizes farm net benefits subject to the evolution of soil capital over a planning horizon of  $t_k - t_0$  with  $t_0$  denoting the initial point and  $t_k$  the end of the planning horizon.

Plots cultivated by farmers are under ownership, restricted ownership, fixed-rentership and sharecropping with a differing time horizon. For fixed-rent tenants and sharecroppers, time horizon is restricted to duration of tenure  $k$  determined by  $(0, k)$ , for owners with restricted rights they are also restricted by time of usage  $k$ , and for owners it is  $(0, T)$ , with  $T$  indicating the end of the planning horizon. The residual value of soil capital is given by  $r(S(t_k))$  and will be zero for sharecroppers and tenants, as they are restricted from selling the land. For owners with restricted rights, who can only rent the land out, it will be smaller than for owners with unrestricted rights, since they are the only ones permitted to sell the land. In order to simplify the analysis, we merge the two types of ownership to one category in the conceptual framework given similar characteristics of these two.

The farmers' decision problem can be stated as<sup>11</sup>:

$$\begin{aligned} \max_{X_M, X_O, M, L} = & \int_{t_0}^{t_k} e^{-\rho t} [(pf(S(t), X_M(t), X_O(t)) - (p_M + (1 + C)^{-\alpha} tc_M^v)X_M(t) - (p_O \\ & + (1 + C)^{-\alpha} tc_O^v)X_O(t) - (\omega c_{omu} + (1 + C)^{-\alpha} tc_{mu}^v)M(t))L_{CR}(t) \\ & - (\omega c_{oD} + (1 + C)^{-\alpha} tc_D^v)L_D(t) - \tau(1 + C)^{-\alpha} tc_m^f - (1 - \theta)p_L \\ & - \theta \gamma pf(S(t), X_M(t), X_O(t))L_{CR}(t)] dt + e^{-\rho t_k} r(S(t_k)) \end{aligned} \quad (3-4)$$

Subject to:

$$\dot{S}(t) = h(X_O(t))L_{CR}(t) + l(L_D(t)) + m(M(t))L_{CR}(t) - \delta f(S(t), X_M(t), X_O(t))L_{CR}(t)$$

$$0 \leq L_{CR}(t) = 1 - L_D(t)$$

$$X_M(t), X_O(t), M(t), L_D(t) \geq 0$$

<sup>11</sup> In the empirical analysis, we also analyze the effect of off-farm employment on investment decisions which is not considered in the theoretical model, since it is not directly linked to agricultural production. Off-farm activities are part of farm and household characteristics that determine the propensity to invest in the empirical model. Basically, two effects occur when being engaged in off-farm employment: On the one hand the farmer earns more money that will help him pay the price  $p$  of investment, if he is willing to spend money for agricultural investments; however, he also has less time to invest which increases the opportunity costs of investment. The effect will be determined empirically and it will be distinguished between different types of off-farm employment.

where  $\tau$  is equal to 1 for each investment  $m$  in case farmers invest in the respective investment and 0 otherwise,  $(1-\theta)\underline{p}_L$  represents the annual rent paid in cases of fixed-renting for using the land or the annual cost of capital for owners with  $\theta = 0$  for fixed-rent tenants and the rent paid is the constant  $\underline{p}_L$ . and with  $\theta = 1$  for sharecroppers, where  $\gamma pf(S(t), X_M(t), X_O(t))L_{CR}(t)$  is the amount of cultivated crops paid to the owner with  $\gamma$  indicating the respective share of yields that are used as payment.

The market price  $p_m$  includes both the cost of purchasing the investment in case of investment in mineral fertilizer and manure, and the costs of labor involved for each type of investment. Mineral fertilizer and manure are linked to a price  $p$ . Ditches also decrease agricultural outputs since the area is used as indicated by  $L_{CR}$  that is area reduced by  $L_D$ . Multiple cropping and ditches are not associated with a price  $p$  but are associated with costs  $c_0$  that are either a decrease in immediate output or additional cost outlays. For soil conservation measures, costs depend on the sharing rule between the landlord and the tenant, indicated by  $\omega$  and can range between 0 and 1 and indicates the share the tenant is paying, while the magnitude of  $\omega$  differs depending on whether it is a fixed-rentership or sharecropping. When  $\omega$  is 1 the landlord is not paying anything, when  $\omega$  is 0, the tenant is paying nothing. For fixed-rentership, costs paid by the landlord may be included in the rent paid  $\underline{p}_L$ . However, all investments are linked with transaction costs as outlined above.

All parameters except  $t_0, t_k$  and  $S_{t_0}$  are grouped in a vector named  $\underline{\omega}$ . The components are connectivity, the respective transaction costs and prices and for output and inputs and costs for inputs,  $\delta$  degradation of soil capital and  $\varphi$  discount rate, and previously introduced parameters  $\gamma$  and  $\underline{p}_L$ .

The solution of the farmer's maximization problem (3-4) is given by:

$$J(X_M^*(t), X_O^*(t), M^*(t), L_D^*(t); t_0, t_k, S(t_0), \underline{\omega}) = J^*(t_0, t_k, S(t_0)) \quad (3-5)$$

where the superscript  $*$  represents the evaluation of the variable along its optimal trajectory given the parameter values of  $(t_0, t_k, S(t_0))$  and  $\underline{\omega}$ . Consequently,  $J^*(t_0, t_k, S(t_0))$  illustrates the maximized discounted farm net benefits aggregated over the time horizon  $t_k-t_0$  given the initial soil capital  $S(t_0) = S_{t_0}$ .

For analyzing the effect land tenure may have on investment choices, while also considering the effect of connectivity, we evaluate the first order conditions of the farmer's decision-making problem given in equation (3-4). In order to simplify notation, we remove the argument  $t$  from the variables, as well as those of the costate variables and Lagrange multipliers, which will be

introduced later, and define according to Abdulai *et al.* (2001) the current value Lagrangian,  $L$ , by:

$$\begin{aligned}
L = & (pf(S, X_M, X_O) - (p_M + (1 + C)^{-\alpha} tc_M^v) X_M - (p_O + (1 + C)^{-\alpha} tc_O^v) X_O \\
& - ((\omega c_{omu} + (1 + C)^{-\alpha} tc_{mu}^v) M) L_{CR} - (\omega c_{OD} + (1 + C)^{-\alpha} tc_D^v) L_D \\
& - \tau (1 + C)^{-\alpha} tc_m^f - p_l(\cdot) \\
& + \mu_1 L_{CR} + \mu_2 (1 - L_D - L_{CR}) \\
& + \xi_1 X_M + \xi_2 X_O + \xi_3 M + \xi_4 L_D \\
& + \lambda_s (h(X_O) L_{CR} + l(L_D) + m(M) L_{CR} - \delta f(S, X_M, X_O) L_{CR})
\end{aligned} \tag{3-6}$$

with  $p_l(\cdot) = (1 - \theta) \underline{p}_L + \theta \gamma pf(S, X_M, X_O) L_{CR}$  is defined as above and where  $\mu_1$  and  $\mu_2$  are the Lagrange multipliers associated with the restrictions related to availability of land,  $\xi_1, \xi_2, \xi_3$  and  $\xi_4$  are the Lagrange multipliers related to non-negativity of control variables and  $\lambda_s$  is the corresponding costate variable to the state variable soil capital.

The first order conditions are given by:

$$\frac{\delta L}{\delta L_{CR}} = pf - (p_M + (1 + C)^{-\alpha} tc_M^v) X_M - (p_O + (1 + C)^{-\alpha} tc_O^v) X_O - (p_{mu} + (1 + C)^{-\alpha} tc_{mu}^v) M - \theta \gamma pf + \lambda_s (h + m - \delta f) + \mu_1 - \mu_2 = 0 \tag{3-7}$$

$$\frac{\delta L}{\delta X_M} = (pf_{X_M} - p_M - (1 + C)^{-\alpha} tc_M^v - (\theta \gamma p + \lambda_s \delta) f_{X_M}) L_{CR} + \xi_1 = 0 \tag{3-8}$$

$$\frac{\delta L}{\delta X_O} = (pf_{X_O} - p_O - (1 + C)^{-\alpha} tc_O^v - \theta \gamma pf_{X_O} + \lambda_s (h' - \delta f_{X_O})) L_{CR} + \xi_2 = 0 \tag{3-9}$$

$$\frac{\delta L}{\delta M} = -(\omega c_{omu} - (1 + C)^{-\alpha} tc_{mu}^v + \lambda_s (m')) L_{CR} + \xi_3 = 0 \tag{3-10}$$

$$\frac{\delta L}{\delta L_D} = -(\omega c_{OD} - (1 + C)^{-\alpha} tc_D^v + \lambda_s (l') + \xi_4 - \mu_2 = 0 \tag{3-11}$$

$$\dot{\lambda}_s = \varphi \lambda_s - ((p - \theta \gamma p - \lambda_s \delta) f_s L_{CR}) \tag{3-12}$$

We do not consider endogeneity of tenure, even if we do account for it in the empirical analysis, a further exploration of the issue can be found by Abdulai *et al.* (2011). The first-order conditions differ by the payment of the sharecropper's share of the value of the marginal product and by the planning horizon that is  $k$ -years for fixed-renters and sharecroppers and  $T$  for owners. In addition, the value of transaction costs determines the costs of each soil conservation measure.

In the following section, we analyze the effect of land tenure arrangements and connectivity on the optimal choice of investment in mineral fertilizer, manure, multiple cropping, and ditches. In order to derive the optimal short-run behavior, we assume the initial soil capital  $S(0) = S_0$  to be identical for all tenure arrangements. However, soil capital is subject to change over time and we will consider this individual change within the long-run behavior.

*Short-run behavior*

Since the cross derivatives of the agricultural production function with respect to  $X_0(t)$  and  $X_M(t)$  are zero, we can analyze the first order conditions (3-8) and (3-9) for each investment option notwithstanding the value of the other investment option given that  $S(t) = S_0$ . For an interior solution  $\xi_1 = 0$ , and  $pf_{X_M}(\cdot)|_{S(t)=S_0}$  the solution of equation (3-8) is presented in figure 3-1 (continuous lines)<sup>12</sup>. We can see that owner-cultivators do consider the shadow cost of the soil  $\lambda_s$ , where tenants and sharecroppers do not consider these costs. The levels of mineral fertilizer applied for fixed-rent tenants, sharecroppers, and owners are  $X_M^R$ ,  $X_M^{Sh}$  and  $X_M^O$  respectively.

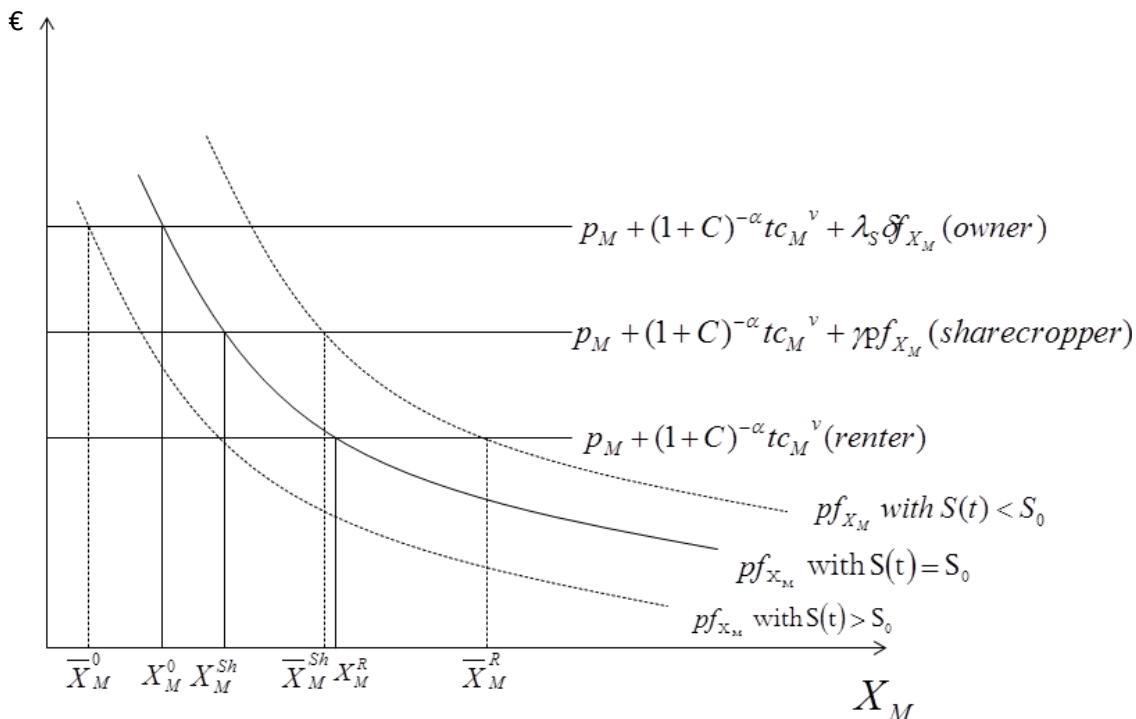


Figure 3-1: The optimal amount of mineral fertilizer

<sup>12</sup> The short-run solutions are only shown graphically for investment in mineral fertilizer and manure, since we can observe the production function here. Multiple cropping and ditches are not directly linked to output and therefore their solutions are only shown for the long-term and not the short-term.

**Observation 1:** Given that initial soil capital is identical for all three types of farmers, figure 3-1 shows that fixed-rent tenants initially apply more mineral fertilizer than sharecroppers and owner-cultivators. A direct comparison between sharecroppers and owners is not feasible.

In the short-run, owners and sharecroppers tend to apply similar levels of mineral fertilizer given  $\gamma = \lambda_s \delta / p$ . The behavior of sharecroppers depends on the share of harvest  $\gamma$  given to the landlord. In addition, transaction costs of investment are determined by connectivity of the farmer. A high value of  $C$  leads to a low value of  $tc_M^v$ , shifting the cost curve downwards. Hence, each unit of mineral fertilizer applied becomes cheaper for them due to variable costs being lower. Farmers who face fewer transaction costs thanks to being highly connected apply more mineral fertilizer, since it is cheaper for them. In detail, higher connectivity involves better information and more assistance, which lowers the costs associated with investment in mineral fertilizer, like gathering information on how to apply it correctly and where to buy it. To what extent connectivity (social networks) influences investment decisions can only be derived empirically.

The optimal amount of organic fertilizer can be derived from an interior solution  $\xi_2 = 0$ , and  $pf_{X_0}(\cdot)|_{S(t)=S_0}$  of the first order equation (3-9) and is presented in figure 3-2 (continuous lines).

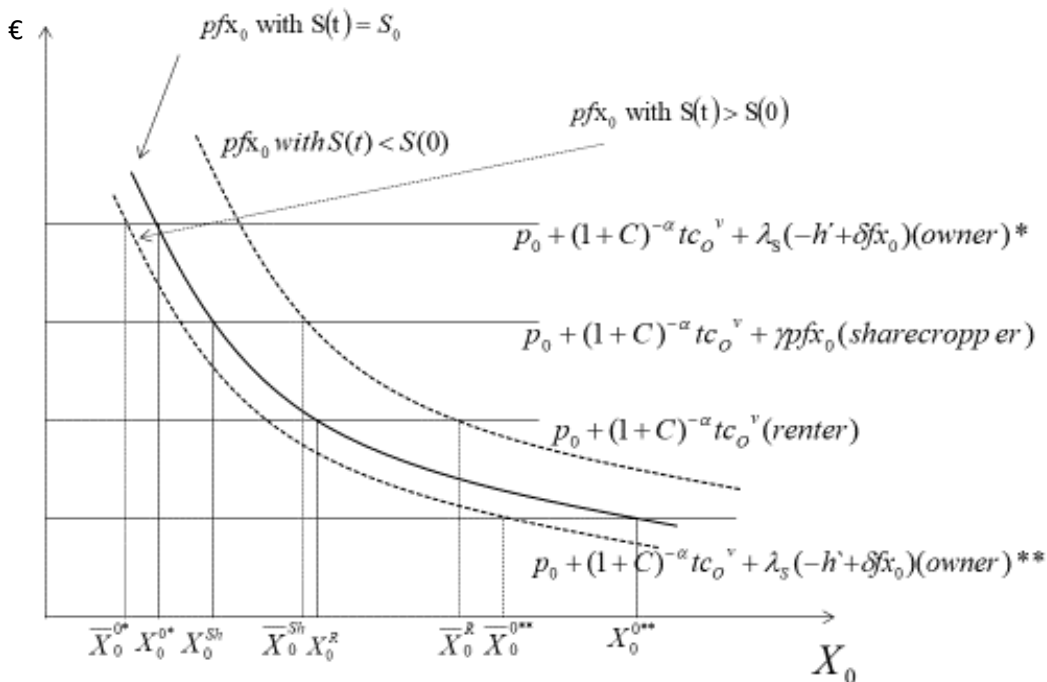


Figure 3-2: The optimal amount of manure



Note:  $*h' - \delta f_{x_0} < 0$ , soil degradation effect of manure due to increase in quantity harvested outweighs soil improvement effect;  $**h' - \delta f_{x_0} > 0$ , soil improvement effect of manure outweighs its soil degradation effect, due to increase in quantity harvested.

**Observation 2:** Given that initial soil capital is identical for all three types of farmers, figure 3-2 shows that owners apply more manure than fixed-rent tenants if the effect on soil improvement by the manure outweighs the effect of soil degradation produced by an increase in harvest. Fixed-rent tenants apply more manure than sharecroppers.

Since owners consider the shadow cost of the soil ( $\lambda_s$ ), they apply more manure than fixed-rent tenants since they do not place any value on the shadow costs of the soil, provided that the soil improvement effect  $h'$  is greater than the soil degradation effect  $\delta f_{x_0}$  and can be seen by comparing  $X_0^{O**}$  and  $X_0^R$ . However, in cases where the soil degradation effect outweighs the soil improvement effect  $h' - \delta f_{x_0} < 0$  fixed-rent tenants apply more manure than owners and that is illustrated by comparing  $X_0^{O*}$  and  $X_0^R$  respectively. Figure 3-2 also shows that sharecroppers apply less manure  $X_0^{Sh}$  than fixed-rent tenants since their costs are higher than the share of output given to the landlord. Additionally, in cases of connectivity  $C$  being high, transaction costs  $tc_0^V$  will be low respectively. The horizontal cost curve indicating the direct price of manure plus transaction costs and share of output for sharecroppers or shadow cost of the soil for owners is shifted downwards, and farmers apply more manure because it is cheaper for them. A higher connectivity results in, for example, more information on how to apply it, where to get it and practical assistance linked to bringing manure onto the fields. Farmers without a high connectivity need more resources to get information and practical help, increasing transaction costs and shifting the cost curve upwards.

### *Long-run behavior*

The previous analysis is valid for the cases, where  $S(t) = S_0$  is identical for all tenure arrangements. This assumption is reasonable for the beginning of the planning horizon. However, it is unlikely over a longer time-horizon, since owners, sharecroppers and fixed-rent tenants value soil capital differently. For the determination of the long-run behavior of farmers, we establish the optimal evolution of soil capital over time. We distinguish between two scenarios: one in which  $S(t) > S_0$ , initial soil capital is below long-run soil capital, and the other  $S(t) < S_0$  in which initial soil capital is above long-run soil capital. Even if fixed-rent tenants and sharecroppers do have short-term contracts for periods around two or three years, we still consider their long-term behavior by interpreting and extrapolating the sequence of their short-term behavior into a theoretical model of their behavior in the long-run.

In figures 3-1 and 3-2, we see that (dashed lines), provided owners build up soil capital, owners will tend to reduce the application of mineral fertilizer  $\underline{X}_M^O$  and manure  $\underline{X}_O^{O**}$  or  $\underline{X}_O^{O*}$ , whereas sharecroppers and fixed-rent tenants increase the application of both, given that their soil capital declines, indicated by  $\underline{X}_M^R, \underline{X}_M^{Sh}$  and  $\underline{X}_O^R, \underline{X}_O^{Sh}$  respectively<sup>13</sup>. Connectivity does still have the same effect as outlined within the short-run behavior. Other situations can also be depicted from figure 3-1 and 3-2; however, we only focus on the most likely ones. The shift of graphs is taken randomly and cannot be analyzed within the model.

To determine the effect of land tenure on investment in multiple cropping, we analyze the first order condition (3-10). This condition shows that the marginal value of soil capital due to application of multiple cropping  $\lambda_s(m')$  has to equal the marginal costs that are costs of application and transaction costs and therefore  $\xi_3 = 0$ . So far, we have indicated  $\lambda_s = 0$  for sharecroppers and fixed-rent tenants. However, this is not totally true. There will be a marginal value of soil capital due to investment in multiple cropping for all farmers, as across all tenure arrangements, soil capital,  $S(t)$ , influences yields<sup>14</sup>. The more immediate the effect of the investment on soil capital, the higher is  $\lambda_s$  also for sharecroppers and fixed-rent tenants<sup>15</sup> along with longer contract period. Figure 3.3 shows that to what extent owners and tenants invest, depends on  $\omega$ . The tenant's share of the cost ( $\omega$ ) declines as the owner is covering some part of the costs, the marginal cost function rotates to the right and the optimal amount of multiple cropping increases. For example, if costs decrease from 1 to  $\hat{\omega}$  or  $\tilde{\omega}$  for renters, investment increases from  $M^{Sh/R}$  to  $\tilde{M}^{Sh/R}$  and  $\check{M}^{Sh/R}$  respectively.

Investment also depends on the shadow value of the soil. Shadow value is based on the willingness to pay principle, the most accurate measure of the value of a good is what, in this case farmers, are willing to give up in order to increase soil capital. The shadow value of the fixed-rent tenant or sharecropper is less than the shadow value of the owner given for any similar soil capital  $S$  due to the shorter time period  $t < T$ . Since the shadow value of the soil is determined by the discounted farm profits with respect to a marginal improvement of soil quality from time  $t$  until the end of the planning horizon, their values are dependent on the length of the planning horizon. If the contract duration is short, the shadow value of the soil is zero and

<sup>13</sup> In the short-run, given that the soil improvement effect outweighs the soil degradation effect of manure, owners apply more manure than fixed-rent tenants and sharecroppers, hence soil capital increases and  $\text{pf}X_0$  evaluated when the initial soil capital is below the long-run soil capital, moves to the left due to the cross derivative  $\text{f}X_0S$  being negative. Concerning fixed-rent tenants and sharecroppers, the analysis in the short-run shows they apply less manure than owners. We can either assume they build up soil capital, but to a lesser extent than owners, or they are depleting soil capital. This is the case accordingly  $\text{pf}X_0$  moves to the right.

<sup>14</sup> Concerning investment in mineral fertilizer and manure  $\lambda_s$  will also be unequal to zero for sharecroppers and fixed-rent tenants, however, for a more explicit graphical illustration it was neglected. The argumentation would not change.

<sup>15</sup> Immediate denotes the investment increases soil capital directly and in the short-run and the marginal value arises due to more agricultural output.

it would be optimal for tenants not to invest at all. Yet, as indicated above the shadow value increases with tenure duration and given that the shadow value is positive, the landlord can choose duration of rental period  $k$  and  $\omega$  so that the optimal long-term investment in multiple cropping is in line with the investment behavior of the tenant. When the landowner fully commits to rewarding improvements in soil quality (i.e. committing to a long term tenure duration for the tenant), fixed-rent tenants and sharecroppers as residual claimants should be fully incentivized and there is no hold-up problem (commitment problem).

This situation is shown in Fig. 3.3. where investment in multiple cropping for the owner and investment in multiple cropping for the tenant match. We can conclude, investment in multiple cropping on rented plots is apart from the tenancy arrangement, also driven by the share of the cost of investment covered by the landlord and time of rental period, which is not depicted here.

Connectivity of farmers has the same influence as indicated for investment in mineral fertilizer and manure, which is lowering transaction costs of investment by gaining knowledge linked to the management of the complex system of various crops with individual nutritional and water needs and possible allelopathic consequences (FAO, 2012: 62).

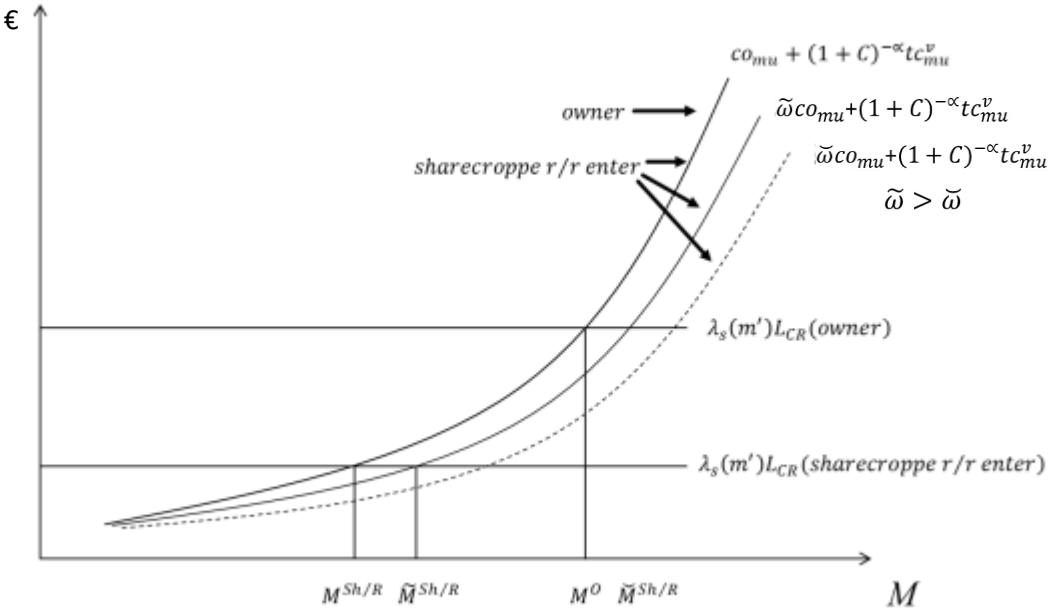


Figure 3-3: The optimal amount of multiple cropping

**Observation 3:** Figure 3.3 shows, the optimal investment in multiple cropping by owners is higher than by both, fixed-renters or sharecroppers. The optimal investment in multiple cropping on leased plots increases with the share of cost covered by the landlord.

Lastly, to determine the influence of tenure arrangements on investment in ditches, we analyze the first order condition (3-11). This condition again suggests that the marginal value of soil capital due to building ditches  $\lambda_s(I')$  has to equal its costs plus the opportunity costs of land  $\mu_2$ , and consequently  $\xi_4 = 0$ . Given the opportunity costs of land are equal for all types of farmers, the extent to which owners, fixed-renters, and sharecroppers invest in ditches is in a similar way as outlined above dependent on the sharing rule of cost  $\omega$  and the shadow value of the soil, which increases with tenure duration and as such a longer tenure duration enhances investment. The latter is not shown in the theoretical model directly and can be found in Abdulai and Goetz (2014).

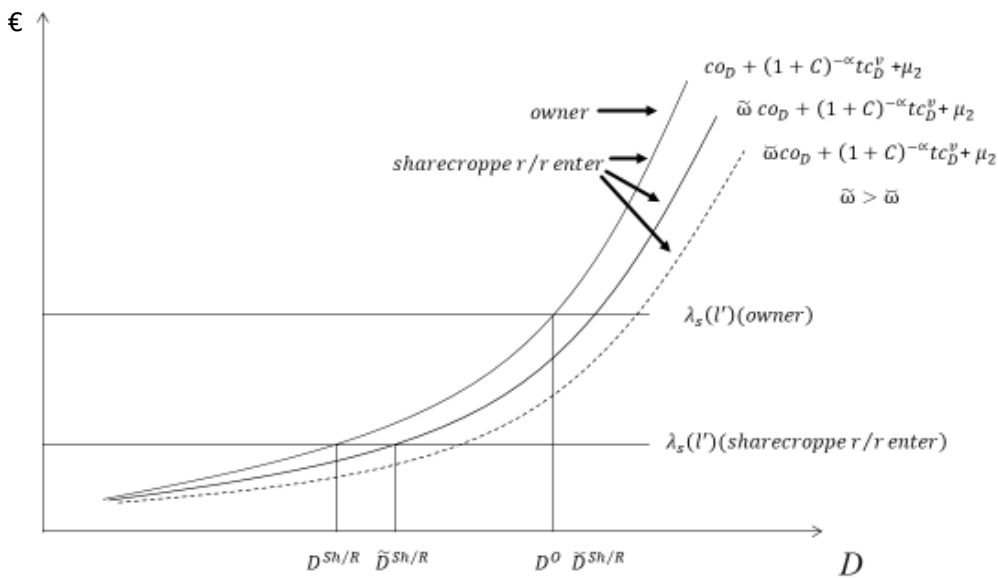


Figure 3-4: The optimal amount of ditches

**Observation 4:** Figure 3.4 shows, the optimal investment in ditches by owners is higher than by both, fixed-renters or sharecroppers. The optimal investment in ditches on leased plots increases with the share of cost covered by the landlord.

The opportunity costs of land, in case of land abundance, is zero  $\mu_2 = 0$ , . However, in case land for agricultural production is scarce, the opportunity cost of land, according to equation (3-7) is  $\mu_2 = pf - (p_M + (1 + C)^{-\alpha}tc_M^v)X_M - (p_0 + (1 + C)^{-\alpha}tc_0^v)X_0 - ((1 + C)^{-\alpha}tc_{mu}^v)M - \theta\gamma pf + \lambda_s(h + m - \delta f) + \mu_1$ . Differences in the opportunity costs of land between the types of farmers will lead to diverse results. The effect of connectivity will be the same for the other investment options. A high connectivity of the farmer  $C$  reduces costs of investment and implies more investment in ditches. For example, a higher connectivity linked to practical assistance would make it easier for the farmer to build ditches than hiring someone to help him or building ditches on his own.

### 3.4 Multivariate probit model

From the first order conditions (3-8)-(3-12) in section 3.3 we derive that farmers invest in soil conservation measures if it leads to positive expected farm net benefits, taken as an aggregate over the length of planning horizon. Yet, we do not observe the expected farm net benefit because of its subjective nature, but we observe the decision of farmers to undertake investments. According to the maximization problem outlined in equation (3-6), farmers invest in soil conservation measures only if it maximizes farm net benefit, i.e.  $\delta J/\delta L_D, \delta J/\delta X_M, \delta J/\delta X_O, \delta J/\delta M > 0$ . The empirical model determines factors exerting an influence on the likelihood of farmers investing in soil conservation measures.

As indicated previously, expected farm net benefit  $J^*$  cannot be observed but can be stated as a function of observables and generates an observable variable  $J$  representing the household's decision to invest in soil conservations measures or not. We define the latent propensity variable for investment  $m$  on plot  $j$ , by farmer  $l$  as  $J_{jlm}^*$  that can be linked to plot and farm and household characteristics  $Z_{jlm}$  among others such as plot size, household size and education, tenure arrangements  $R_{jlm}$ , social capital of the farmer  $SC_{lm}$ , off-farm activities of farmers  $NF_{lm}$  and unobservables  $\varepsilon_{jlm}$  in the following latent variable model:

$$J_{jlm}^* = \beta_1 Z_{jlm} + \beta_2 R_{jlm} + \beta_3 SC_{lm} + \beta_4 NF_{lm} + \varepsilon_{jlm}, \quad (m = \text{ditches, fertilizer, manure, multiple cropping}) \quad (3-13)$$

Ditches, mineral fertilizer, manure and multiple cropping can be denoted according to the theoretical model by  $L_D, X_M, X_O, M$  respectively, and farmers face a discrete binary choice. An applicable model would be a binary probit model with the following link to the underlying latent variable.

$$\hat{J}_{jlm} = \{1 \text{ if } J_{jlm}^* > 0; 0 \text{ if } J_{jlm}^* \leq 0.\} \quad (m = L_D, X_M, X_O, M) \quad (3-14)$$

Investment in the soil conservation measure is observed if  $J_{jlm}^* > 0$ , in which case  $\hat{J}_{jlm} = 1$ . Else, investment in the soil conservation measure is not observed,  $\hat{J}_{jlm} = 0$ .

However, investment decisions are likely to be substitutes or complements for one plot. A multivariate model can be employed building an extension to binary models as equations are added and addressing interrelations of investments (Ali *et al.*, 2012). Hence, we assume that  $\varepsilon_{jlm}$  ( $m = L_D, X_M, X_O, M$ ) jointly follow a multivariate normal distribution with mean 0 and variance 1 and the variance-covariance matrix  $\Sigma$ , expressed as  $(\varepsilon_{L_D}, \varepsilon_{X_M}, \varepsilon_{X_O}, \varepsilon_M) \sim MVN(0, \Sigma)$  (Abdulai *et al.*, 2011).

Land tenure arrangements, social capital, and off-farm activities are assumed to be endogenous when estimating the effect of these concepts on investment decisions, as theory and empirical results have indicated. The most underlying effect for tenure arrangements to be endogenous is the assurance effect, investment incentive comes through security of reaping benefits of investment. Social networks are linked to information sharing enhancing investments, whereas off-farm activities are linked to both enhancing as well as diminishing effects on investment (see Oseni and Winters, 2009; Abdulai *et al.*, 2011; Beekman and Bulte, 2012). The variables become correlated with the error term and estimates will be biased and inconsistent (Jackson, 2008: 437; Wooldridge, 2010: 54).

The most common procedure when accounting for endogeneity is the Two-Stage Least Squares (2SLS) method, which is an instrumental variable approach. Given the use of a nonlinear model, where the dependent variable is discrete, a standard instrumental variable approach is not applicable, since standard errors would be downward-biased (Brasselle *et al.*, 2002). Therefore, we make use of the control function approach. Given the endogenous variables are discrete, and the investment specifications as well, both the Rivers and Vuong (1988) (which requires the endogenous variable to be continuous) and Smith and Blundell (1986) (which also requires the outcome variable to be continuous) approaches are not suitable. Following this, we used the Wooldridge (2014) control function approach, where we first estimate probit models and then retrieve the generalized residuals to use in the second stage. These generalized residuals in the second stage account for endogeneity of potential endogenous variables. This approach provides consistent estimates in the average structural function.

Land tenure arrangements, and off-farm activities each were regressed by a probit on the instrument, a vector of variables, and all other variables used for specifying investment:

Endogeneity of other variables, i.e. social capital, will be addressed differently and discussed in chapter 3.6.2. 'variables subject to endogeneity'.

$$R_{jlm} = \gamma_0 + \gamma_1 Z_{jlm} + \gamma_2 SC_{lm} + \gamma_3 NF_{lm} + \gamma_4 W_{jlm} + \rho_{jlm} \quad (3-15)$$

$$NF_{lm} = \delta_0 + \delta_1 Z_{jlm} + \delta_2 SC_{lm} + \delta_3 R_{jlm} + \delta_4 X_{lm} + \varphi_{jlm} \quad (3-16)$$

where  $W_{jlm}$  and  $X_{lm}$  are vectors of instrumental variables for each vector of variables that is subject to endogeneity that are correlated with the particular variable subject to endogeneity

and uncorrelated with  $\varepsilon_{jlm}$ . The variables  $\rho_{jlm}$  and  $\varphi_{jlm}$  are the respective generalized error terms and the other variables are defined as above<sup>16</sup>.

The equations need to be identified considering the fact that they include as many instruments as possible for the endogenous variables we want to instrument, satisfying the order condition. In case of having more instruments than variables subject to endogeneity, the model is overidentified. The rank condition asks for enough correlation between the instruments and the possible endogenous variables (Baum, 2006: 190-191)<sup>17</sup>.

The generalized residuals from equations (3-15) - (3-16) will be used in the second stage for determining the investment decision of the farmer:

$$J_{jlm}^* = \beta_1 Z_{jlm} + \beta_2 R_{jlm} + \beta_3 SC_{lm} + \beta_4 NF_{lm} + \beta_5 \rho_{jlm} + \beta_6 \varphi_{jlm} + \vartheta_{jlm} \quad (3-17)$$

The t-statistics on each of the residuals provide a valid test for exogeneity of land tenure arrangements and off-farm activities in estimating investment in soil conservation measures,  $\beta_5 \neq 0$ ,  $\beta_6 \neq 0$  and reveal endogeneity, whereas  $\beta_5 = 0$  and  $\beta_6 = 0$  suggest that they are exogenous variables and  $\rho_{jlm} = \vartheta_{jlm}$ , and  $\varphi_{jlm} = \vartheta_{jlm}$ . In case of endogeneity, standard errors and test statistics are not strictly valid and the parameters  $\beta_1$ ,  $\beta_2$ ,  $\beta_3$  and  $\beta_4$  are only estimated up to scale that is tackled by making use of an M-estimator (Wooldridge, 2010: 587). A joint Wald test can be performed on the vector  $\beta$  in order to analyze overall exogeneity of tenure arrangements (Brasselle *et al.*, 2002)<sup>18</sup>.

### 3.5 Hypotheses of the study

The main hypothesis is that secure land tenure arrangements have a positive impact on farmers' decision to invest in soil conservation measures. In line with previous literature we use the term tenure security to refer to the insecurity of the claim of the investment at the end of the contract (Abdulai and Goetz, 2014). Secure land tenure arrangements are believed to

---

<sup>16</sup> We define the latent propensity variable for investment  $m$  on plot  $j$ , by farmer  $l$  as  $J_{jlm}^*$  that can be linked to plot and farm and household characteristics  $Z_{jlm}$  among others such as plot size, household size and education, tenure arrangements  $R_{jlm}$ , social capital of the farmer  $SC_{lm}$ , off-farm activities of farmers  $NF_{lm}$ .

<sup>17</sup> In general, it is preferred to have more instruments than possible in case of endogenous variables, so as to increase accuracy and also to test validity of instruments. However, due to not being able to observe the true error terms, our instrument might not be the best to use. Additionally, the relationship with the variables that need to be instrumented for might not be strong enough to produce estimates where endogeneity has been sufficiently accounted for (Manski, 1993; Davidson and MacKinnon, 1993: 234; Jackson, 2008: 437).

<sup>18</sup> Wooldridge (2014) proposed an alternative procedure, quasi-LIML approach that can be used to obtain one-step estimators for nonlinear models with endogenous explanatory variables. In case of 2SML, it maintains specification of a full set of conditional distributions. It must be assumed that the reduced forms of the endogenous variables have additive errors that are independent of the variables exogenous in the structural equation.

influence investment decisions positively through the assurance, the realizability and to a lesser extent through the collateral effect that they intrinsically offer.

### 3.6 Results and discussions

#### 3.6.1 Descriptive results

##### *Household characteristics*

Socio-economic characteristics of the household that are employed within the empirical analyses are presented in table 3-1.

Table 3-1: Household characteristics

Variable	Definition	Mean	S.D.
Age	Age of farmer (years)	46.75	13.22
Male	1 if farmer is male, 0 otherwise	0.84	0.37
HH-size	Household size	5.8	2.05
Adults	Number of household members between 15 and 64 years old	3.35	1.70
Educyrs	Years of formal education of farmer	3.80	4.89
Distm	Distance to the nearest market (km)	6.49	4.95
Yrsr	Years of residence in the village	19.61	15.47
Lvstckvlue	Value of farmers' livestock in GHS* 0.01	7.76	14.59
Implts	Number of farmers' implements	15.36	15.80
Assetn	Number of farmers' assets	1.28	1.15
Mobile	1 if farmer has a mobile phone, 0 otherwise	0.61	0.49
Credit	1 if farmer has access to credit, 0 otherwise	0.09	0.28
Chrstn	1 if farmer is Christian, 0 otherwise	0.59	0.49
Moslem	1 if farmer is Moslem, 0 otherwise	0.29	0.46
Reloth	1 if farmer belongs to traditional, other or no religion, 0 otherwise	0.12	0.32
Off-farmb	1 if the farmer participates in off-farm activities, 0 otherwise	0.49	0.50
Extens	1 if farmer received technical assistance from an extension officer, 0 otherwise	0.36	0.48



Ghanaian Cedis (GHS). Exchange rate: €1 = c3.6 in 2014<sup>19</sup>  
Source: Survey data

The average farmer is around 47 years old with 84% of male respondents and a household of five or six family members, including three adults and almost 4 years of formal schooling. The average distance to the nearest market is about 6.5km and farmers have lived in the village for an average of 20 years. With respect to wealth, the average farm owns livestock amounting to c776 and has 15 farm implements such as cutlasses or hoes. No farmer owns a tractor, they perhaps possess one asset such as a bicycle or television, and half of them own a house. More than half of the farmers own a mobile phone as an essential tool for communication. There is only a small proportion of farmers, less than 10%, that have access to credit and who are not feeling credit constrained<sup>20</sup>. With respect to religion, 59% of the households are Christian, 29% are Moslems, and 12% belong to another religious denomination, being representative for this area. Nearly half of the farmers participate in off-farm activities. Since we analyzed off-farm activities in more detail, we provide a more precise overview of off-farm activities in table 3-3.

### ***Tenure arrangements***

400 farmers were interviewed about the number of plots they are cultivating and the type of tenure arrangement (see Abdulai *et al.*, 2011). Thus, we are not concentrating on several perceived rights, we determine major forms of tenure arrangements in the study area and assess the subjective perceptions at a different stage, with respect to constraints on investment placed on the farmer.

In summary, those 400 farmers are cultivating 656 plots, with 198 farmers cultivating multiple plots. Out of the 656 plots, 215 are owner-operated with the remaining 441 being tenant-operated. Regarding the latter, 158 of these are under fixed-rentership, 139 are sharecropping, 71 are cultivated under *taungya*, 20 are leased from grant chief, and 19 received the plot and its usage as a gift<sup>21</sup>.

Ownership implies unrestricted property rights, such as transfer rights, which means the plot can be sold. Sharecroppers provide some of their output to the landlord as a payment for using the land. Two systems can be distinguished here: *Abunu*, where one-half of the output belongs to the tenant and the other half is given to the owner of the plot; and *abusa*, where one-third of the output belongs to the tenant. In the dataset, only a small share operates under *abunu* (10

---

<sup>19</sup> Data is for all exchange rates from the 10<sup>th</sup> of March 2014

<sup>20</sup> Access to credit is assessed by means of a subjective measure since farmers had to rank from 5 (very high) to 1 (very low) if they feel credit constrained in order to invest in soil conservation measures and apart from this, a dummy variable has been constructed with those feeling very low and low credit constrained in relation to having access to credit, 0 otherwise.

<sup>21</sup> For the non-owner operated plots we have 34 missing values, as not all tenants indicated the type of tenure.

plots). Fixed-rent tenants pay a rent to the landlord. Due to the small number of farmers who leased the plot from the grant chief, and since this is also one type of fixed-rent tenure, we merged the two to form one category. Plots obtained as a gift or under the forest management system *taungya* are characterized by restricted ownership since transfer rights are limited and are also merged into one category, ownership with restricted rights. *Taungya* is a forest-management system by which food crops are purposively planted simultaneously with seedlings of trees. After a couple of years, the tree canopy closes and the farmer is prevented from further agricultural production. He then must give back the land, in most cases to the state forest agency (Agyeman *et al.*, 2003). The following descriptive statistics presented in the table 3-2 summarize land tenure security:

Table 3-2: Tenure arrangements

Variable	Definition	Mean	S.D.
Owner	1 if plot is owner-operated with full rights, 0 otherwise	0.34	0.48
Sharecrop	1 if plot is under sharecropping contract, 0 otherwise	0.22	0.41
Rent	1 if plot is under fixed-rent contract, 0 otherwise	0.29	0.45
Other	1 if plot is owner-operated with no rights, 0 otherwise	0.15	0.35

Source: Survey data

### ***Plot characteristics***<sup>22</sup>

Plot characteristics are assessed since the analysis of investment and productivity is subject to the individual plot.

Half of the plots are cultivated with more than one crop in the major rainy season with nearly one third being planted with three crops, whilst the minor rainy season adds even more variability. We obtain shares of crops cultivated on the plot, based on an area devoted to crops, two times for both major and minor rainy season, and deduce from these results that the major crop cultivated on the plot, as is presented in table 3-3.

Table 3-3: Main crops cultivated on plot

Variable	Definition	Mean	S.D.
Maize	1 if maize is major crop cultivated on plot, 0 otherwise	0.58	0.49
Yams	1 if yams is major crop cultivated on plot, 0 otherwise	0.27	0.44
Cass	1 if cassava is major crop cultivated on plot, 0 otherwise	0.06	0.23
Othrs	1 if others are major crops cultivated on plot, 0 otherwise	0.09	0.28

<sup>22</sup> Descriptives of plot characteristics and investment options are only presented for those, who indicated a specific type of tenure.

Source: Survey data

Maize and yams are the major crops, while cassava and other crops have minor importance. Other crops are an aggregate of plantain, cocoa, vegetables, and beans. Table 3-4 presents plot characteristics other than crop composition.

Table 3-4: Plot characteristics

Variable	Definition	Mean	S.D.
Pltsize	Size of plot in acres	4.31	4.88
Slope	1=flat, 2=mild, 3=severe	1.37	0.53
Pltforest	1 if vegetation on plot is forest, 0 savanna	0.40	0.49
Soilfert	1 if farmer perceives soil on plot as fertile, 0 otherwise	0.88	0.33
Sand	1 if soil on plot is sandy, 0 otherwise	0.49	0.50
Clay	1 if soil on plot is clay, 0 otherwise	0.13	0.34
Loam	1 if soil on plot is loamy, 0 otherwise	0.34	0.48
Soilothr	1 if soil on plot is other soil, 0 otherwise	0.04	0.19
Yield	Value of output per acre 2009 (GHC*0.1)	56.37	124.23

Ghanaian Cedis (GHS). Exchange rate: €1 = ₵3.6 in 2014; Source: Survey data

The average plot size is 4.3 acres though with quite some variation. The plot is mostly flat, with a nearly equal distribution of forest and savanna, and mainly perceived as fertile. Half of the plots consist of sandy soil followed by loam and clay soils. Sandy soils are the easiest to work with and cultivate, however, they dry out quickly and do not contain a lot of nutrients. The rest of the plots are covered by clay soil which is very fertile and drains slowly, while loamy soils is a mixture of both, well-drained and easy to work with (Royal Horticultural Society, 2011). The value of crop output per acre 2009 was on average ₵563.7 not considered for the share used for own consumption.

### ***Investment options***

One can differentiate between diverse types of investment options. We classify them into four groups: erosion control measures (terraces, ditches, windbreaks, and earth dams), agronomic measures (multiple cropping, mulching, and cover crops), soil management measures (farm and green manure, deep ploughing, and compost) and cultivation measures (minimum and zero tillage, ridging across and along the slope). Trees planted on the plot are also assessed. Farmers mentioned the use of mineral fertilizer (NPK 15-15-15, NP 20-20, urea (sulfate of

ammonia)) and pesticides (pesticides, fungicides, herbicides and weedicides), planting material and new seeds purchased.

We also asked farmers to quantify investments in monetary terms. However, in the case of some investment options, it seems difficult for farmers to attach a monetary value to it. For the sake of brevity, the extent of investment is not presented here. An overview of investment options by group of investment is provided in the tables 3-5 – 3-9. Trees are added to the category erosion control measures since they also control for soil erosion alongside other functions.

Table 3-5: Erosion control measures

Variable	Definition	Mean	S.D.
Terraces	1 if farmer invests in terraces on plot, 0 otherwise	0.03	0.18
Ditches	1 if farmer invests in ditches on plot, 0 otherwise	0.35	0.48
Windbreaks	1 if farmer invests in windbreaks on plot, 0 otherwise	0.03	0.17
Earth dams	1 if farmer invests in earth dams on plot, 0 otherwise	0.03	0.17
Trees	1 if farmer has planted trees on plot, 0 otherwise	0.32	0.47

Source: Survey data

Of the erosion control measures, the most prevalent is investment in ditches up to a 35%, whereas the other investment options are only rarely applied. Trees have been planted on 1/3 of the plots.

Table 3-6: Agronomic measures

Variable	Definition	Mean	S.D.
Multiple cropping	1 if farmer applies multiple cropping on plot, 0 otherwise	0.53	0.50
Mulch	1 if farmer applies mulching on plot, 0 otherwise	0.16	0.36
Cover crops	1 if farmer applies cover crops on plot, 0 otherwise	0.06	0.23

Source: Survey data

The most prevalent agronomic measure with on more than half of plots applied is multiple cropping, whereas only on a minor share of plots mulching and cover crops are applied.

Table 3-7: Soil management measures

Variable	Definition	Mean	S.D.
Deep ploughing	1 if farmer applies deep ploughing on plot, 0 otherwise	0.06	0.24
Compost	1 if farmer applies compost on plot, 0 otherwise	0.04	0.19

Farm manure	1 if farmer applies farm manure on plot, 0 otherwise	0.09	0.29
Green manure	1 if farmer applies green manure on plot, 0 otherwise	0.04	0.20

Source: Survey data

Soil management measures are quite rare in application. In the analysis, we do merge compost, farm and green manure to manure.

Table 3-8: Cultivation measures

Variable	Definition	Mean	S.D.
Mtillage	1 if farmer applies minimum tillage on plot, 0 otherwise	0.47	0.50
Ztillage	1 if farmer applies zero tillage on plot, 0 otherwise	0.18	0.38
Racrsl	1 if farmer applies ridging across slope on plot, 0 otherwise	0.21	0.40
Ralosl	1 if farmer applies ridging along slope on plot, 0 otherwise	0.06	0.23

Source: Survey data

Within investment options, minimum and zero tillage are the least laborious ones. The farmer does not need to be active; he is rather passive not undertaking tillage operations that are applied in sum on 65% of the plots. Ridging operations are undertaken on around one quarter of the plots.

Table 3-9: Input use

Variable	Definition	Mean	S.D.
Fert	1 if farmer applies fertilizer on plot, 0 otherwise	0.33	0.47
Pest	1 if farmer applies pesticides on plot, 0 otherwise	0.46	0.50
Input	1 if farmer applies planting material/improved seeds on plot, 0 otherwise	0.58	0.49

Source: Survey data

Input use is quite common. A third part of the plots use fertilizer, almost a half of the plots use pesticides and for more than half of the plots planting material and improved seeds are purchased.

### **What needs to change from the farmer's point of view in order to invest**

In order to assess data from the farmers' point of view, farmers interviewed had to mention at most three necessary changes in order to invest in soil conservation measures starting with the most crucial one and proceeding in descending order. Table 3-10 below presents these changes and their respective frequency according to farmers' responses, which suggest options of how investment can be facilitated.

Table 3-10: Necessary changes from the farmer's point of view in %

Change	1 <sup>st</sup> change	2 <sup>nd</sup> change	3 <sup>rd</sup> change
Access to credit	45.31	24.77	14.29
Access/lower prices of inputs	38.54	42.90	28.11
Improved knowledge about how to apply measures	4.17	14.80	26.73
Banning of bushfires	2.86	2.72	2.43
Change in land tenure system	1.04	6.95	7.83
Enhanced practical assistance		3.02	4.62
Others	1.09	4.84	15.99

Source: Survey data

The most important change that should be taken into consideration in relation to credit is that nearly half of the 384 farmers interviewed mentioned better access to/lower prices of inputs. Of minor importance and in descending order, we can mention an improved knowledge about how to apply measures, a banning of bushfires and a change in land tenure systems. Other named changes are very diverse.

Out of the 331 farmers who stated their second necessary change, slightly more than 40% of them named better access/lower prices of inputs, while a 25% mentioned a change in credit availability. 15% of the farmers interviewed stated the necessity of improved knowledge about how to apply measures. Almost 7% preferred a change in the land tenure system. Among minor issues, we can mention enhanced practical assistance, banning of bushfires and others related to infrastructure.

217 farmers answered questions in relation to the third necessary change. Better access/lower prices of inputs is still the most preferred change with 28%, followed by improved knowledge with nearly 27%, and access to credit with around 14%. Nearly 8% of the answers are related to a change in the land tenure system. Minor issues are in line with those indicated previously.

The answers reveal a few issues with high relevance, such as access to credit and access and prices of inputs. The strong notion concerning access to credit is also mentioned by Pande and Udry (2007). Private mortgage lending is very restricted in Ghana since interest rates of up to 50% are charged per annum from banks and other formal lending institutions (Berry, 2009). The results indicate a minor priority given to insecurity of tenure. However, these findings should be taken with care, since these are merely qualitative statements. Still, they reveal the complexity of constraints farmers face in terms of investment. The following quantitative analyses will provide more insight into the relevance of tenure arrangements for investment decisions.

### Descriptive comparison of plots under different tenure arrangements

Before investment decisions are determined, we examine differences by means of the variables included in the model (except village dummies) among farmers of owned, sharecropped and fixed-rented plots, by bonferroni multiple comparison t-tests that are presented in table 3-11. We want to test the Marshallian inefficiency hypothesis suggesting that sharecroppers invest less on their plots than owner cultivators and fixed-renters, due to high transaction costs of monitoring, leading to lower outputs (Shaban, 1987). Therefore, we expect investments to be lower on sharecropped plots compared to the other plots; along with lower outputs.

Table 3-11: Differences in key characteristics between tenure arrangements

Variable	Owner <sup>1</sup>	Sharecropper <sup>2</sup>	Tenant <sup>3</sup>	2-1	3-1	3-2
Yield (GHS*0.1/acre)	39.80	72.94	62.19	33.18*	22.39	-10.75
Maize (dummy)	0.47	0.64	0.63	0.17**	0.16**	-0.01
Yams (dummy)	0.09	0.03	0.03	-0.06	-0.06	0.00
Cassava (dummy)	0.33	0.26	0.24	-0.07	-0.09	0.00
Othrs (dummy)	0.10	0.07	0.10	-0.02	0.00	0.03
Trees (dummy)	0.45	0.16	0.14	-0.29***	-0.31***	-0.02
Plot size (acre)	5.78	3.73	3.73	-2.05***	-2.05***	0.00
Loamy soil (dummy)	0.35	0.34	0.31	-0.01	-0.04	-0.03
Credit (dummy)	0.05	0.06	0.10	0.01	0.05	0.04
HH-size per acre	1.3	1.4	1.6	0.1	0.3	0.2
Livestock (GHS*0.01)	8.57	8.10	11.36	-0.47	2.79	3.26
Age (years)	49.20	45.70	46.91	-3.5**	-2.29	1.21
Years of residence	26.7	13.2	18.2	-13.5***	-8.5***	5.0***
Extension (dummy)	0.39	0.27	0.34	-0.12*	-0.05	0.07
Fbo (dummy)	0.24	0.33	0.23	0.09	-0.01	-0.10
Distm (km)	7.14	6.50	5.40	-0.64	-1.74***	-1.10
Ditches (dummy)	0,39	0,40	0,36	0,01	0,04	-0,04
Fertilizer (dummy)	0,28	0,30	0,48	0,02	-0,20***	0,12***
Manure (dummy)	0,14	0,22	0,14	0,08	0,00	-0,08
Mult.Crop. (dummy)	0,55	0,65	0,59	0,10	0,04	-0,06

Note: The difference measured for each combination of tenure arrangements is difference = mean (tenure arrangement X)-mean (tenure arrangement Y), with  $H_0$ : diff = 0 and  $H_1$ : diff  $\neq$  0; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

The test is carried out by rejecting  $H_1$  if  $p_i < \alpha_i$ , where  $\alpha_i = \frac{\alpha}{n}$  and  $n$  is the number of comparisons

Source: Survey data

Output on plots under sharecropping (72.94 Ghs\*0.1/acre) is 45 percentage points higher than on plots under ownership (39.80 Ghs\*0.1/acre) and this difference is statistically significant,

albeit only at the 10% level. Soil conservation measures do not directly lead to higher yields or even decrease yields in the short-run. As outlined in the theoretical framework, ditches reduce land used for cultivation of crops, which is one explanation for owners having lower outputs. It is also important to note that lower yields per acre do not necessarily translate into total lower production (see Stiefel and Minten, 2008).

Crop choices differ between tenure arrangements. Maize is mostly planted on sharecropped and fixed-rented plots compared to owned plots, whereas for other crop choices no difference exists. Maize is the most predominant crop. Trees are most common on plots that are owner-cultivated. This finding is not surprising, as a range of studies provide evidence that owners are more likely to plant trees (see Deininger and Ali, 2008; Abdulai *et al.*, 2011; Ali *et al.*, 2011). Most trees planted are teak and cashew, respective outputs do not provide such a high return per acre as food and cash crops planted on sharecropped plots and provide one additional explanation for the difference in revenues. Having trees might be linked to lower output per plot due to space needed by plots and linked to higher outputs for sharecroppers and fixed-rent tenants.

Household characteristics differ little between types of tenure except years of residence in the village. There is no difference in access to credit with only a small share of farmers having access. Concerning age, farmers of sharecropping contracts are younger than farmers who own land. Years of residence in the village differs greatly among those different types of tenure. Owners live on average already 27 years in the village, sharecroppers only 13 years. Sharecroppers are mostly national migrants from the North settling in the commonly notated 'Food basket of Ghana'<sup>23</sup> and as such are characterized by a shorter period of time living in the area (Geest *et al.*, 2010). Sharecroppers also have less contact with an extension officer than farmers of the other two tenure arrangements.

With respect to location, farmers of fixed-rent contracts live closer to the nearest market than farmers who own land. Oppositely, owner-operated plots are the largest.

We also observe differences in investment across land tenure arrangements. Fertilizer is significantly more applied in case of plots with fixed-rentership and is in line with our theoretical framework in that, fixed-renters extract nutrients from the soil in a very short time without considering long-time effects. The Marshallian inefficiency hypothesis suggests that sharecroppers invest less on their plots than owner cultivators, due to lower incentives as they do not receive the full benefit of their inputs due to giving away part of the output to the landlord and therefore invest too little. One way of overcoming the Marshallian inefficiency has been

---

<sup>23</sup> <http://www.ghana.travel/places-to-visit/regions/brong-ahafo/>, accessed 07.02.2019



claimed to be monitoring, yet this is limited due to high transaction costs of monitoring (Shaban, 1987). From the descriptive data, it appears that sharecroppers invest more in ditches, manure and multiple cropping than owners or renters and are also not producing less output compared to owners and fixed-renters. Hence, the Marshallian inefficiency hypothesis cannot be confirmed by only looking at the descriptive comparisons and will be analyzed in detail in the empirical analysis. In addition, it is in line with the above observation that sharecroppers have mostly moved to the area<sup>24</sup> and engaging in farming might be their main purpose of staying there creating an incentive to invest highly in farming.

### 3.6.2 Empirical results

#### *Variables included in the model*

We make use of plot-level data. The variables included in the model are presented in table 3-12. Four different types of investment, as indicated earlier in the conceptual framework, have been chosen to cover a broad range of investment options. These belong to the main innovations a farmer in Sub-Saharan Africa can invest in to enhance production (Rijn *et al.*, 2012). We have decided for the erosion control measure ditches, the productivity-enhancing input fertilizer, the soil management measure manure and the agronomic measure multiple cropping. As it was previously stated, all investment options, except for fertilizer, are soil improving, together with fertilizer and manure as productivity enhancing techniques. The incidence of each investment option is measured by dummy variables, where one indicates a respective investment was made on the plot and zero otherwise.

The choice of the explanatory variables is based on previous research and the conceptual framework in section 3.3. Tenure arrangements are included according to the differentiation by Abdulai *et al.* (2011). Accordingly, we distinguish between unrestricted ownership of plots, restricted ownership of plots, fixed-rentership and sharecropping. As previously mentioned in section 3.6.1, unrestricted ownership implies unrestricted property rights, including transfer rights so the plot can be sold. Restricted ownership limits transfer rights since the plot cannot be transferred by selling it. These plots are obtained as a gift or under the forest management system *taungya*. Fixed-rent tenants pay a rent and sharecroppers provide some of their output to the landlord. Empirical findings of the effect of tenure arrangements on investment differ (Place, 2009). Still, according to the conceptual framework, we assume ownership to exert a positive effect on investment in soil conservation measures, in particular on those with long-term effects.

---

<sup>24</sup> Only 10% of sharecroppers are originally from Techiman and Kintampo North, whereas more than 60% of owners are from either Techiman or Kintampo North

Social capital is assumed to foster positive investment decisions, as outlined in the conceptual framework. The latent nature of social networks is employed, and observable factors are used in an explorative principal component analysis. Components are interactions related to investment and as well as to different types of assistance while including the underlying factor trust in the community. Information on the principal component analysis (PCA) in detail is provided in the next section ‘variables subject to endogeneity’. In addition, the observable formal social network, membership of an fbo is included as a binary variable to evaluate its individual effect.

Off-farm activities are added to the model. Since extant empirical results concerning the effect on investment behavior on the farm are ambiguous and chapter 07 is focusing on off-farm employment only, we forego to assume a certain direction of influence. However, wage employment as part of off-farm employment is more related to push factors (Woldenhanna and Oskam, 2001) because cash constraints may be overcome. It is likely that wage employment is used to obtain cash for investment on the farm. In case of self-employment, income can be used for both, investment on the farm and investment in the self-employment business, depending on where the farmer expects a higher payoff.

Control variables consist of plot characteristics and farm and household characteristics. Plot characteristics determine the differences in plot quality, which influences investment (Abdulai *et al.*, 2011). Household size, age, education and its squared term, contact to an extension officer, the value of livestock and farm implements represent household characteristics. The latter two are a proxy for wealth of the household.

The use of instruments that are excluded from the second-stage regression of the investment specification is due to variables that are possibly subject to endogeneity and are explained in the following section.

Table 3-12: Descriptive statistics of variables used in the empirical analysis

Variables	Variable definition	Mean	S.D.
<i>Investment options</i>			
Ditches	1 if farmer applies ditches on plot, 0 otherwise	0.39	0.49
Fert	1 if farmers applies fertilizer on plot, 0 otherwise	0.34	0.47
Manure	1 if farmer applies organic manure on plot, 0 otherwise	0.14	0.34
Multicrop	1 if farmer applies multiple cropping on plot, 0 otherwise	0.58	0.49
<i>Independent variables</i>			
Owner	1 if plot is under owner-operated with full rights, 0 otherwise	0.36	0.48
Sharecropping	1 if plot is under sharecropping contract, 0 otherwise	0.20	0.40
Rent	1 if plot is under fixed-rent contract, 0 otherwise	0.28	0.45

Other	1 if plot is under owner-operated with no rights, 0 otherwise	0.16	0.37
Pltsize	Plot size in acres	4.35	5.08
Pltyrs	Years plot has been under use by current cultivator	8.70	9.62
Age	Age of farmer (years)	48.12	13.15
Educyrs	Years of formal education of farmer	4.13	5.08
Educyrs2		42.77	56.85
Lvstckvlue	Value of livestock wealth (GHS*0.01)	9.05	17.55
Implts	Number of implements the farmer owns	15.58	14.87
HH-size	Number of permanent household members between 15 and 65 years	3.36	1.63
Netw_inv	Principal component network investment	0.01	1.14
Netw_ass	Principal component network assistance	0.03	1.01
Extens	1 if farmer received assistance by extension officer, 0 otherwise	0.36	0.48
Fbo	1 if farmer is member of an fbo, 0 otherwise	0.31	0.46
Off-farm	1 if farmer is engaged in off-farm activities, 0 otherwise	0.49	0.50
District	1 if district of household is Kintampo North, 0 Techiman	0.63	0.48
<i>Instruments</i>			
Yrsr	Years of residence in village	20.23	15.47
Ethnic	1 if farmer belongs to ethnic group Brong, 0 otherwise	0.25	0.43
Pop_nonagr	Share of population in non-agricultural employment in district	34.86	7.78
Distm	Distance to the market in km	6.74	5.25
Observations		505	

Ghanaian Cedis (GHS). Exchange rate: €1 = ₵3.6 in 2014

Source: Survey data

### ***Variables subject to endogeneity***

#### *Possible endogeneity of tenure arrangements*

Tenure arrangements might be subject to endogeneity as outlined before. Ownership with restricted rights is the base category in the empirical analysis and we only need to consider endogeneity of the other three tenure arrangements. Ownership without restricted rights is less likely to be subject to endogeneity in our context since ownership is mainly determined by inheriting a plot (correlation 75%).

The use of instruments is based on previous research and accounts for the context of the study. Ethnicity and years of residence in the village are not determinants of investment yet influence access to land. According to literature, membership in social groups determines access to land rights (Udry, 2012). In line with this argument, one variable used as an instrument for sharecroppers is ethnic identity. Being part of the most common ethnicity, Brong, makes engagement in sharecropping less likely; minority ethnic groups are more likely to

engage in sharecropping. As outlined in the descriptive comparisons across tenure rights in section 3.6.1, sharecroppers are also characterized by significantly fewer years of residence in the community. We also apply years of residence as an instrument, since those farmers who haven't lived in a village for a lengthy period of time are more likely to be tenants (see Pender and Fafchamps, 2006), in this case sharecroppers. The share of population engaged in nonagricultural employment by district describes the economic possibilities in the district making the need to lease land stronger in cases of fewer other viable options. Therefore, the instrument used for fixed-rentership is share of population engaged in nonagricultural employment by district. The higher the share of nonagricultural employment, the less likely the engagement in fixed-rentership since other income opportunities are accessible.

Figure 3-5 provides an overview of tenure arrangements and the respective instruments used.

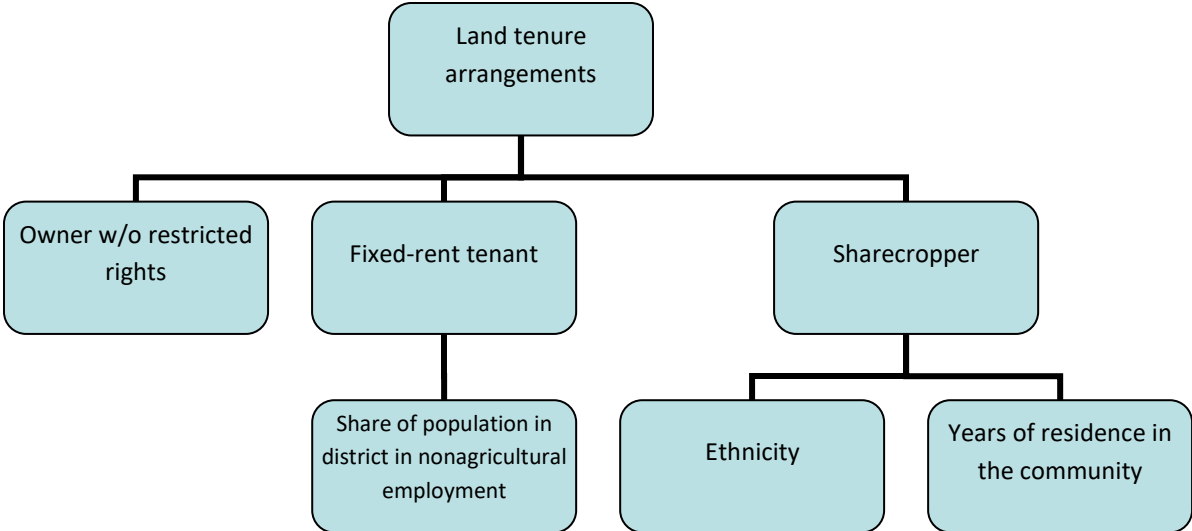


Figure 3-5: Tenure arrangements and instruments

*Possible endogeneity of social networks*

Social capital is based on individual choices that might be subject to endogeneity. Endogeneity of social capital was approached by using latent social networks that are part of social capital and are not subject to endogeneity. We apply a principal component analysis (PCA) in order to make use of observable factors of the social environment to generate these latent social capital variables as has been used by Genius *et al.*, (2013) in Greece as well as in a similar approach by Willy and Holm-Müller (2013) on Kenya and Hunecke *et al.* (2017) in Chile.

We used several social capital variables, as shown in table 3-13, that go beyond interaction related to farming and investment in farming, such as trust in the community and membership in a religious organization. We have captured several other types of social interaction: interactions linked to investments, monetary assistance in case of any need, as well as practical assistance and farming advice. These social capital variables are potentially relevant in explaining investment behavior and capture general trust in the community as well as networks based on information exchange, and practical and monetary assistance (Genius *et al.*, 2013; Fafchamps, 2006).

The social network variable: investment networks (component 01) and assistance networks (component 03), are important aspects of social capital, but not directly observable (Krishna, 2004). Different networks provide a platform for information exchange and lower the cost of access to information as well as practical and monetary assistance (Hunecke *et al.*, 2017).

Table 3-13: Descriptives social capital variables

Variable	Definition	Mean	S.D.
Trust	1 if farmer thinks people can be trusted, 0 otherwise	0.80	0.40
Nnboa	1 if farmer gets practical assistance by nnboa, 0 otherwise	0.35	0.48
Monasall	How many individuals farmer knows he would get monetary assistance from in case of need	1.23	2.59
Tradass	1 if farmer gets assistance in trading, 0 otherwise	0.67	0.47
Advice	1 if farmer gets advice about farming business from family, friends, neighbors and others, 0 otherwise	0.80	0.40
Invstall	How many individuals farmer knows who invest in soil conservation measures	2.05	4.15
Tlkothrs	1 if farmer discusses investments with others, who invest, 0 otherwise	0.36	0.49
Relorg	1 if farmer is a member of a religious organization, 0 otherwise	0.42	0.49

Source: Survey data

A PCA is applied with orthogonal rotation, adequacy for the analysis is verified using Kaiser–Meyer–Oklin (KMO) statistics and the Bartlett's test of sphericity to test whether correlations between variables were large enough. Components obtained with eigenvalues greater than 1 were selected. The factor scores in each PCA component were summed up for each social

capital component to obtain a single score. Further specifications of the analysis can be found in the appendix, as well as a more thorough overview of the methodology in section 4.

Table 3-14: KMO and Bartlett test of sphericity

Kaiser-Meyer-Olkin Measure of Sampling Adequacy			0.549
Bartlett Test of Sphericity	Approx. Chi-square		416.446
	df		15
	Sig.		0.00

The KMO value of 0.549 is above the cut-off point 0.5 and is a mediocre value. Patterns of correlations are compact, and they provide distinct and reliable components for principal component analysis (Field, 2005: 640). We also have to reject the null hypothesis of Bartlett’s test of sphericity that explains that variables are not correlated with each other, confirming the prior KMO value and supporting the assumption that the data is suitable for principal component analysis. After assessing suitability of the data, eigenvalues are determined (see appendix). The loadings of the observed social capital variables on the three extracted latent social capital components after rotation<sup>25</sup> are presented in the component matrix table 3-15; loadings below 0.4 are left blank. The loadings show that component 01 is mainly linked to investment networks (number of people the farmer knows who have invested in soil conservation measures; if farmer discusses investment with others). Component 02 is linked to general trust (trust in the community, farming advice given by friends, family, and neighbors), and component 03 is linked to assistance networks (how many individuals the farmer knows he would get monetary assistance from if needed; if farmer gets practical assistance by nnboa).

Table 3-15: Component matrix

	Comp. 1 Netw_inv	Comp. 2 Netw_trust	Comp. 3 Netw_ass
trust		0.7727	
nnboa			0.6677
monasall			0.8305
invstall	0.7960		
tlkothrs	0.7846		
advice		0.7494	

<sup>25</sup> Rotation of the data serves to ease the structure of the principal components. Oblique rotation is applied (oblimin (0.5) oblique), hence the components are allowed to correlate with each other (terminal punctuation?)

Finally, farm-based organizations also constitute a social network that has not been part of the PCA, since we wanted to analyze its own distinguished effect. Participation in a farm-based organization is less likely to be endogenous in our context since, apart from the individual choice of farmers participating in an fbo, some farmers are participating in more than one fbo. As such, participation reflects external local availabilities of farm-based organizations rather than individual choice (Key *et al.*, 2000) and participation in an fbo resembles a union of local availabilities. farm-based organizations serve several different purposes ranging from education, labor provision, access to inputs and loans as well as land, and support in selling produce, as farmers stated in an open-ended question.

#### *Possible endogeneity of off-farm activities*

In order to analyze possible endogeneity of off-farm activities (see section 7.2.1 for more details), we make use of local availabilities of off-farm employment, that is, distance to the market. A smaller distance to the market is associated with less rural areas providing more sources of off-farm activities, but not linked to investment choices (see Abdulai and Huffman, 2005; Abdulai and Huffmann, 2014).

Table 3-16: Probit estimates of determinants of land tenure arrangements

VARIABLES	Fixed-rent	Sharecropping
Pop_nonagr/ethnic	-0.035*** (0.008)	-0.967*** (0.223)
Yrsr		-0.024*** (0.007)
Pltsize	-0.027* (0.014)	0.003 (0.014)
Pltyrs	-0.015** (0.007)	-0.014 (0.011)
Off_farmb	0.290** (0.126)	-0.377*** (0.146)
Age	0.001 (0.005)	0.002 (0.006)
Male	0.345* (0.204)	0.028 (0.244)
HH-size	-0.041 (0.039)	0.066 (0.047)
Implts	0.001 (0.004)	-0.004 (0.005)
Educyrs	-0.112** (0.054)	0.030 (0.078)
Educyrs2	0.008* (0.00)	-0.006 (0.007)
Lvstckvlue	0.006* (0.003)	-0.003 (0.005)
Fbo	-0.298** (0.141)	0.180 (0.157)
Extens	0.067 (0.135)	-0.258 (0.162)
Network_inv	0.108* (0.058)	-0.102 (0.072)
Network_ass	0.024 (0.063)	0.087 (0.072)
Constant	0.600 (0.501)	-0.128 (0.378)
F-test of instruments [p-values]		30.48 [0.000]
Observations	539	531

Note: Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>a</sup>The variable 'pop\_nonagr' is the respective instrument for fixed-rentership, and 'ethnic' is the instrument used for sharecropping

Table 3-16 presents the results of the (first-stage) estimations of determinants of tenure arrangements. The instruments applied are all significant at the 1% level. In addition, F-tests on the joint significance of the instruments for sharecropping are reported. The hypothesis that the instruments are jointly equal to zero is rejected at the 1% level of significance. The sign of these instruments is as described. Years of residence in the village and belonging to the Brong



ethnicity have a negative influence on sharecropping. Share of population engaged in nonagricultural employment has a negative influence on engagement in fixed-rentership.

Table 3-17: Probit estimates of determinants of off-farm employment

VARIABLES	off_farmb
Distm	-0.029** (0.012)
Owner	-0.010 (0.196)
Sharecropping	-0.381* (0.200)
Fixed-rent	0.142 (0.193)
Pltsize	-0.007 (0.012)
Pltyrs	-0.014* (0.007)
Age	-0.014*** (0.005)
Male	0.142 (0.186)
HH-size	-0.023 (0.038)
Implts	-0.001 (0.004)
Educyrs	0.112** (0.053)
Educyrs2	-0.006 (0.005)
Lvstckvlue	0.014*** (0.004)
Fbo	0.004 (0.134)
Extens	-0.087 (0.131)
Network_inv	-0.012 (0.057)
Network_ass	-0.084 (0.062)
Constant	0.709** (0.348)
Observations	509

Table 3-17 presents the results of the (first-stage) estimations of determinants of off-farm employment. The instrument distance to the market is significant at a level of 5% and negative. A smaller distance to the market is positively related to engagement in off-farm employment due to having more possibilities in less rural areas. We forego any interpretation of other variables as we analyze participation in off-farm work at the household level in Chapter 7 while additionally differentiating across wage employment and self-employment.

### **Results multivariate probit (2SCML)**

The empirical results for the second-stage investment specifications are presented in table 3-18. For estimating a multivariate probit model, the most common procedure is to make use of a simulation method, the Geweke–Hajivassiliou–Keane (GHK) simulator is applied. This simulator makes use of the property of a multivariate normal distribution function which can be constructed as “the product of sequentially conditional univariate normal distribution functions” (Cappellari and Jenkins, 2003: 281)<sup>26</sup>. The model is estimated with heteroscedasticity-robust standard errors. These are asymptotically valid irrespective of the type of heteroscedasticity and in case of homoscedasticity (Wooldridge, 2010: 61).

The log-likelihood ratio statistic is 299.35 and is significant at the 1% level, which indicates that the independent variables together influence the decision of the farmer to invest<sup>27</sup>. The cross-equation correlations<sup>28</sup> ( $\rho$ ) show that it is more efficient to estimate these investment choices jointly since, except for ditches and fertilizer, ditches and multiple cropping, as well as fertilizer and manure, all other investment decisions are statistically interrelated. A positive value of rho, as is the case for all significant correlation coefficients, shows that unobserved factors that influence one investment decision positively also increase the likelihood of a positive investment decision of the other, suggesting complementarity between the investment options (Marenya and Barrett, 2007).

We also aimed at estimating a household fixed effects model in order to analyze unobservables at the household-level. However, for estimating the unconditional fixed effects probit model, there is too little variation within the household with respect to investment on various plots.

---

<sup>26</sup> The multivariate probit model was specified with the `cmp` option in STATA, with no difference in results compared to the classical `mvprobit` command except computation time which makes the `cmp` option more convenient.

<sup>27</sup> Multicollinearity (spellcheck this) of the explanatory variables is tested (see table A1 in the Appendix); test statistics reveal no problem of highly correlated variables.

<sup>28</sup> For checking on correlation between the error terms justifying the joint estimation, the `cmp` option specifies ‘`atanhrho`’ being a transformed parameter ‘rho’, the transformation is the inverse arc-hyperbolic of rho (Roodman, 2009).

Table 3-18: Multivariate probit regression of investment in soil conservation measures

VARIABLES	Ditches	Fertilizer	Manure	Multiple Cropping
Owner	0.241 (0.235)	-0.040 (0.224)	0.378 (0.273)	0.331 (0.211)
Sharecropper	1.302** (0.572)	1.069* (0.578)	2.834*** (0.722)	1.326** (0.528)
Fixed-rent	4.575*** (0.807)	1.577** (0.753)	-3.975*** (1.005)	0.895 (0.743)
Pltsize	0.017 (0.016)	0.032** (0.015)	0.001 (0.022)	0.064*** (0.018)
Pltyrs	0.038*** (0.010)	0.028*** (0.010)	0.021* (0.013)	0.023** (0.009)
Off_farmb	1.501 (1.090)	5.166*** (1.120)	5.995*** (1.729)	2.78*** (1.037)
Age	0.016** (0.010)	0.017** (0.010)	0.033*** (0.011)	0.001 (0.007)
Male	-0.410* (0.238)	-0.274 (0.236)	0.570* (0.331)	-0.608*** (0.223)
HH-size	0.039 (0.041)	0.0472 (0.041)	0.060 (0.050)	0.087** (0.040)
Implts	0.005 (0.004)	0.004 (0.004)	0.015*** (0.005)	-0.003 (0.004)
Educyrs	0.011 (0.076)	-0.167** (0.075)	-0.189 (0.115)	-0.188*** (0.072)
Educyrs2	-0.001 (0.006)	0.008 (0.006)	0.007 (0.009)	0.011* (0.006)
Lvstckvlue	-0.024*** (0.006)	-0.025*** (0.006)	-0.017* (0.010)	-0.003 (0.006)
Fbo	0.506*** (0.172)	0.372** (0.166)	-0.135 (0.205)	0.329** (0.161)
Extens	0.057 (0.145)	0.456*** (0.143)	0.326* (0.182)	0.164 (0.138)
Network_inv	0.169*** (0.065)	-0.045 (0.065)	0.351*** (0.080)	0.138** (0.063)
Network_ass	0.164** (0.081)	0.187** (0.079)	0.373*** (0.103)	0.166** (0.078)
Res_off_farmb	-1.300* (0.675)	-3.091*** (0.686)	-3.159*** (1.052)	-1.600** (0.639)
Res_fixedrent	-2.796*** (0.509)	-0.928* (0.474)	2.109*** (0.605)	-0.452 (0.472)
Res_sharecrop	-0.424 (0.331)	-0.269 (0.325)	-1.095*** (0.402)	-0.398 (0.299)
Constant	-3.694*** (0.837)	-4.544*** (0.853)	-6.021*** (1.285)	-1.818** (0.778)
$\chi^2$ -statistic for joint sig. of tenure residuals [p-value]	33.14 [0.000]	5.62 [0.10]	15.45 [0.000]	2.53 [0.280]
Cross-equation correlations				
$\rho_{DF}$ 0.007	$\rho_{DMa}$ 0.299***	$\rho_{DMu}$ 0.086		
$\rho_{FMu}$ 0.385***	$\rho_{MaMu}$ 0.431***	$\rho_{FMa}$ -0.037		

Log-likelihood ratio  
 statistic<sup>a</sup> 299.3 >  $\chi^2(80)$

Observations	503	503	503	503
--------------	-----	-----	-----	-----

Note: Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>a</sup> The log-likelihood ratio statistic is given by  $LR = 2(L_{\Omega} - L_{\omega})$  where  $L_{\Omega}$  is the unrestricted maximum likelihood and  $L_{\omega}$  is the restricted maximum likelihood with an asymptotic  $\chi^2(k)$  distribution, where k is the number of restrictions.

The significance of several variables representing the residuals derived from the first-stage estimations indicates the importance of controlling for endogeneity. With the exception of multiple cropping, the coefficients of the residual for fixed-rentership for all other investments are significant. The results suggest that the tenure arrangement is correlated with the error term which influences investment. We also observe a significant coefficient of the residual for sharecropping on investment in manure, suggesting that the tenure arrangement is correlated with the error term which influences investment in manure.

We tested the hypothesis that the residuals from the first-stage estimations for tenure arrangements are jointly equal to zero. We performed a Wald test on the vector of these residuals for each individual investment specification with the null hypothesis that the residuals are jointly equal to zero. Rightly, the null hypothesis for investment in ditches and manure has to be rejected. For multiple cropping, the null hypothesis cannot be rejected as there is no simultaneity bias and the parameters have been consistently estimated. However, the null hypothesis cannot be rejected for investment in fertilizer with one individual residual that is marginally significant. Overall, a simultaneity bias is present and not controlling for endogeneity would have resulted in biased and inconsistent estimates for tenure rights.

The residual from the first-stage estimation for off-farm activities is significant for all investment options. A simultaneity bias is present and not controlling for endogeneity would have resulted in biased and inconsistent estimates for off-farm activities.

Property rights have been analyzed to a great extent in the past. Due to the diverse empirical findings on the relationship between land tenure arrangements and investment, its importance still needs to be analyzed in different settings (Ali *et al.*, 2011). These results shed some more light on the relevance of these institutions.

Owners are not more likely to invest in soil conservation measures compared to restricted ownership. We merely observe a positive non-significant effect for all three investments that entail long-term positive effects and a negative non-significant effect for investment in fertilizer. The results are in line with Place and Hazell (1993) who, on data from several African countries, could not link higher tenure security with more input usage on plots, as well as Pender and Fafchamps (2006) who also reveal that the extent of input use is not influenced by

the type of tenure arrangement on survey data in Ethiopia. However, a positive significant effect of ownership on soil conservation measures has been found by several empirical studies for Ghana (see Besley, 1995; Goldstein and Udry, 2008; Abdulai *et al.*, 2011; Abdulai and Goetz, 2014).

Farmers on owned plots are not more likely to invest in ditches. This finding is not straightforward regarding the conceptual framework, and also that farmers on sharecropping and fixed-rent contracts are more likely to invest in ditches compared to plots under restricted ownership. The marginal value of soil capital should be higher for owners, which would lend support to the Marshallian inefficiency hypothesis for sharecroppers. The effect of fixed-rentership and sharecropping on investment in ditches is given in relation to the base category, restricted ownership, and can serve as one possible explanation. Restricted ownership includes the forest management system *taungya*, where seedlings of trees are purposely planted to provide soil erosion control, making investment in ditches less likely. As shown in the descriptive results, owners are much more likely to have planted trees on their plots, serving as a soil erosion measure possibly being a substitute to ditches.

Fixed-rentership and sharecropping are positive and significant determinants of investment in fertilizer which is an investment with private short-run effects (Beekman and Bulte, 2012). This finding is partly supported by results reported by Abdulai *et al.* (2011), where fixed-rentership is also positive and significant for investment in fertilizer. The result is in line with our conceptual framework indicating fixed-renters apply more fertilizer compared to owners.

Fixed-rentership is negative and significant for investment in manure, an investment with positive long-term effects, compared to ownership with restricted rights. These results are in line with the conceptual framework showing that fixed-renters are less likely to invest in manure than owners if the effect on soil improvement by the manure outweighs the effect of soil degradation produced by an increase in harvest. Overall, we can disentangle complex mechanisms of how diverse tenure arrangements influence various types of investment. Deininger and Jin (2006) have rightly noted that the influence of tenure security is diverse across different types of investment.

The results can also be explained in light of the three main presumed effects of tenure security on investment decisions. The first, and in our case the most important one, is the assurance effect. The investment incentive comes through security of reaping benefits of investment. The second one is the realizability effect; investment increases the value of the plot along with expected returns in case of exchange. Abdulai *et al.* (2011) indicate land purchase to be rare in the Brong Ahafo region of Ghana. In addition, Atwood (1990) argues that even in cases of land market existence, the increased value of the plot due to investment does not play any

role. Owners simply do not have an interest in selling the land. Hence, the realizability effect might be negligible. The third, the collateral effect, is also of minor importance. Nearly all farmers in the data set (94%) obtained credit, however, only 0.05% did so from a formal credit source, i.e. a bank or credit union. The collateral effect cannot enhance investment with a predominantly informal lending sector (see Atwood, 1990; Gavian and Fafchamps, 1996; Brasselle *et al.*, 2002).

The negative effect of fixed-rentership on investment in manure compared to owners with restricted rights underlines the assurance effect of ownership. The positive effect of sharecropping and fixed-rentership on investment in ditches compared to owners with restricted rights suggests that even if there was a risk of expropriation, this effect would be too little to exert an effect on investment behavior (see Fenske, 2010a). Usage rights of the plot by tenants are sufficient to increase investment in ditches even for sharecroppers. This shows that in our context the Marshallian inefficiency hypothesis does not reveal this one to be a dominant mechanism driving underinvestment.

Sharecroppers appear to be more likely to invest in all investment options compared to owners with restricted rights in our study that might be linked to the special context of renters in our study. As already outlined, sharecroppers and fixed-renters typically have significantly fewer years of residence in the community and are most often from other districts. The Brong-Ahafo region has experienced internal migration since colonial times from the North to the South of Ghana due to the so-called environmental push, finding better natural conditions for farming in the Brong-Ahafo region (Geest *et al.*, 2010).

Plot characteristics do play a role in some investment decisions. Plot size is positively and significantly associated with investment in fertilizer and multiple cropping. This might be due to larger plots being run more commercially, increasing investment in fertilizer as well as having the needed space for multiple cropping. The number of years the plot has been used by the cultivator is positive and significantly different from zero for all investment choices. The longer a plot has been cultivated, the more likely investments are in fertilizer and measures that increase soil capital. This might be due to learning effects or due to increased security of cultivating the plot in the future. This finding is consistent with empirical results of studies by Wollni *et al.* (2010) for Honduras and Abdulai *et al.* (2011) and Abdulai and Goetz (2014) for Ghana. The overall positive effect of years the plot is under use on investment indicates that, in cases where the rental contract has been renewed in the past, farmers are assured to reap the benefits of their investment even without formal ownership.

Farm and household characteristics are important since they explain investment decisions, albeit differing between investments. Age appears to have a positive and significant impact on

investment in ditches, fertilizer, and manure. Older farmers might have gained more experience in farming linked to higher investment.

The effect of education on investment is non-linear. Years of formal education is negative and significant for investment in fertilizer and multiple cropping, yet positive for the squared term. The general level of education is low, and within the average years of education (4 years) there is no positive significant effect. Beyond the average level of education, the probability to invest increases. Investment is knowledge-intensive and human capital is important for positive investment decisions, as has been found, for example, by Smith (2004), Deininger and Jin (2006) and Abdulai *et al.* (2011).

Livestock is a negative and significant predictor of investment in all investment options despite multiple cropping that might be linked to deprioritizing farming in the case of owned livestock. Household size is positively and significantly associated with investment in multiple cropping indicating the more labor available in the family, the more investment likely in multiple cropping.

Social networks linked to information along with a reduction in transaction costs of investment are beneficial for the farmer's decision making. The component information networks and the component assistance networks are highly significant for all investment options except information networks for investment in fertilizer, indicating that other types of assistance are more relevant. Therefore, being part of a network with others who invest in soil conservation measures as well as discussing investment proves to be a significant determinant of investment; similarly, knowing people who would assist in the case of monetary need as well as assist practically influences investment positively. This proves that there is interaction related to the farming business that facilitates investment in soil conservation measures. Social learning plays a significant role in fostering investment, as it has been found also in other applications (see Foster and Rosenzweig, 1995; Bandiera and Rasul, 2006; Conley and Udry, 2010).

The variable membership of an fbo is positive and significant for investment in ditches, fertilizer, and multiple cropping. These institutions reduce information search costs concerning investment (Wollni *et al.*, 2010) and highlight the relevance of formal social networks to support investment behavior.

We have outlined three main hypotheses around social interaction, namely endogenous interaction, contextual interaction, and correlated effects. We accounted for endogeneity of social capital variables by making use of observable factors and translating it into latent social interaction variables that are not subject to endogeneity by means of principal component analysis. In addition, the approach reduces the reflection problem by employing social

interaction variables that go beyond interaction linked to investment, and the latent nature of the components affords us the opportunity to account for some of the correlated unobservable factors. Unfortunately, this approach does not allow us to disentangle the endogenous effects from the contextual and correlated effects.

Being a member of a farm-based organization was not controlled for endogeneity. Individual participation might be an endogenous choice. However, some farmers are participating in more than one fbo, as such participation reflects external local availabilities of fbos rather than individual choice (Key *et al.*, 2000) and participation in an fbo resembles a union of local availabilities. farm-based organizations serve several different purposes, as farmers stated in an open-ended question, ranging from education, labor provision, access to input, loans as well as land, and support in selling produce.

Having contact with an extension officer is also positively and significantly associated with investment in fertilizer and manure and suggests that access to information influences investment decisions greatly. The findings are consistent with results reported by Saint-Macary *et al.* (2010), where having contact with an extension officer increases the likelihood of knowledge about a soil conservation technology. Abdulai and Huffman (2014) also find a positive and significant effect of extension services on adoption and underline extension services to be crucial for adoption through being a major source of information.

The effect of off-farm work on investment relates to the new economics of labor migration. There are two main effects: the insurance and income effect, and the lost-labor effect. The first indicates a strategy for family members to generate income and liquidity to invest in on-farm activities and ensure against production risks. It is an approach of a household to overcome obstacles in local production (Taylor, 2003). According to Taylor and Martin (2001), family members migrating provide liquidity and insurance overcoming lost labor on the farm. The mechanism can be tested by the effect of off-farm work on cost intensive investments, like investment in mineral fertilizer. Higher income obtained might lead to improved liquidity and reduced risk of investments. In contrast to this possible positive effect, labor on the farm gets lost and might reduce labor intensive investments, like building ditches.

Off-farm employment is positive and highly significant for investment in fertilizer, manure and multiple cropping linked to the income effect of new economics of labor migration. With respect to investment in fertilizer, income obtained seems to be used to purchase fertilizer since monetary constraints are overcome. In the case of investment in multiple cropping, cash earned in off-farm activities can also be used to hire labor since wages for hiring labor are usually lower than the wage rate in other off-farm activities (Reardon, 1997). Generally, off-farm work can be the reason for the farmer having more access to information facilitating



investment (Wollni *et al.*, 2010). Similar results have been found by Oseni and Winters (2009) for Nigeria. The study on tenure arrangements and investment in Ethiopia by Deininger and Jin (2006) also shows a positive and important effect of off-farm work of the head of the household on investment decisions; for possible endogeneity bias is not controlled.

Marginal effects are presented in table 3-19. Marginal effects indicate to what extent the probability to invest in each investment option changes if the independent variable changes by one unit, holding all the other variables constant (*ceteris paribus*)<sup>29</sup>. The marginal effects are calculated at the mean of the regressors. Since the model is nonlinear, the standard errors of the marginal effects are constructed by the delta method (see Greene, 2008: 69)<sup>30</sup>. Given the focus of this study, we are particularly interested in the marginal effects of tenure arrangements and social networks and forego a detailed interpretation of the other marginal effects.

Table 3-19: Marginal effects on the marginal probability of investment (%)

VARIABLES	Ditches	Fertilizer	Manure	Multiple Cropping
Owner	0.092 (0.090)	-0.014 (0.080)	0.065 (0.051)	0.126 (0.079)
Sharecropper	0.484** (0.180)	0.40* (0.021)	0.793*** (0.156)	0.416** (0.116)
Fixed-rent	0.944*** (0.029)	0.567** (0.228)	-0.408*** (0.104)	0.317 (0.288)
Pltsize	0.006 (0.006)	0.001** (0.005)	0.000 (0.004)	0.025*** (0.007)
Pltyrs	0.014*** (0.004)	0.010*** (0.003)	0.003* (0.002)	0.009** (0.004)
Off_farmb	0.524 (0.321)	0.982*** (0.025)	0.954*** (0.988)	0.822*** (0.161)
Age	0.006* (0.094)	0.006** (0.003)	0.005*** (0.002)	0.0003 (0.003)
Male	-0.160 (0.238)	-0.069 (0.029)	0.069* (0.029)	-0.215*** (0.068)
Adults	0.014 (0.015)	0.017 (0.015)	0.010 (0.008)	0.033** (0.015)
Nimplts	0.001 (0.001)	0.001 (0.001)	0.002*** (0.002)	-0.001 (0.002)
Educyrs	0.004 (0.029)	-0.060** (0.027)	-0.030 (0.019)	-0.073 (0.028)
Educyrs2	-0.0004 (0.002)	0.003 (0.002)	0.001 (0.001)	0.004 (0.002)
Nlvstckvlue	-0.009*** (0.002)	-0.009*** (0.002)	-0.003* (0.002)	-0.001* (0.002)
Fbo	0.194***	0.136**	-0.021	0.125**

<sup>29</sup> With a multivariate probit model, there is also the option of estimating conditional marginal effects (Greene, 2008: 821), however, we have chosen for unconditional marginal effects given by multiplying the coefficient estimates  $\beta$  by  $\phi(\beta'Z)$  at the mean values of the independent variables  $Z$  (Maddala, 1997: 23).

<sup>30</sup> The delta method is a common procedure to estimate standard errors of estimates of a nonlinear function with an asymptotic approximation (Davidson and MacKinnon, 2004: 202-203).

	(0.066)	(0.006)	(0.031)	(0.060)
Extens	0.021	0.166***	0.056*	0.063*
	(0.055)	(0.053)	(0.013)	(0.053)
Network_inv	0.064***	-0.016	0.057***	0.054***
	(0.024)	(0.023)	(0.013)	(0.024)
Network_ass	0.0621**	0.067**	0.060***	0.064***
	(0.031)	(0.028)	(0.016)	(0.030)

Considering the marginal effects of tenure arrangements, farmers on plots that are sharecropping are more likely to invest in ditches by 48%, in fertilizer by 40%, in manure by 79% and in multiple cropping by 41%. Being a fixed-renter increases the probability to invest in ditches by 94%, as well as to invest in fertilizer by 57%, yet decreases the probability to invest in manure by 41%.

Looking at the marginal effects of social capital, knowing one more person who invests in soil conservation measures and talking those who invested (component information network) increases the probability to invest by 5%-6% for all investment options except fertilizer. Knowing one more person who would assist in case of monetary need as well as assisting practically (component assistance network) increases the likelihood to invest in all investment options by around 6%. Being part of a farm-based organization increases investment in ditches by 19%, in fertilizer by 14%, and in multiple cropping by 13%.

### 3.7 Summary and conclusions

This analysis, which uses cross-sectional data of farmers in the Brong-Ahafo region in Ghana, has shed some further light on the relationship between land tenure arrangements and investment in soil conservation and productivity-enhancing measures. A dynamic framework has been deployed to examine the relationship between diverse tenure arrangements, social networks and farmers' investment in soil conservation measures. Diverse tenure arrangements lead to different time horizons and costs of investment differ depending on the type of tenure. Our empirical results are mainly consistent with the conclusions from the conceptual framework.

In particular, results of the multivariate probit model explaining investment decisions at plot-level, while controlling for endogeneity of tenure arrangements, social capital, and off-farm activities, reveal that farmers who rent land are less likely to invest in manure, a soil improving investment option with positive long-term effects. Farmers on sharecropping contracts and under fixed-rentership are more likely to invest in fertilizer, a short-term investment option decreasing soil quality over time. The number of years the plot is under use by the cultivator is positively associated with all investment options, supporting the notion of tenure security as an important factor to enhance investment in soil conservation measures. In our specific context,

we observe sharecroppers to be more likely to invest in all investment options, possibly due to the fact that sharecroppers tend to be national migrants from the North of Ghana.

Investment is largely driven by social networks. Being part of information networks as well as networks related to other types of assistance is positively related to nearly all investment options. In addition, participation in a farm-based organization increases the likelihood of investment in ditches, fertilizer and multiple cropping. These results are consistent with the theoretical framework which suggests the positive effect of social networks to occur through a reduction in transaction costs.

Off-farm employment increases the likelihood to invest in fertilizer, manure and multiple cropping. Income obtained might be used for overcoming monetary and labor constraints enhancing investment. The crucial role of human capital for progress in the agricultural sector is indicated by education revealing a nonlinear pattern.

Generally, the results support the call for improved tenure security of farmers. This can be done in different ways, for example, by land registration programs or offering long-term contracts to tenants. Long-term contracts seem to be especially appealing based on our study results. The effect of social networks and off-farm work along with statements by farmers revealing access to credit and inputs as major obstacles of investment show that there is no simple solution. Solving the issue of tenure security alone is not enough. Investments in institutions which provide information and social interaction, like fbos or extension officers, and in institutions which provide access to credit and off-farm employment need to be considered in order to foster sustainability in agriculture. In addition, investment in education provides a payoff in terms of decision making on the farm.

## Annex

After having accessed suitability of the data for a principal component analysis, eigenvalues are determined. Table A1 presents the variance explained by each component in column two, the proportion of variance as explained in column three and the respective cumulative values in the last column.

Table 3-1: Eigenvalues

Component	Eigenvalue	Proportion	Cumulative
1	1.48	0.25	0.25
2	1.05	0.17	0.42
3	1.02	0.17	0.59
4	0.97	0.16	0.75
5	0.83	0.14	0.89
6	0.65	0.11	1.00

According to Kaiser's criterion, all components with an eigenvalue above 1 are extracted with 3 components respectively, with the first having the highest eigenvalue and the others are decreasing in its eigenvalue.

Table 3-2: Variance inflation factors multivariate investment decision

VARIABLES	VIF <sup>a</sup>
Owner	2.71
Sharecropper	1.96
Fixed-rent	2.29
Pltsize	1.11
Pltyrs	1.31
Off_farmb	1.14
Age	1.33
Male	1.06
Adults	1.13
Nimplts	1.07
Educyrs	21.32
Educyrs2	20.86
Nlvstckvlue	1.13
Fbo	1.17
Extens	1.15
Network_inv	1.21
Network_ass	1.18

<sup>a</sup>The VIF is defined as:  $VIF_j = \frac{1}{1-R_j^2}$  where  $R_j^2$  is the  $R^2$  belonging to the regression of the  $j$ th explanatory variable on the remaining explanatory variables

All individual VIF values and the mean VIF are far below 10, except education where we created the squared term, a value where one has to worry about multicollinearity.

## **4 Land tenure arrangements and social networks**

### **4.1 Introduction**

In this chapter, we will analyze the linkage between social networks, land tenure arrangements and investment in soil conservation measures. This allows a deeper insight into the relations determined in the conceptual framework and the investment specification in Chapter 3. First, an overview of the concept and empirical literature is given. Next, in depth results including qualitative analysis of constraints placed upon investment from the farmer's point of view are presented, shedding further light on the influence of social networks on investment in soil conservation measures.

### **4.2 Literature review**

#### **4.2.1 Social networks**

The social networks concept, closely related to social capital, responds to the metacultural thought that we humans are social beings and this influences other issues of relevance (Woolcock, 2010). The underlying intuition of social capital is that social networks provide an asset to the individual that has intrinsic value, assistance in times of need or the like and helps with material issues (Woolcock and Narayan, 2000). Analyzing social capital implies analyzing "network-based processes that generate beneficial outcomes through norms and trust" (Durlauf and Fafchamps, 2005: 1644), which indicates that social capital can also be referred to as 'social network capital' (Hayami, 2009). Accordingly, we define social networks as social capital and make use of the concepts interchangeably.

Economic theory has begun to concentrate on social networks and there is a tendency towards this increase in focus providing a basis for social capital analysis within economics (Fafchamps, 2006). There is a large range of theory on social capital. Some writers have proven themselves influential, although their individual views differ. They are Putnam, Coleman and Bourdieu and Wacquant (Field, 2003: 13). Putnam can claim most of the credit for the popularity of the term (Paldam, 2000). Several concepts and approaches evolved (see Nahapiet and Ghoshal, 1998; Woolcock and Narayan, 2000; Pretty and Ward, 2001). A range of literature exists providing an overview of the various definitions and conceptualizing these (see Paldam, 2000; Adam and Roncevic, 2003; Durlauf and Fafchamps, 2005). Paldam (2000) distinguishes between three families of social capital definitions: trust, networks, and cooperation. Trust is an essential aspect of social capital (Dowling & Chin-Fang, 2007: 259). According to Fukuyama (1996, 26) "Trust is the expectation that arises within a community of regular, honest, and cooperative behavior, based on commonly shared norms, on the part of

other members of that community...”. However, in other conceptualizations, trust is seen as an outcome of social capital with inherent feedback loops (Woolcock, 2010) indicating the dynamic aspect of social capital.

The networks view stresses social capital to be a multidimensional concept with different forms (Woolcock and Narayan, 2000) – bonding, bridging and linking – Dufhues *et al.* (2012). The distinction on these 3 different forms is based on Granovetter (1973), who differentiates between weak and strong ties, whereby strength is defined by time invested in the relationship, the intensity of emotions attached to the relationship, the familiarity of each with one another, and also any reciprocal actions. In case of weak ties; the counterpart of the network is more likely to have access to diverse amounts of information as he circulates in other networks that are different from strong ties. Bonding refers to close relations between family, friends or neighbors and bridging refers to more distant relations to associates or acquaintances (Gittel and Vidal, 1998: 15; Woolcock, 2001). These are both horizontal relations, whereas linking refers to vertical relations with differences in power (Titeca and Vervisch, 2008). Each form has different characteristics and effects on behavior, and diverse combinations of characteristics lead to different outcomes (Woolcock and Narayan, 2000; Woolcock, 2001). A distinction is made between formal networks such as organizations and informal networks with specific social support (Pichler and Wallace, 2007).

Measuring social capital empirically by membership of groups and networks is now widespread (Fafchamps, 2004) and is linked to social network analysis in assuming that individuals are surrounded by and are part of social exchanges (Borgatti *et al.*, 2009). Udry and Conley (2004) analyze diverse social networks in Ghana and rightly note that these impose benefits, yet also imply costs of creation, maintenance, and responsibility.

Social network analysis differentiates between diverse purposes of networks such as risk-sharing (see Fafchamps and Lund, 2003), labor-sharing (see Krishnan and Sciubba, 2009) and information (see Conley and Udry, 2010). Networks within the family or with friends that provide learning effects have been studied in different applications (see Bandiera and Rasul, 2006; Kremer and Miguel, 2007). Fafchamps and Minten (2002), in their analysis on social networks of agricultural traders in Madagascar, distinguish between several different types of networks. There are networks with respect to trade within the family and non-family and family and friends willing to help in cases where it is needed.

Recent literature has increasingly focused on information networks. One approach is to also include data on geographic proximity. This could indicate a strong presence of social effects but also only reflect strong correlations in, for example, growing conditions. Bandiera and Rasul (2006), in analyzing technology adoption decisions in Mozambique, base their measure of

social networks on direct data on conversation between individuals. Whereas Conley and Udry (2010) use information about actual identities of individuals who might represent social networks for information flows to determine a willingness to adopt a technology in Ghana. Other approaches, such as the one by Krishnan and Sciubba (2009) on Ethiopia, include network structure, which indicates who is connected to whom within a network in order to analyze farm performance.

#### **4.2.2 Land tenure arrangements and social networks**

Land tenure arrangements and social networks are interrelated. Access to credit, for instance, is not only determined by the collateral the farmer provides, but also by social networks, as credit decisions are based on how well the lender knows and trusts the borrower (Feder *et al.*, 1988: 6). Social networks can thus fulfill the requirements necessary for the farmer to invest in soil conservation measures. The significance of social capital arises mostly in situations where natural resources are to be managed in a sustainable manner (Sanginga *et al.*, 2007) and new agricultural technologies are to be adopted (Rijn *et al.*, 2012). Secure tenure arrangements might not sufficiently provide incentives to invest, especially in soil conservation measures which produce positive externalities, and might even clash with the goal of increasing yields in the short-run. Social capital comes to the fore as it changes attitudes (Bruni, 2009), a precondition for positively influencing sustainability in the long-run (Bouma *et al.*, 2008).

Investment in conservation measures where especially long-term benefits are expected, tend to be knowledge-intensive. Farmers need to gain knowledge concerning new skills and biophysical processes (Wollni *et al.*, 2012). The necessary knowledge is due to interdependencies between diverse measures and multiple resources used. For instance, plants need soil capital and water as well. Thus, it is the proper management and allocation of these resources, and not simply the use of an input, that is required (Barrett *et al.*, 2002b). Consequently, among other determinants explaining investment, specific attention is given to information access, with information rarely being costless and symmetric, and learning (Aker, 2011).

Social capital is also assumed to enhance access to information (Rijn *et al.*, 2012). The process of learning in developing countries is a social one. Social learning, or simply the interaction between individuals, is the main way of assessing the benefits and applicability of innovations (Barrett *et al.*, 2002a). Thus, social learning is closely linked to soil conservation measures, and it is “a process that fosters innovation and adaptation of technologies embedded in individual and social transformation” (Pretty, 2003: 26). Social networks are related to social learning since the latter takes place in social groups and by means of interaction (Pretty and Buck, 2002).

A lack of practical help can also cause a barrier to investment. One approach that addresses the challenges of natural resource management is collective action. It has been defined in many ways, and yet all of the definitions include the deliberate involvement of a group of individuals with a common interest leading to a common action (Meinzen-Dick *et al.*, 2004). Collective action is also assumed to raise awareness of environmental threats and investment in conservation measures (Cramb, 2006). Social capital is linked to collective action. It determines the capacity of collective action (Pretty and Buck, 2002). Transaction costs of acting together are reduced and this then enables cooperation (Pretty, 2003).

Tenure arrangements might constitute a precondition for capturing the benefits of social capital. Pretty (2003) points out that only strengthening social and human capital is insufficient in obtaining desired outcomes with respect to agricultural production and natural resource usage. For example, Ostrom (1994) delineates necessary assumptions in order to carry out collective action. Apart from conditions related to the network, tenure arrangements have to be secure, in order to be able to receive the benefits from collective action at a later stage. Land that changes its user every year will probably not be subject to investment in work-intensive soil conservation measures, as no farmer using the land for just one year has any incentive to invest in land that someone else will then cultivate next year (Hayami, 2009). A holistic framework that takes national policy into consideration, among other things such as property rights, is needed.

The link between social capital and investment is not analyzed as frequently as the relationship between land tenure and investment, but it is more homogenous (Beekman and Bulte, 2012). For example, Isham (2002) finds that social capital, estimated at the village level, increases the likelihood of fertilizer adoption in Tanzania while employing a probit model. Cramb (2006) analyzes the effect of social capital, measured by means of participation in networks, on adoption of soil management practices in the Philippines. The logit estimates reveal that social capital enhances adoption. Similarly, Wollni *et al.* (2010) analyzes the determinants of adoption of soil conservation practices such as crop rotation and manure in Honduras and finds farm-based groups to be a positive predictor applying an ordered probit model. Bouma *et al.* (2008) study the effect of social capital on community resource management in India. Trust and social homogeneity serve as proxies for social capital. Both proxies at the village level are positively correlated with soil conservation measures. The relationship is analyzed by estimating the determinants of soil and water conservation and the determinants of maintaining existing conservation infrastructure by two separate probit models. Rijn *et al.* (2012) distinguishes between bonding and bridging social capital while analyzing the adoption of several agricultural innovations such as multiple cropping and fertilizer use in various African countries. Empirical



results of OLS and Poisson regressions suggest bridging social capital to be particularly important since access to knowledge and resources is facilitated.

Many studies have attempted to investigate knowledge accumulation through social networks. Foster and Rosenzweig (1995), using panel data on India, find that lack of information is a main barrier for rural Indian households' adoption of new high-yielding seed varieties (HYV). Learning from others constitutes a main element in overcoming this barrier. Specifically, how much of HYV is used, determined by hectares and in monetary terms, is equally positively influenced by experience of the neighbor and experience of the individual that are represented by previous HYV use. The study by Conley and Udry (2010) shows that social learning is important for diffusion of a new technology in Ghana. In particular, they analyze the change in fertilizer use per pineapple plant as a result of information from neighbors, based on direct data on communication. They reveal that veteran pineapple farmers are less responsive to information networks. Bandiera and Rasul (2006) analyze sunflower adoption in Mozambique. The results of the linear probability model show that friends and family, being adopters of the new crop and adopters within religious networks, influence adoption. The impact of the friends and family is four times larger than religious networks, which reflects the strength of social ties to exert an effect. However, the relationship between propensity of adoption and number of individuals within the social network is shaped as an inverse U, showing strategic delay. Strikingly, the effect of land tenure has not been considered in these studies, missing out on explaining a possible main driver of investment decisions. Merely Bandiera and Rasul (2006), when asking farmers about reasons for non-adoption, learned that having no land available constitutes, among other things, a barrier to adoption.

The effect of social networks might not always be linear. Social networks can also lead to strategic delay, free riding on the knowledge gained by others in the network (Bardhan and Udry, 1999). Bandiera and Razul (2006) analyze strategic delay empirically in the context of sunflower adoption in Mozambique. Their results reveal that the relationship between technology adoption and number of adopters is shaped as an inverse U. Farmers are more likely to adopt when a few farmers in the network have already adopted but are less likely to adopt when many in the network have already adopted.

Few economic studies have given attention to both tenure arrangements and social networks, in terms of analyzing investment decisions. Gong *et al.* (2010) explain participation in a forest project qualitatively. They conclude that social capital, determined by daily interactions between and across village members, can overcome insecure tenure. Weak social capital on the other hand adds to the negative effect of insecure tenure arrangements. Katz (2000) indicates, in her qualitative analysis on Guatemala, that social capital can be a substitute for

insecure tenure with regards to investment in natural resource management by inducing rules and sanctions. A lack of social capital, since farmers are migrants from different regions with no collective action in the past and little homogeneity, leads to farmers exploiting natural resources and not conserving the resource base.

Saint-Macary *et al.* (2010) analyze knowledge and adoption of a soil conservation technology (agro-forestry) in Vietnam. The variables representing tenure security are only based on titled land and expectations about reallocation. Both are significant determinants of adoption. Formal social networks are differentiated between horizontal (farmer union) and vertical (extension service) social capital, which influence knowledge about agro-forestry positively. However, social networks have not been used for explaining adoption. A paper by Beekman and Bulte (2012) studies the effect of social norms and tenure security on fertilizer use and erosion management in Burundi. They show that tenure security influences investment in erosion management positively, but not fertilizer use. They apply similar proxies as Saint-Macary *et al.* (2010) for tenure security. Investments are aggregated, in that planting trees and building ditches or terraces are one category, while fertilizer implies both mineral and organic fertilizer, neglecting that the latter has long-term effects. In addition, the decision whether to invest or not, in both types of investment, is estimated independently by two probit models. Various social norms influence soil erosion measures positively when estimated at the community level. Social norms do not explain social networks in detail, merely build the basis for cooperative behavior. In addition, altruism, trust and voting behavior account for social capital. Willy and Holm-Müller (2013) determine the influence of collective action on soil conservation measures by means of an ordered probit model, counting the number of soil conservation measures in Kenya after having analyzed participation in collective action by social participation and support, trust and reciprocity. Collective action is positively associated with investment in soil conservation measures due to the possibility of exchanging labor, information and planting material. Land tenure is positively, albeit not significantly, linked with investment.

### **4.3 Conceptual framework**

In explaining social capital, we focus on social networks, since these are concrete and accessible aspects of social capital (Sabatini, 2008).

Social networks are subdivided according to the type of assistance. The possible effect of information networks accounting for social learning is represented by other farmers investing in soil conservation measures the farmer is in contact with (see e.g. Conley and Udry, 2010), general advice about the farming business from various sources and membership in a farm-based organization (fbo). Networks for specific purposes are differentiated into networks for

financial, trading and practical assistance, the latter accounting for some form of collective action (see Fafchamps and Lund, 2003; Krishnan and Sciubba, 2009).

The distinction between the three forms of social capital based on the networks view - bonding, bridging and linking - is applied in order to enlarge the multidimensional concept of social capital (see Woolcock, 2001, Rijn *et al.*, 2012). Bonding implies interaction between neighbors, family, and friends. Bridging is assessed by membership of an fbo or by membership in a religious community.

Figure 4-1 below presents a classification of social capital, with some examples based on level of assessment, (village level green-colored, individual level red-colored), and type of assistance. Information networks can be distinguished as formal networks or informal networks.

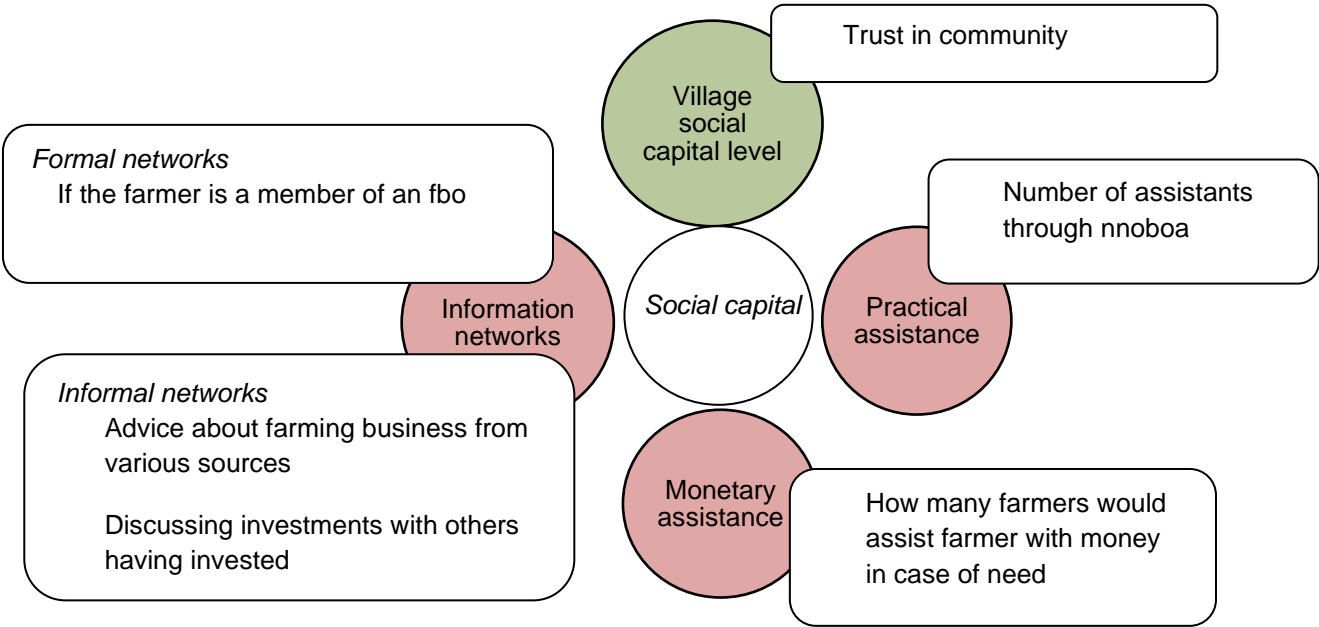


Figure 4-1: Classification of social capital

In Chapter 3, in the conceptual framework, we have already outlined the positive effect of social networks on investment in productivity-enhancing and soil-improving measures, by means of decreasing transaction costs. Based on this model, we have included social networks in the empirical investment specification in the same chapter in section 3.6. Now, a thorough analysis improves our understanding of interdependencies between social capital and incidence of investment.

**4.4 Hypothesis**

Since social capital is linked with positive outcomes in various respects (Durlauf and Fafchamps, 2005), we hypothesize that social networks, representing social capital, enhance

investment in soil conservation measures by various forms of assistance, such as access to information.

## 4.5 Results and discussion

### 4.5.1 Descriptive results

In table 4-1 you see an overview of the social network variables assessed in the survey:

Table 4-1: Social capital

Variable	Definition	Mean	S.D.
Trust	1 if farmer thinks people can be trusted, 0 otherwise	0.80	0.40
Nnboa	1 if farmer gets practical assistance by nnboa, 0 otherwise	0.35	0.48
Monasall	How many individuals farmer knows he would get monetary assistance from in case of need	1.23	2.59
Tradass	1 if farmer gets assistance in trading, 0 otherwise	0.67	0.47
Advice	1 if farmer gets advice about farming business from family, friends, neighbors and others, 0 otherwise	0.80	0.40
Invstall	How many individuals farmer knows who invest in soil conservation measures	2.05	4.15
Tlkothrs	1 if farmer discusses investments with others, who invest, 0 otherwise	0.36	0.49
Relorg	1 if farmer is a member of a religious organization, 0 otherwise	0.42	0.49
Fbo	1 if farmer is member of an fbo, 0 otherwise	0.32	0.46

Source: Survey data

The measure of trust in the community reveals that 80% of respondents trust people in general within the community. With regards to the several types of assistance, 35% of all farmers have received practical assistance from nnboa<sup>31</sup>, and each farmer knows at least one person to whom he could turn to for monetary assistance in case of need. 67% of all farmers are or have been assisted in trading activities. Advice on farming business is provided to 80% of the farmers by family, friends, neighbors, and others. The farmer knows an average of two persons who have invested in soil conservation measures, though only slightly more than 30% discuss

<sup>31</sup> Form of practical assistance in rural Ghana, by which farmers get assistance by other farmers within the community to support in agriculture (Gyekye, 2013: 230).

their investment with other investors. Membership in organizations is common and 42% are in a religious organization with around 30% being members of an fbo.

To continue, we test if social capital is higher for those having invested than those that have not. By this, we analyze if social capital is positively associated with investment decisions. Results of a simple t-test comparing means can be found in table 4-2.

Table 4-2: Social capital by type of investment

Variable	Ditches	Mineral Fertilizer	Manure	Multiple Cropping
Trust	+***	+	-	+**
Nnboa	-	+	+	+*
Monasall	+***	+	+***	+
Tradass	+	+	-	+
Advice	-*	+	-	+
Invstall	+***	-	+	+**
Tlkothrs	+***	-	+	+**
Relorg	-*	-*	-*	-*
Fbo	+**	+	+	+

Note: The difference measured is difference = mean (no investment)-mean (investment), with  $H_0$ : diff = 0 and  $H_1$ : diff > 0 ; + difference is positive, - difference is negative;  
 \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

We find several social capital variables that are positively associated with investment options. At first glance, it stands out that ditches and multiple cropping are strongly associated with social capital, which supports the notion that it is mainly soil conservation measures that are fostered by social capital. Fertilizer, a short-term investment, is not significantly and positively linked with social networks. Investment in ditches is deeply associated with many social capital variables that are trust, receiving monetary assistance, getting advice, knowing farmers who have invested in soil conservation measures and having talked to others who have invested and being a member of an fbo. Thus, specific social networks either linked to investment decisions directly or not and general trust in the community is likely to foster positive investment decisions. Investment in manure is only positively and significantly associated with monetary assistance. These results reveal that own livestock is not the only source of manure and that it is also purchased. Multiple cropping is positively related to several social networks (i.e. trust, nnboa) knowing farmers who have invested and having talked to them. The association with talking to others who have invested underlines the assumptions made in the conceptual

framework. Multiple cropping is linked to knowledge required that leads to transaction costs of implementation. Social networks reduce these costs.

#### 4.5.2 Qualitative analysis

We assessed constraints on investment from the farmer’s point of view, in order to bring out the relationship between constraints on investment, tenure arrangements, and social networks clearly.

Constraints are covered by 18 individual items that relate to socio-economic and structural issues. Constraints are based on previous research and the context of the study. The extent of constraints on investment is assessed by a 5-point Likert Scale, ranging from 1 (none) to 5 (very high). Table 4-3 provides an overview of the 18 specific items rated by the farmer.

Table 4-3: Constraints on investment

Category	Specific constraints
Socio-economic issues	1 lack of access to inputs, 2 high prices of inputs, 3 lack of access to credit, 4 lack of land, 5 insecurity in extension of tenure duration, 6 high effort of applying practices, 7 lack of practical help, 8 lack of implements/tools to apply practices, 9 lack of remunerative options to gain benefits from investment, 10 insecurity in reaping benefits of investments, 11 lack of good experience from others, 12 high social pressure, 13 high complexity of applying combination of practices, 14 lack of support from family/neighbors, 15 low increase in (short-term) productivity in comparison to increase in cost of production due to investment
Structural issues	16 lack of information on possible practices, 17 lack of knowledge of how to apply practices, 18 lack of advice/guidance on how to apply practices

Source: Own data

In order to reduce dimensionality of the 18 constraints, a principal component analysis is conducted. The two main preliminary tests, the KMO criterion for all constraints together and Bartlett’s test of sphericity, are presented in table 4-4.

Table 4-4: KMO and Bartlett’s test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		0.77
Bartlett Test of Sphericity	Approx. Chi-square	9768.55
	df	136
	Sig.	0.00

The KMO value of 0.771 is above the cut-off point 0.5 and is a mediocre value. Patterns of correlations are compact and they provide distinct and reliable components for principal component analysis (Field, 2005: 640). We also have to reject the null hypothesis of Bartlett's test of sphericity that explains that variables are not correlated with each other, confirming the prior KMO value and supporting the assumption that the data is suitable for principal component analysis<sup>32</sup>. KMO values for each individual variable confirm the results of the two previous test statistics that the data is appropriate for principal component analysis as shown in the Annex A2.

After assessing suitability of the data, eigenvalues are determined. Table 4-5 presents the variance explained by each component in column two, the proportion of variance as explained in column three and the respective cumulative values in the last column.

Table 4-5: Total variance explained

Component	Eigenvalue	Proportion	Cumulative
1	4.22	0.25	0.25
2	2.13	0.13	0.38
3	1.47	0.08	0.46
4	1.29	0.08	0.54
5	1.04	0.06	0.60
6	0.98	0.06	0.66
7	0.83	0.05	0.71
8	0.80	0.05	0.76
9	0.68	0.04	0.80
10	0.66	0.04	0.84
11	0.57	0.03	0.87
12	0.55	0.03	0.90
13	0.49	0.03	0.93
14	0.43	0.02	0.95
15	0.34	0.02	0.97
16	0.26	0.02	0.99
17	0.25	0.01	1.00

According to Kaiser's criterion, all components with an eigenvalue above 1 are extracted with 5 components respectively, with the first having the highest eigenvalue and the others are decreasing in its eigenvalue. Figure A1 in the Annex provides a graphical illustration of the eigenvalues.

Rotation of the data serves to ease the structure of the principal components. Oblique rotation is applied (oblimin (0.5) oblique), hence the components are allowed to correlate with each

<sup>32</sup> Constraint 1 is characterized by a KMO value, which is smaller than 0.5, the cut-off point. Constraint 1 represents lack of access to inputs, a low KMO value indicates diffusion in the structure of correlations and this constraint might not correlate well with other variables to a composite component (Field, 2005: 640) and hence is neglected in the analysis.

other<sup>33</sup>. The loadings of the constraints on the five extracted components after rotation are presented in the component matrix in table 4-6, loadings below 0.4 are left blank.

Table 4-6: Component matrix

	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5
constr_2		0.99			
constr_3		0.91			
constr_4				1.02	
constr_5				0.95	
constr_6			0.83		
constr_7			0.65		
constr_8	-0.41		0.70		
constr_9			0.54		0.79
constr_10					1.04
constr_11	0.44	0.51			
constr_12		0.47	0.55		
constr_13			0.63		0.50
constr_14		0.53			
constr_15		0.78		-0.60	
constr_16	0.93				
constr_17	0.93				
constr_18	0.90				

A factorially confounded structure is revealed. Since the loadings of the crossloading constraints mostly are not above 0.5 and higher, the component structure seems to be not erroneous with no poor quality of the constraints (Costello and Osborne, 2005). It stands out that for two items the value is above 1 (constraint 4 and constraint 10). When correlation between the components is allowed, the loadings are no longer correlations, instead, they are regression determinants and can be larger than 1<sup>34</sup>. The results of principal component analysis without rotation are presented in table A3 in the Annex; loadings improve by rotation. A correlation matrix of the components (see Annex table A4) provides evidence of having decided correctly for allowing the components to be correlated when applying rotation, and the SMC statistic reveals reasonable communalities, variance that is shared with other constraints, for each constraint after extraction of components (Annex table A5).

The reliability of the components and constraints loading on the component is tested by Cronbach's alpha. The results of the reliability analysis are presented in tables 4-7 – 4-11. In

<sup>33</sup> We also tried the promax rotation as another option of oblique rotation. However, the results of the factor loadings were not satisfactory. The same accounts for the oblimin oblique option given by default.

<sup>34</sup> Values above 1 might indicate multicollinearity (Jöreskog, 1999). However, since the values are only slightly higher than one, the issue can be neglected.



case one item loads on more than one component with a value above 0.4, it is decided for the component with the highest loading for constructing the test of reliability and interpreting the components. Next to the constraints used for each component, the second column refers to the sign of covariance with other constraints, and the third column represents the overall alpha, in case the respective constraint is not used for the analysis. Given that only two constraints make up one component, the alpha, in case one constraint is deleted, is not provided, since then only one variable is left. At the bottom of each table, the overall reliability of the component is presented. As previously indicated, we extract five components by the Kaiser's criterion and apply a cut-off point for the loadings of each constraint of 0.4.

Table 4-7: Cronbach's alpha component 1

Item	Sign	alpha	Label
constr_16	+	0.84	constraint 16 lack of information on possible practices
constr_17	+	0.76	constraint 17 lack of knowledge on how to apply practices
constr_18	+	0.75	constraint 18 lack of advice/guidance on how to apply practices
Test scale		0.84	Mean

Table 4-8: Cronbach's alpha component 2

Item	Sign	alpha	Label
constr_2	+	0.51	constraint 2 high prices of inputs
constr_3	+	0.42	constraint 3 lack of access to credit
constr_11	+	0.48	constraint 11 lack of good experiences from others
constr_14	+	0.51	constraint 14 lack of support from family/friends to invest
constr_15	+	0.46	constraint 15 low increase in (short-term) productivity in comparison to cost in investment
Test scale		0.53	Mean

Table 4-9: Cronbach's alpha component 3

Item	Sign	alpha	Label
constr_6	+	0.57	constraint 6 high effort of applying practices
constr_7	+	0.58	constraint 7 lack of practical help
constr_8	+	0.64	constraint 8 lack of implements and/or tools to apply practices
constr_12	+	0.62	constraint 12 high social pressure
constr_13	+	0.60	constraint 13 high complexity of applying combination of practices
Test scale		0.66	Mean

Table 4-10: Cronbach's alpha component 4

Item	Sign	alpha	Label
constr_4	+		constraint 4 lack of land
constr_5	+		constraint 5 insecurity in extension of tenure duration
Test scale		0.62	Mean

Table 4-11: Cronbach's alpha component 5

Item	Sign	alpha	Label
constr_9	+		constraint 9 lack of remunerative options to gain benefits from investment
constr_10	+		constraint 10 insecurity in reaping benefits from investment
Test scale		0.74	Mean

Overall, Cronbach's alpha values for each component range between 0.5 and 0.8, which is of considerable size, since below 0.5 would be unacceptable. However, it is not bounded below by a strict cut-off value (George and Mallery, 2003: 231; Gliem and Gliem, 2003). The values suggest that the constraints cover similar aspects and the components are characterized by internal consistency. The individual Cronbach's alpha values fulfill the requirements that they are lower than the overall Cronbach's alpha, but around the same value (Field, 2005: 672-673). A component with less than three items needs to be considered with care since it might be weak and unstable (Costello and Osborne, 2005). However, for the last two components with only two constraints for each component, the reliability is considerably high.

Scores for each component are extracted that are standard variables. Based on the constraints loading highly on the five components, we construct a label representing the general meaning

of the component. Component one consists of three items loading highly on it that are linked to gaining expertise by others. Thus, we name the component **missing expertise**. The second component comprises five items. These relate to monetary constraints but also refer to social aspects. We sum the constraints to the component **monetary constraints**, being aware that social aspects play a role. The third component is also composed of five items, mostly related to practical constraints leading to the component to be named **practical effort**. The fourth component consists of two items, both are linked to tenure arrangements, the component is labeled **tenure constraint**. The last component also comprises two items being related to unprofitability of investment and hence can be summed up in the component **unprofitable options**.

**Constraints on investment, tenure arrangements, and social networks<sup>35</sup>**

We link constraints placed upon investment from the farmer’s point of view to tenure arrangements and social networks in order gain more insight into the interdependencies between social networks and tenure arrangements. The principal components can be treated as usual variables. However, they cannot be interpreted that straightforward, since the change in one principal component can only be interpreted qualitatively. Therefore, the comparison of constraints on investment between tenure arrangements and by social networks is undertaken by merely showing if there is a significant difference in means for each component. Comparisons between tenure arrangements at plot-level estimated by a bonferroni multiple comparison t-test, and the direction of difference are presented in table 4-12. Having a high positive value indicates that the farmer feels highly constrained.

Table 4-12: Comparison constraints on investment between tenure arrangements

Principal component	Sharecropper-Owner	Fixed-rent tenant-Owner	Fixed-rent tenant-Sharecropper
Missing expertise	+**	-***	-***
Monetary constraint	+	+***	+
Practical effort	+	-***	-***
Tenure constraint	+***	+***	+
Unprofitable options	+*	+***	+

Note: The difference measured is the difference for each combination of tenure arrangements difference = mean (tenure arrangement X)-mean (tenure arrangement Y), with H<sub>0</sub>: diff = 0 and H<sub>1</sub>: diff ≠ 0; + difference is positive, - difference is negative The bonferroni test is carried out by rejecting H<sub>1</sub> if p<sub>i</sub> < α<sub>i</sub>, where α<sub>i</sub> =  $\frac{\alpha}{n}$  and n is the number of comparisons. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

We observe significant differences in constraints between types of tenure arrangements that can be related to the empirical results of the investment specification in section 3.6.2. Farmers on sharecropped plots feel more constrained by missing expertise than farmers on owned and

fixed-rented plots, with the latter feeling less constrained than farmers who own land. With respect to monetary constraints, farmers on fixed-rent contracts feel more constrained than farmers on plots that are owner-cultivated. The constraint practical effort is least prevalent among farmers on fixed-rent contracts compared to farmers of the other two tenure arrangements and might be one possible explanation for the significant positive effect of fixed-rentership on investment in ditches that are labor-intensive in the investment specification. As expected, farmers on sharecropped and fixed-rented plots feel more tenure constrained compared to farmers on plots that are owner-cultivated. The same relation holds for unprofitable options. Generally, it stands out that farmers on sharecropping contracts feel most constrained in various aspects with no observable ranking for the other farmers, despite them investing more based on the descriptive comparisons and the investment specification.

Next, we also connect constraints placed upon investment from the farmer's point of view to social networks, in order to reveal possible interdependencies between the farmer feeling constrained and his social capital. In particular, we analyze if those farmers who are part of social networks and have contact to an extension officer as a source of information, employed in the investment specification and productivity analysis, feel less constrained than those that are not, by means of simple t-tests of comparing means presented in table 4-13.

Table 4-13: Comparison constraints on investment by social capital variables<sup>36</sup>

Principal component	trust	nnboa	Monasall <sup>a</sup>	tradass	advice	Invstall <sup>a</sup>	tlkothrs	relorg	fbo
Missing expertise	-.***	-	-.**	+	+	-.**	-.**	-	+
Monetary constraint	+	+	+	-.**	+	+	+	-	+
Practical effort	+	-	+	+	-	+	-	-.****	+
Tenure constraint	-.**	+	-	-.***	-	-	+	-	-
Unprofitable options	+	+	+	+	-	+	+	-.***	+

Note: The difference measured is difference = mean (no social capital) - mean (social capital), with  $H_0$ : diff = 0 and  $H_1$ : diff > 0 ; + difference is positive, - difference is negative; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1; <sup>a</sup> variables have been converted to binary variables, either getting monetary assistance or not, knowing people who have invested or not, for analysis

The comparison of constraints reveals partly positive and significant correlations between social capital variables and feeling less constrained concerning investment. This is consistent with the effect of social capital on investment behavior in the investment specification, where we observe a positive significant effect on most investment options.

<sup>36</sup> Results are at plot-level; however, for results at the household-level, we observe the same results.

In particular, trust in the community is positively linked to feeling less constrained by missing expertise and tenure constraints. The latter links to the fact, that tenure rights are formed within social groups and trust in the community in general fostering tenure security. Those who receive monetary assistance in case of need feel less constrained by missing expertise, probably due to compensating lack of expertise with monetary assets. Those, who receive trade assistance feel less constrained by missing expertise and tenure constraints. Knowing others who invested in soil conservation measures and talking to those who invested is not surprisingly linked to farmers feeling less constrained by missing expertise; social interaction accounts for knowledge transfer, i.e. social learning. Being part of a religious organization is positively associated with farmers feeling less constrained by practical effort and unprofitable options; farmers might get practical assistance through the religious community.

#### **4.6 Summary and conclusions**

The linkages between several types of social capital and investment decisions have been examined by means of descriptive statistics and making use of qualitative data.

Social networks are certainly associated with soil conservation measures. Investment in ditches and multiple cropping are positively linked with several types of social capital, such as trust in the community, knowing others who have invested in soil conservation measures and talking to them. These results underline the theoretical and empirical literature stating the positive effect of social capital on sustainability in agriculture. In addition, constraints placed upon investment from the farmer's point of view are related to both tenure arrangements and social networks. As expected, farmers on sharecropped and fixed-rented plots feel more tenure constrained compared to farmers on plots that are owner-cultivated. The same relation holds for unprofitable options. Generally, it stands out that farmers on sharecropping contracts feel most constrained in various aspects with no observable ranking for the other farmers, despite them investing more based on the descriptive comparisons and the investment specification. Constraints placed upon investment are also linked to social capital to some extent. This is consistent with the effect of social capital on investment behavior in the investment specification, where we observe a positive significant effect on most investment options

Taken together, the analysis reveals the importance of social networks for investment. Hence, efforts to increase tenure security, as indicated in the previous chapter, should be accompanied by efforts to enable farmers to partake in social networks.

## Annex

### A1 Methodology Principal Component Analysis

Dimensionality of the constraints on investment, ranked by the farmer by means of a 5-point Likert Scale, shall be reduced. Basically, two methods are available for this purpose, the factor analysis and the principal component analysis (Jolliffe, 2002: 160). Data, i.e. correlated variables, is reduced to a reasonable amount of components. Principal component analysis constructs linear components from the data, and the analysis aims at revealing the contribution of variables (constraints on investment) to that component, whereas factor analysis estimates underlying factors that are explanatory concepts (Field, 2005: 630-631; Hamilton, 2009: 346; Brown *et al.*, 2012: 176). Since our objective is more in line with the underlying reasoning of principal component analysis, we decided on this method.

Principal component analysis is a method with various steps, in order to reduce variables to components. A reliable principal component analysis shall be applied to sample sizes that are at least three times as large as the number of items (Backhaus *et al.*, 2006: 331)<sup>37</sup>. Preliminary analysis consists of mainly two tests. The first one is the Kaiser-Meyer-Olkin criterion (KMO), described as the “ratio of the squared correlation between variables to the squared partial correlation between variables” (Field, 2005: 640), ranging between 0 and 1, with a cut-off point of 0.5. A value close to 0 includes the sum of partial correlations to be large in relation to the sum of correlations that is an indicator for diffusion in the structure of correlations. In contrast, a value close to 1 suggests the structure of correlations to be compact and accordingly principal component analysis to be suitable. The KMO not only describes the sum of variables, it can also be interpreted for each variable. A related preliminary analysis is the anti-image-correlation matrix that constitutes a measure of adequate sampling for the variables respectively that can be assessed in the matrix on diagonal, that are the KMO statistics for individual variables. These along with the overall KMO criterion shall be above 0.5. The second one, Bartlett’s test of sphericity, identifies if the correlation matrix of the constraints is an identity matrix implying variables to be independent of each other. However, with a principal component analysis clusters of variables are built measuring related issues. When rejecting the null hypothesis that the variables are not correlated with each other, the data is appropriate for a principal component analysis. (Field, 2005: 640-642; 650).

After having assessed suitability of the data, components are extracted with the construction of eigenvalues as the first step. Eigenvalues linked to each component are the variation explained by the particular component. The most common criterion taken for components is the Kaiser’s one, with a value of 1 being the lowest value allowed to be extracted as a

---

<sup>37</sup> This requirement is fulfilled in our analysis.

component. The rationale behind it is that the sum of eigenvalues of all possible components equals the number of variables. An eigenvalue that is smaller than one does not assist in the main goal of principal component analysis, data reduction since it accounts for a smaller amount of variation than one variable. Another tool to be used for components is a graphical representation; each eigenvalue is plotted against the associated component, which is a screeplot. At the inflection of the emerging curve the cut-off point can be found (Field, 2005: 632-633; Brown *et al.*, 2012: 148).

Principal component analysis constructs a component matrix that displays the loadings of each variable onto each component. These loadings serve to determine how clusters of variables are most linked to one or another component. A common practice for a cut-off point for loadings is 0.4; however, several guidelines exist (Field, 2005: 637; Acock, 2008: 302). One variable can load on more than one component implying the structure to be factorially confounded. These crossloading variables which load very high on several components might link to poor quality of the variables or the component structure to be erroneous (Costello and Osborne, 2005; Acock, 2008: 302). Generally, loadings are correlations between the variable and the component, thus range between -1 and 1. However, in case one allows the components to be correlated, loadings become regression determinants that can be higher than 1 (Jöreskog, 1999).

In order to allow components to be correlated, rotation can be employed. Rotation leads to simplification and clarification of the data structure (Costello and Osborne, 2005). It aims at maximizing loadings of each constraint on one of the principal components and, at the same time, minimizing the loading on the other components, thus to ease the structure of the components. The mechanism is the change in absolute values of the constraints and, at the same time, not changing their differential values. Basically, two rotation options are available depending on the structure of the data, orthogonal and oblique rotation, where the first assumes the components to be independent of each other and the latter enables correlation between them. Mostly, it is reasonable to allow for correlation between components. Various options are available, being distinct in the way components are rotated (Field, 2005: 636, 644; Hamilton, 2009: 341)<sup>38</sup>.

Eigenvalues are a characteristic of the component and communalities are a characteristic of each variable. The amount of variance in each constraint that can be explained by the extracted components are the communalities after extraction. Several ways of estimating the communalities are available, one of them is the squared multiple correlations (SMC) which is the most common application to measure the amount of common variance and are lower

---

<sup>38</sup> An overview of various options can be found in Field (2005).

bounds of communalities. The SMC ranges between 0 and 1, a high value indicates a high common variance with other variables. However, principal component analysis firstly assumes a common variance of 1. After extraction of the components we gain insight into the real common variance. The retained components cannot explain all the variance, as some information is omitted, due to not making use of all components (Field, 2005: 630,653-654.; Brown *et al.*, 2012: 158; 195). Magnitudes of communalities in social science range between 0.4 and 0.7. Low values might link to another component to be explored (Costello and Osborne, 2005). The formula for SMC, the squared multiple correlation coefficients  $R_i^2$ , is given by (Brown *et al.*, 2012: 201-202):

$$SMC = R_i^2 = 1 - \frac{1}{r^{ii}} \quad (6-1)$$

where  $r^{ii}$  is the  $i$ th diagonal entry of the inverse correlation matrix  $R^{-1}$ .

Reliability is tested by means of Cronbach's alpha (Cronbach, 1951), the most widespread measure of scale reliability (Bland and Altman, 1997):

$$\alpha = \frac{k}{k-1} \left( 1 - \frac{\sum s_i^2}{s_T^2} \right) \quad (6-2)$$

where  $k$  is the number of constraints,  $s_i^2$  is the variance of the  $i$ th constraint and  $s_T^2$  is the variance of the total score calculated by summing all constraints. The idea behind the formula is to split data in two parts in every possible combination, and to compute the correlation coefficient for each with the average of these values being Cronbach's alpha. (Field, 2005: 667-668). Cronbach's alpha values range between 0 and 1, a value close to 1 suggests greater internal consistency of the constraints in the component (Gliem and Gliem, 2003). Several guidelines for  $\alpha$  exist, George and Mallery (2003: 231) provide threshold values for evaluating  $\alpha$  with a value of below 0.5 being unacceptable. Another important tool of this reliability test is to consider alpha in case one variable of the respective component is deleted. This value shall not differ considerably from the overall alpha for the component, and it shall also not be higher in that deleting this constraint would not increase alpha (Field, 2005: 676).

After having assessed reliability, the extracted components are named according to their constraints they load on. The components are scores that are linear composites by constructing constraints to a mean of zero and a unit variance and then using score coefficients as weights, and lastly summing up these standardized weighted constraints for each component. The scores for each component are standard variables like others in the data set and can be used for consecutive analysis (Hamilton, 2009: 344-346). Generally, these scores range between values of -3 and +3 (Bühl and Zöfel, 2005: 470).



Table 4-1: Kaiser-Meyer-Olkin Measure of Sampling Adequacy

Variable	KMO
Constr_2	0.54
Constr_3	0.82
Constr_4	0.59
Constr_5	0.58
Constr_6	0.81
Constr_7	0.86
Constr_8	0.76
Constr_9	0.69
Constr_10	0.71
Constr_11	0.84
Constr_12	0.81
Constr_13	0.79
Constr_14	0.77
Constr_15	0.80
Constr_16	0.77
Constr_17	0.80
Constr_18	0.82

Table 4-2: Component matrix unrotated\*

Variable	Comp. 1	Comp. 2	Comp. 3	Comp.4	Comp. 5
constr_2				0.64	
constr_3					
constr_4			0.55		
constr_5			0.42	0.43	
constr_6					
constr_7					
constr_8		0.41			
constr_9		0.43			
constr_10					0.65
constr_11					
constr_12					
constr_13					
constr_14					
constr_15			-0.42		
constr_16					
constr_17					
constr_18					

\*blanks are abs(loading)<0.4

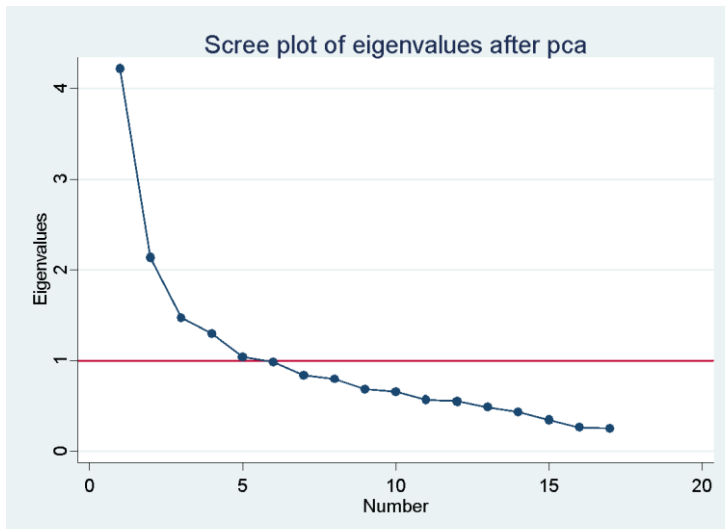


Figure Appendix 1: Screeplot

The screeplot plots the eigenvalues on the vertical axis against the components with which they are associated on the horizontal axis and reveals their importance. The red horizontal line at eigenvalue 1 indicates the cut-off point due to the Kaiser’s criterion. The screeplot supports the Kaiser’s criterion in that the flexion of the curve can be observed at component 5; therefore the screeplot is consistent with the Kaiser’s criterion.

Table 4-3: Correlation matrix of components

	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5
Comp. 1	1				
Comp. 2	-0.62	1			
Comp. 3	0.73	-0.63	1		
Comp. 4	-0.59	0.69	-0.61	1	
Comp. 5	-0.55	0.70	-0.44	0.53	1

Table 4-4: Squared Multiple Correlations

Variable SMC		Variable SMC	
constr_2	0.15	constr_11	0.39
constr_3	0.26	constr_12	0.35
constr_4	0.33	constr_13	0.28
constr_5	0.26	constr_14	0.14
constr_6	0.32	constr_15	0.22
constr_7	0.40	constr_16	0.55
constr_8	0.26	constr_17	0.61
constr_9	0.57	constr_18	0.62
constr_10	0.39		

## **5 Land tenure arrangements and productivity**

### **5.1 Introduction**

The main purpose of the productivity analysis is to determine the possible influence of land tenure arrangements on productivity at plot-level. Knowing the influence of tenure arrangements on productivity is decisive for policy. In the previous analysis of this work, the linkage between land tenure arrangements, social networks, and investment has been analyzed. Since investment is a means to an end, to increase productivity in the long-run, it makes sense to examine the direct effect of land tenure arrangements on productivity. Therefore, no intermediate effect of land tenure arrangements on investment and in turn on productivity is analyzed. This perspective along with empirical analysis will be covered in chapter 06. This chapter presents a literature overview of existing bibliography, the conceptual framework and empirical specification and results.

### **5.2. Literature review**

#### **5.2.1 Land tenure arrangements and productivity**

The linkage between land tenure arrangement and productivity remains a hotly debated topic and is part of broader literature about the influence of institutions on development (Chand and Yala, 2009). The assumed underlying mechanisms are the influence of tenure security on incentives of the farmer to invest and make efforts and might be linked with unobservable stocks of previous non-visible investments (Deininger *et al.*, 2008). Again, the three effects (the assurance, the realizability, and the collateral effects), between secure land tenure arrangements and investment decisions outlined in chapter 3 leading to higher investments, are assumed to lead to higher productivity in turn (Bellemaire, 2013).

A number of studies have investigated the influence of land tenure arrangements on productivity that has been estimated by employing a Cobb-Douglas production function (e.g. Place and Hazell, 1993) or a linear function (e.g. Abdulai *et al.*, 2011).

Empirical findings concerning the relationship between land tenure arrangements and productivity differ (Place, 2009). This might be due to the fact that land tenure arrangements that are not secure can still be efficient (Fenske, 2010a). One of the early studies by Place and Hazell (1993) determines the effect of land tenure arrangements on productivity in Ghana, Kenya, and Rwanda. Input use, land improvement, and yields are regressed amongst other variables on tenure security. Yields are assessed by value of crop output per hectare. No

significant relationship has been found between land tenure arrangements and yields. In addition, no significant relationship between land tenure arrangements and inputs could be determined, confirming the previous result. Place and Otsuka (2002), in analyzing the effect of land tenure arrangements on investment and productivity in Uganda, explain the insignificance of tenure in the value of production and profit regressions, concluding that the effort of managing the land is equal across diverse land tenure arrangements. Otsuka *et al.* (2003) analyze the effect of tenure arrangements on tree planting, leaving land fallow, net revenue and labor use in a cocoa growing area in Ghana. With regard to the effect of land tenure arrangements on net revenue, tenure security appears to have no significant positive effect. The levels regression and fixed-effect models reveal that all tenure dummies are not significantly related to productivity. They explain the insignificance by management intensity which is equal across different tenure arrangements after cocoa trees have been planted. Studies from Holden *et al.* (2001) on Ethiopia and Fenske (2010b) on Cote d'Ivoire have also found no effect of tenure security on productivity.

In his analysis on tenure arrangements and productivity in Madagascar, Bellemare (2013) distinguishes between formal titles and informal land tenure, measured by perceived rights of the farmer on what they are allowed to do with the plot. Instrumental variable estimations reveal no significant positive effect of land titles on productivity when accounting for possible endogeneity of titles and fixed effects estimations in case of unobserved heterogeneity between households. Informal land tenure rights appear to show diverse effects depending on the estimation specification and the type of perceived rights. The right to plant trees is certainly associated with productivity. However, the right to build a tomb has a negative effect. The latter is associated with plots belonging to a clan without any chance of becoming private ownership (Bellemare, 2013).

Some of the more recent studies appear to show a positive relationship between security of tenure and productivity. Deininger and Jin (2006) confirm a positive effect of terracing on net revenues that, in turn, is determined by security and transferability of tenure rights by means of an instrumental variable approach. Thus, no direct effect is estimated. Chand and Yala (2009) analyze the influence of private, common and indigenous land tenure on fresh fruit bunches per ha of palm oil in Papua New Guinea. Land purchased under the settlement scheme appears to be positively related to productivity compared to village-owned plantations. Abdulai *et al.* (2011) examine the impact of four diverse tenure arrangements<sup>39</sup> on productivity. Productivity is measured at plot-level by the value of crop output per acre. The study reveals

---

<sup>39</sup> owner-operated with full property rights, owner-operated with restricted property rights, fixed-rent and sharecropping contracts

that ownership exerts a positive and significant effect on productivity. This effect can also be observed when household fixed effects are employed. Goldstein and Udry (2008) analyze the relationship between fallowing and productivity in Ghana. Results reveal that a fallow period is positively associated with profits, while fallow duration is determined by tenure security. Consequently, output is lost because tenure is insecure, and these plots are left fallow for shorter periods. Another study on Pakistan by Ali *et al.* (2012) also finds a significant positive relationship between ownership, fixed-rentership and output per hectare, compared to sharecropping which supports the Marshallian inefficiency hypothesis.

Relatively little attention has been paid to the effect of social capital on productivity. Social capital is more analyzed in light of long-term sustainable solutions (Bouma *et al.*, 2008). However, a few empirical studies indicate a positive relationship between social networks and productivity. Foster and Rosenzweig (1995), when analyzing adoption and profitability of HYV and employing panel data on India, reveal that, apart from own experience, learning from others (learning spillovers) exerts a positive effect on profitability and diminishes over time. Fafchamps and Minten (1999) analyze social networks of traders in Madagascar and point to various roles they might have among others when sharing information, access to credit and risk. They conclude that the success of traders is determined by their networks. A follow-up study (2002) investigates the effect of social capital on firm performance by productivity analysis. The study reveals that social capital has a positive effect on firm performance and provides preliminary evidence that part of the effect is due to a reduction in transaction costs. The study by Krishnan and Sciubba (2009) on Ethiopia also reveals that social networks influence farm performance in a positive manner.

### 5.3 Conceptual framework and empirical specification

Productivity analysis determines plot-level productivity. Productivity is the chosen measure since various multiple crops are planted on one plot. Hence, a linear regression, OLS, can be employed to determine productivity. Production is estimated by means of a linear function (see Abdulai *et al.*, 2011) and can be specified as:

$$Y_{jl} = \beta_0 + \beta_1 R_{jl} + \beta_2 SC_l + \beta_3 Z_{jl} + \beta_4 P_{jl} + \varepsilon_{jl} \quad (5-1)$$

where  $Y_{jl}$  is the value of output per acre on plot  $j$  of farmer  $l$ ,  $\beta_0$  is the intercept,  $R_{jl}$  are tenure arrangements,  $SC_l$  is social capital,  $Z_{jl}$  are household characteristics,  $P_{jl}$  is a vector of variables at plot-level other than tenure arrangements, and  $\varepsilon_{jl}$  is the error term. Since yields may vary systematically between villages, village dummies are included to account for climatic and other local conditions.

'Access to credit', a household characteristic, might be subject to endogeneity in analyzing the effect of credit on productivity, because land and crops might serve as collateral for obtaining credit (see Abdulai *et al.*, 2011). Since productivity is determined by OLS, the Two-Stage Least Squares method (2SLS) is used in order to control for endogeneity (see Wooldridge, 2010: 96-97). The first-stage estimation is a probit model that determines credit by means of an instrument and the other variables that determine productivity:

$$C_l = \alpha_0 + \alpha_1 R_{jl} + \alpha_2 SC_l + \alpha_3 Z_{jl} + \alpha_4 P_{jl} + \alpha_5 I_l + \delta_{jl} \quad (5-2)$$

where  $C_l$  is access to credit of the farmer,  $I_l$  is the instrument applied that is strongly correlated with credit and uncorrelated with the error term of the production function,  $Z_{jl}$  is defined as above with credit being excluded from  $Z_{jl}$  and  $\delta_{jl}$  is the error term.

In the production function, the original credit variable is substituted by the predicted value  $\hat{C}_l$ :

$$Y_{jl} = \beta_0 + \beta_1 R_{jl} + \beta_2 SC_l + \beta_3 Z_{jl} + \beta_4 P_{jl} + \beta_5 \hat{C}_l + \varepsilon_{jl} \quad (5-3)$$

According to Wooldridge (2010: 97), it is better to apply 2SLS jointly rather than apply the two-step procedure by hand, as otherwise, the standard errors will be incorrect, and we follow the advice.

Validity of the instrument is tested by the Wu-Hausman test. A Wald statistic is employed, the residual from the production function without accounting for endogeneity is regressed on the instrument used (see Fafchamps and Minten, 2002). In case the null hypothesis cannot be rejected, the instrument is exogenous and valid. Thus, the instrument is rightly excluded from the production function and not correlated with the error term with  $TR^2$  as the test statistic,  $T$  being the number of observations and  $R^2$  being the uncentered  $R^2$  from the regression, with degrees of freedom equal to the number of instruments and a  $\chi^2$  distribution (see Davidson and McKinnon, 2004: 337-338; Greene, 2008: 387).

To analyze unobserved household effects that might influence productivity, household fixed effects are employed. This procedure allows for removing all influences arising from differences among households (Markussen, 2008). Any variables that do not vary across plots of one household drop out of the regression. This is due to the random correlation of the latent variable with the independent variables, and that it cannot be differentiated between observables and unobservables that do not vary across plots (Wooldridge, 2010: 285 et seq.) Household fixed effects estimation leads to the following specification:

$$Y_{jl} = \beta_0 + \beta_1 R_{jl} + \beta_2 P_{jl} + \vartheta_{jl} \quad (5-4)$$

where  $\gamma_1$  represents all household-specific characteristics not considered,  $P_{ji}$  is a vector of variables at plot-level other than tenure arrangements and  $\vartheta_{ji}$  is the error term.

## 5.4 Hypothesis

In regard to productivity, we hypothesize secure land tenure arrangements to exert a positive influence on farm performance. We also assume a positive effect of social capital on farm performance.

## 5.5 Results and discussion

### Variables included in the model

Table 5-1 presents the descriptive statistics of the variables at plot-level. The number of observations used reduces to 438 due to missing observations. Productivity is assessed by an aggregate measure of output that includes revenues from crops and trees. Amount harvested per each crop/tree type on the plot is multiplied by the price the farmer obtained (see Place and Hazell, 1993; Abdulai *et al.*, 2011). In so doing, one neglects that a share of the output is used for own consumption.

The four respective tenure arrangements are employed in order to see the likely effect of tenure on plot-level productivity. We assume secure tenure rights to enhance farm performance.

We take into consideration differences in productivity due to crop composition by making use of dummy variables which indicate the most prevalent crop based on area devoted to the respective crop in both major and minor rainy season (see Jacoby and Mansuri, 2009). For prevalence of trees on plot is controlled for. We assume a negative effect on outcome, as more trees imply less focus on crops reducing the output per acre (see Hayes *et al.*, 1997). In addition, trees having been planted recently do not provide any return.

Other plot characteristics included are the size of the plot and if the soil of the plot is loamy. Loamy soil contains the best soil characteristics compared to sandy and clay soils since this one combines advantages of both (Royal Horticultural Society, 2011).

Information on individual and household characteristics is included. Having access to credit underlines the possible importance and already proven significance of access to credit in enhancing productivity. As indicated previously, access to credit might be endogenous (see Abdulai *et al.*, 2011). The instrument applied is the number of implements the farmer owns and serve as a proxy for determining access to credit. The number of household members between 15 and 64 years old per acre represents family labor force (see Smith, 2004) along with the number of days hired labor is used throughout the year per acre. For the age of the farmer is controlled for. On the one hand, it might account for experience of older farmers, while on the



other hand it accounts for entrepreneurial skills of younger farmers. The value of livestock represents wealth of the household. The variable representing social capital is also added to determine productivity, given the partly positive and significant results in the investment specification, and having contact with an extension officer, which represents access to information as well. Additionally, having a mobile phone is included in the specification. It is assumed that a mobile phone is a means of providing information and coordination and enhances productivity (Jensen, 2007; Aker, 2011). The district dummy represents climatic and other local conditions.

The natural logarithm of the variables size of plot, household size per acre, hired labor days per acre, value of livestock and the output per acre are applied in order to see the percentage changes in output, due to percentage changes in the respective variables and to provide a clearer interpretation.

Table 5-1: Descriptive statistics of variables used in the empirical analysis

Variable	Variable definition	Mean	S.D.
Yield	Value of output per acre on plot (GHS*0.1)	59.38	117.06
Owner	1 if plot is under owner-operated with full rights, 0 otherwise	0.34	0.47
Sharecrop	1 if plot is under sharecropping contract, 0 otherwise	0.22	0.41
Rent	1 if plot is under fixed-rent contract, 0 otherwise	0.30	0.46
Other	1 if plot is under owner-operated with no rights, 0 otherwise	0.14	0.35
Maize	1 if farmer mainly cultivates maize on plot, 0 otherwise	0.61	0.49
Yams	1 if farmer mainly cultivates yams on plot, 0 otherwise	0.26	0.44
Cass	1 if farmer mainly cultivates cassava on plot, 0 otherwise	0.05	0.21
Othrs	1 if farmer mainly cultivates other crops on plot, 0 otherwise	0.09	0.29
Trees	1 if trees have been planted on plot, 0 otherwise	0.33	0.47
Pltsize	Plot size in acres	4.58	0.81
Loam	1 if soil on plot is loamy, 0 otherwise	0.34	0.47
Credit	1 if farmer has access to credit, 0 otherwise	0.05	0.22
HH-size per acre	Number of permanent household members between 15 and 64 years per acre	1.37	1.30
Hlabour	Hired labour days per acre	32.24	65.07
Age	Age of farmer (years)	47.79	13.11
Lvstckvlue	Value of livestock wealth (GHS*0.01)	9.00	17.25
Fbo	1 if farmer is member of an fbo, 0 otherwise	0.28	0.45
Extens	1 if farmer received assistance by extension officer, 0 otherwise	0.37	0.48
Advice	1 if farmer gets advice about farming business, 0 otherwise	0.81	0.39
Mobile	1 if farmer has a mobile phone, 0 otherwise	0.63	0.48
District	District of household, 1=Kintampo, 0=Techiman	0.59	0.49
<i>Instrument</i>			
Implts	Number of implements the farmer owns	15.21	13.50
Observations		438	

Ghanaian Cedis (GHS). Exchange rate: €1 = ₵3.6 in 2014

Source: Survey data

### Empirical Results

In table 5-3 the results of the 2SLS plot-level productivity analysis and the household fixed effects model are presented. In the pooled cross-section model, the adjusted  $R^2$  is nearly 0.2 and indicates how much variance in the outcome is explained by the explanatory variables, in

case the model has been obtained from the population from which the sample has been drawn (Field, 2005: 723)<sup>40</sup>. The model is estimated to be robust to arbitrary heteroscedasticity.

The instrument for the possible endogenous variable access to credit is tested on its exogeneity and validity by means of a Wu-Hausman test. The  $\chi^2$  statistic fails to reject the hypothesis that the variable 'number of implements the farmer owns' is exogenous and valid. The first stage estimation is presented in table 5.2.

---

<sup>40</sup> We test multicollinearity of the explanatory variables and normal distribution (see Annex this chapter), test statistics reveal no problem of highly correlated variables and nearly normal distribution.

Table 5-2: Results First stage estimation credit

Variables	credit
Implts	0.003*** (0.001)
HH size per acre (log)	-0.010 (0.021)
Owner	0.013 (0.038)
Sharecrop	0.017 (0.041)
Rent	0.027 (0.041)
MAIZE	0.001 (0.037)
YAMS	-0.029 (0.039)
CASS	-0.0540 (0.054)
Trees	-0.029 (0.024)
Pltsize (log)	-0.014 (0.025)
Loam	0.032 (0.022)
Age	-0.001 (0.001)
Lvstckvlue (log)	-0.009 (0.008)
Fbo	-0.006 (0.025)
Extens	0.037 (0.023)
Advice	-0.039 (0.027)
Mobile	0.001 (0.023)
Kintampo	-0.040 (0.043)
Kunso	-0.086* (0.048)
Badukrom	-0.036 (0.045)
Awaropat	-0.015 (0.044)
Fiaso	0.005 (0.053)
Constant	0.085 (0.077)
Observations	449
Adjusted R <sup>2</sup>	0.096

Note: \*predicted value; standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1;  
soil fertility dropped due to high collinearity with villages variables

Table 5-3: Results 2SLS productivity analysis and household fixed effects.

Variables	Pooled cross-section	Household fixed effects
Owner	-0.049 (0.202)	-0.653 (0.579)
Sharecrop	0.183 (0.218)	-0.227 (0.457)
Rent	0.136 (0.219)	-0.004 (0.448)
Maize	0.121 (0.225)	0.107 (0.299)
Yams	0.498** (0.247)	0.595** (0.298)
Cass	-0.187 (0.322)	-0.342 (0.449)
Trees	0.118 (0.119)	-0.258 (0.219)
Pltsize (log)	-0.391*** (0.121)	-0.459** (0.178)
Loam	0.006 (0.106)	0.065 (0.181)
Credit*	0.671 (1.427)	
HH-size per acre (log)	0.090 (0.093)	
Age	-0.002 (0.004)	
Lvstckvlue (log)	0.099** (0.046)	
Fbo	-0.130 (0.110)	
Extens	0.021 (0.116)	
Advice	0.026 (0.150)	
Mobile	0.187* (0.106)	
Kintampo	-0.370* (0.218)	
Kunso	-0.594** (0.277)	
Badukrom	-0.775*** (0.219)	
Awaropat	-0.398 (0.252)	
Fiaso	-0.143 (0.268)	

Constant	3.871*** (0.476)	4.144*** (0.456)
$\chi^2$ statistic on exogeneity of instrument [p-value]	0.008 [0.929]	
Observations	423	459
Adjusted R <sup>2</sup>	0.196	

Note: \*predicted value; standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Starting with our main variables of interest, we do not find any noticeable effect of tenure arrangements on productivity. Security of tenure does not seem to influence the incentive of the farmer to make efforts (Place and Otsuka, 2002). In addition, it lends support to the notion exposed by Fenske (2010a) that unsecured tenure is not necessarily inefficient. This finding corresponds with several other empirical studies on different African countries, who have not found a significant positive relationship between security of tenure and productivity (Place and Hazell, 1993; Holden *et al.*, 2001; Place and Otsuka 2002; Pender and Fafchamps, 2006; Fenske, 2010b). However, the result is contrary to findings by Deininger and Jin (2006), Goldstein and Udry (2008) and Abdulai *et al.* (2011), the latter two are studies on Ghana. However, Deininger and Jin (2006) take predicted values of investment instrumented by tenure and thus only allow for a positive effect on productivity through investment. Goldstein and Udry (2008) consider the effect of tenure on fallowing and, in turn, of fallowing on productivity. The effect of investment on productivity will be analyzed in the next chapter.

Crop composition determines productivity and it corresponds with results reported by, for instance, Place and Otsuka (2002) and Abdulai *et al.* (2011). Plots planted with yams as the main crop indicate a significant and positive effect on productivity. Planting trees is neither negatively nor significantly associated with productivity on the plot within the pooled cross-section analysis. Hence, the assumed effect of trees providing less output per acre has not been proven.

Size of plot appears to be negative and significant and that is hardly surprising, given various empirical studies that have found the same effect (e.g. Gavian and Fafchamps, 1996; Place and Otsuka, 2002; Barrett *et al.*, 2010). An increase in plot size by one percent decreases output per acre by 24%. Smaller sizes of plots require more investment in intensification in order to facilitate a living from agriculture (Holden *et al.*, 2009) also leading to higher output on a smaller plot. The effect of loamy soil is positive albeit insignificant, suggesting that the advantage of good soil on the plot is not decisive for productivity.

Individual and household characteristics matter partly. Having access to credit exerts a favorable —yet insignificant— effect on productivity, in opposition to findings by Abdulai *et al.* (2011). The missing significance might be due to the low share of farmers that have access to

credit. Necessary changes indicated by farmers in section 3.6.1 delineate the relevance of access to credit. The number of adults within the household per acre is positive and marginally significant. Hired labor though seems to be more important, since the family can be substituted by hired labor, and is consistent with results reported by Place and Otsuka (2002) for Uganda. Value of livestock is positive and significantly different from zero. An increase in value of livestock by one percent increases output by nearly 10%. Livestock might be linked to wealth and more possibilities to increase farm output. The result is supported by findings from Smith (2004) on Zambia.

Being a member of an fbo and contact to an extension officer, positively associated with investment decisions, is no significant determinant of productivity on the plot. This result is to be compared to Deininger and Jin (2006), who similarly find that extension visits facilitate farmers' investment but not productivity.

The variable of having a mobile phone shows a highly significant positive sign. It underscores the statement by Powlson *et al.* (2011) that mobile phones can be beneficial in making progress in terms of development, enabling farmers to get information through mobile phones. The empirical findings by Jensen (2007) on Indian fishermen are also in line with our results.

Plots located in Kintampo, appear to be negative and significantly different from zero, suggesting differences in climatic conditions which influence productivity.

#### *Household fixed effects*

In the household fixed effects estimation, only minor changes emerge with respect to the explanatory variables at plot-level. Even when removing the effect of unobservables at the household-level, tenure does not become a significant determinant of productivity. Trees exert a negative, albeit insignificant, effect on productivity, suggesting less output per acre. The effect of other variables is similar to the estimation results without household fixed effects.

## **5.6 Summary and conclusions**

Investment is only a means to an end in order to raise productivity, that is why we analyze the influence of tenure arrangements on productivity. Plot-level productivity is determined by the use of an instrumental variable approach.

We uncover no evidence that both tenure arrangements and social capital are significant determinants of productivity. Having a mobile phone increases productivity, which shows the relevance of communication in raising productivity. Hence, improvements and investments in communication technology in rural areas could foster success of the agricultural sector.

Individual and household characteristics only matter to a minor extent for productivity. Credit is not a significant determinant of productivity, maybe because of the low share of farmers having access to credit. A household fixed effects model has also been employed in order to control for unobservables at the household-level influencing productivity. However, tenure arrangements, again, do not significantly influence productivity. Management intensity seems to be equalized across diverse types of tenure.

The results do not reveal the irrelevance of land reforms suggested in Chapter 3, but reveal possible other more binding constraints influencing productivity. In addition, the chain of interdependencies by means of analyzing the effect of investment that is done in the following chapter needs to be analyzed, not only the direct effect of tenure.



**Annex**

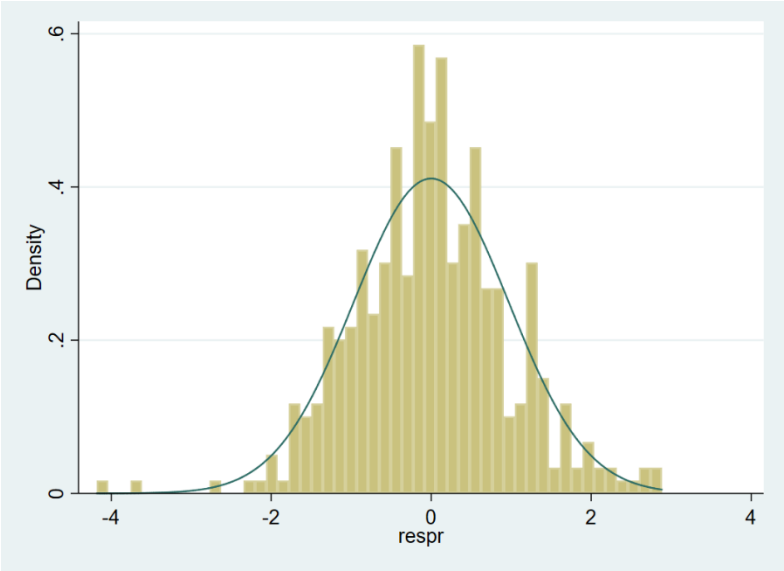


Figure Appendix 2: Distribution residuals from productivity analysis

The graph A2 reveals that the residuals are nearly normally distributed, and the assumption of normal distribution is given.

Table 5-1: Variance inflation factors productivity analysis

Variable	VIF <sup>a</sup>
Credit	3.05
HH-size per acre	2.46
Owner	3.07
Sharecrop	2.43
Rent	3.34
Maize	3.47
Yams	3.32
Cass	1.68
Trees	1.48
Pltsize	2.64
Loam	1.40
Age	1.15
Lvstckvlue	1.17
Hired labour days per acre	1.30
Fbo	1.26
Extens	1.53
Mobile	1.20
District	1.74
Mean VIF	2.09

<sup>a</sup>The VIF is defined as:  $VIF_j = \frac{1}{1-R_j^2}$  where  $R_j^2$  is the  $R^2$  belonging to the regression of the  $j$ th explanatory variable on the remaining explanatory variables

All individual VIF values and the mean VIF are far below 10, a value where one has to worry about multicollinearity.

## 6 Impact of investment in soil conservation on productivity

### 6.1. Introduction

In the previous chapter, the focus of the empirical analysis was on the direct effect of land tenure arrangements on productivity without considering the intermediate effect of investment decisions. This chapter accounts for the effect of productivity-enhancing and soil conservation measures on productivity, in order to acknowledge that investment decisions made by farmers under the influence tenure arrangements since, according to what has been analyzed in Chapter 3, investment decisions are likely to exert an influence on productivity. First, we present an extant empirical literature analyzing the effect of investment decisions on productivity, followed by the conceptual framework and the empirical specification. The descriptive and empirical results are discussed.

### 6.2 Literature review

Sustainability in agriculture implies increasing productivity in the long-run. For decision makers, it is crucial to know the effect of investment on productivity in order to foster the most beneficial investment options. Kato *et al.* (2011) investigate the influence of several soil and water conservation measures on crop yields in Ethiopia. Several measures appear to be greatly related to the mean value of yields, while considering their endogeneity by means of GMM and 2SLS estimations. In particular, measures like waterways and trees are positively and significantly related to crop yields in both low and high rainfall areas. Di Falco *et al.* (2009), in their analysis on Ethiopia, also reveal a positive and significant effect of climate change adaptation measures, such as soil and water conservation measures, on yields and net revenue while controlling for possible endogeneity of these measures by IV estimation. However, one should not neglect the crucial effect of mineral fertilizer. Weligamage *et al.* (2014) analyze the influence of different allocation policies for distributing water on rice production in Sri Lanka. They find water in combination with application of mineral fertilizer to enhance productivity, especially in dry regions.

Few empirical studies have attempted to investigate the impact of investments analyzed in relation to tenure arrangements on productivity. As indicated previously, Deininger and Jin (2006), in their analysis on Ethiopia, applied predicted values of investments, with security and transferability of tenure rights as instruments, confirming a positive effect of both tenure and investment on productivity. Chand and Yala (2009) determine, apart from land tenure effects, the influence of fertilizer use on productivity in Papua New Guinea and reveal a positive significant effect. Fenske (2010b) in Cote d' Ivoire uses to determine productivity, apart from tenure variables, the variable investment following. A positive and significant relationship

between following and yields has been found. However, such analyses have one major shortcoming, since they ignore the fact that investment is not randomly assigned. Those investing and those not investing might be systematically different (Faltermeier and Abdulai, 2009). When estimating the impact of investment on productivity, the question needs to be answered as to what degree of productivity would have been reached without investment (Kassie *et al.*, 2010). In order to estimate the 'direct productivity effects' of investment, the effect needs to be isolated from other determinants of productivity. This refers to self-selection, since farmers self-select to invest, and this decision may be linked to the benefit derived from investment (Mendola, 2007).

To overcome self-selection, the non-parametric method propensity score matching (PSM) can be applied (Mendola, 2007). The underlying basic idea of PSM with regard to investment is to compare observations with and without investment, according to the predicted propensity to invest. Comparisons are made between observations that have similar characteristics and that are relevant for the decision to invest (Kassie *et al.*, 2008). Mendola (2007) examines the potential of new farming technologies on productive capacity of farmers in Bangladesh. The PSM results reveal that adoption of HYVs of rice positively and significantly influences farm income. Amare *et al.* (2012) also analyze the influence of improved farm technologies on household welfare such as income in Tanzania. Improved maize and pigeon pea varieties appear to be positively and significantly associated with income as well.

Some empirical studies have employed PSM, in order to analyze the impact of conservation measures on productivity. For instance, Faltermeier and Abdulai (2009) examine the impact of water conservation and intensification technologies, such as the use of bunds and dibbling seeds on various outcomes like output and net returns in Ghana. They found positive impacts of the respective technologies on their outcome variables, but with varying degrees of importance. Kassie *et al.* (2010) determine the impact of minimum tillage and commercial fertilizer on net returns at plot-level in Ethiopia, with fertilizer having a positive and significant effect in a high-potential area and minimum tillage in a low-potential area. Kassie *et al.* (2008) also apply PSM for analyzing the impact of soil conservation, i.e. stone bunds, on the value of yields in Ethiopia. In order to assess unobservables that might confound the results, since PSM only controls for observables, the Mundlak's approach is followed. Means of plot-varying covariates are included, being possible due to the panel nature of the data. The findings reveal, both with and without Mundlak's approach, a positive and significant impact of soil conservation on productivity in a low-rainfall area, with unfavorable effects in a high rainfall area, suggesting the effects to be specific to agro-ecological conditions.

PSM is a popular method to aim for creating a data set that might have resulted from a randomized experiment, by creating a comparison group like the treatment group based on

observable characteristics. PSM will be explained in the following chapter in detail, but the main assumption is the so-called unconfoundedness and implies that all covariates, which influence both treatment and outcome, are observed by the researcher. If the conditional independence assumption (CIA), holds, matching simulates an experiment and investment is random and uncorrelated with the outcome we want to measure. Thus, the CIA overcomes the issue of unobserved counterfactual observations, since it is assumed that the potential outcome of those who invest can be derived from the average actual outcome of those who do invest. Selection bias due to observables is removed, given the CIA holds, by matching on observables, i.e. conditioning on the propensity score (Imbens, 2004; Mendola, 2007; Caliendo and Kopeinig, 2008).

In case unconfoundedness does not hold, the problem of unobservables arises, i.e. factors that influence selection into treatment and outcome simultaneously that cannot be observed by the researcher such as ability or management capabilities. One possible solution is the Heckman selection method, accounting for possible unobservables, as it controls for possible sample selection bias by calculating the inverse Mills ratio  $\lambda$  from a first-stage estimation, in this case, investment in soil conservation measures. The second-stage estimation includes  $\lambda$  as an additional variable, and it analyzes possible unobservables (Moffitt, 2004; Greene, 2008: 866). An extension to the Heckman selection method is the endogenous selection regression, where outcomes can be observed for the whole sample of those with and without treatment (Abdulai and Huffman, 2014). A further extension to this approach is multinomial endogenous switching regression. Similar to the endogenous switching regression, it allows both consistent and efficient estimates for the treatment variable and accounts for possible selection bias influencing the outcome variable. The added benefit of multinomial endogenous switching regression is applicability when different treatments are not independent from each other. In the case of investments, this framework would analyze both individual and combined investments while capturing the interactions between investments (Kassie *et al.*, 2014). Overall the main benefit of endogenous switching regression is to account for both, observable and unobservable factors superior to PSM only accounting for observable factors. As indicated above, PSM does hold in case one can assume there are no unobservable factors influencing treatment, in our case investment, and all observable factors are captured with the propensity score. In addition, those observations with no match, are discarded from the comparison.

Another benefit of endogenous switching is that the first-stage estimations can be used to determine influencing factors on the treatment, i.e. investment; while estimates in the PSM are rather used to balance the covariates. Yet, in our case this is not the focus, since we already determined investment by means of a multivariate probit model and accounted for endogeneity of several concepts in chapter 03.

An alternative procedure to control for selection bias is the instrumental variable (IV) method, also used in this study. However, the IV method is in need of a variable to be used as an instrument for investment in specifying the outcome equation. The finding of instruments is a demanding task; an instrument needs to be relevant and exogenous, the problem of weak instruments arises. By the same token, OLS and IV approaches impose a linear functional form assumption, with this assumption being inherent that the effect of control variables is the same for those investing and those that do not. However, this is unlikely to be the case (Jalan and Ravallion, 2003; Mendola, 2007). In addition, Heckman selection and IV models both assume that the function of agricultural output would differ only by unobservable factors between those investing and those that do not.

Propensity score matching is applied and, compared to the other parametric methods; it does not rely on any functional form assumption in determining the outcome (Owusu *et al.*, 2011).

### 6.3 Conceptual framework and empirical specification

#### Propensity score matching

The non-parametric propensity score matching (PSM) method presented, suggested by Rosenbaum and Rubin (1983, 1985), is composed of the evaluation framework and implementation of propensity score. The latter is concerned with matching algorithms applied, assessing the matching quality and sensitivity analysis.

#### Evaluation framework

The aim is to estimate the effect of investment on plot-level productivity. From the first order conditions (3-8)-(3-12) in section 3.3, we have already explained in section 3.4 that the farmer invests in soil conservation measures if it leads to an increase in the expected farm net benefit aggregated over the planning horizon. As indicated earlier, expected farm net benefit is a latent variable that cannot be observed, merely the choice of investment. According to the maximization problem outlined in equation (3-6), the farmer invests in soil-improving and conservation measures, if expected farm net benefit is higher with investment  $J_{jlm}^{*I}$  than without investment  $J_{jlm}^{*N}$  ( $J_{jlm}^{*I} > J_{jlm}^{*N}$ ). Given farmers are risk-neutral, we assume that the farmer compares the expected farm net benefit with investment to the expected farm net benefit without investment. In case the expected farm net benefit is higher with investment, a positive investment decision is observed. Expected farm net benefit can be linked to a vector of explanatory variables ( $Z$ ) and be presented by  $D_{jlm}$ , the decision of the farmer  $l$  to invest or not in measure  $m$  (ditches, fertilizer, manure and multiple cropping) on plot  $j$  for which the following relation holds:

$$J_{jlm}^* = \gamma' Z_{jlm} + \varepsilon_{jlm} \quad (6-1)$$

with  $D_{jlm} = 1$  if  $J_{jlm}^* > 0$   
 $D_{jlm} = 0$  if  $J_{jlm}^* \leq 0$

where  $\gamma$  is the vector of parameters to be estimated and  $\varepsilon_{jlm}$  the error term with  $\varepsilon_{jlm} \sim N(0, \sigma)$ . The probability to invest on plot  $j$  can be represented as:

$$\Pr(D_{jlm} = 1) = \Pr(J_{jlm}^* > J_{jlm}^{*N}) = \Pr(\varepsilon_{jlm} < -\gamma'Z_{jlm}) = 1-F(-\gamma'Z_{jlm}) \quad (6-2)$$

where  $F$  is the cumulative distribution function for  $\varepsilon_{jlm}$ .

The relationship between investment and outcome, revenue per acre, can be analyzed by considering the following linear function (Owusu *et al.*, 2011):

$$Y_{jlm} = \alpha_{jlm} + \beta'X_{jlm} + \delta'D_{jlm} + \mu_{jlm} \quad (6-3)$$

where  $Y_{jlm}$  is the value of output per acre on plot,  $\alpha_{jlm}$  is a vector of unknown parameters,  $X_{jlm}$  is a vector of all other explanatory variables such as farm and household characteristics and  $\mu_{jlm}$  is the error term with  $\mu_{jlm} \sim N(0, \sigma)$ .

Equation (6-3) treats investment as an exogenous variable based on the premise that the farmer invests in soil conservation measures to increase productivity. However, it is not straightforward to estimate the effect of investment on revenue assuming investment is exogenous. The issue at stake is missing data. The question arises if revenue is higher due to investment alone or if farmers with higher revenue on plot are more likely to invest, as they have the means to do so (Mendola, 2007). Therefore, investment is not random and the group of those investing is likely to be systematically different (Faltermeier and Abdulai, 2009). Selection bias occurs in case unobservable factors do influence both, the error term of the investment specification ( $\varepsilon_{jlm}$ ) and the error term of the outcome specification ( $\mu_{jlm}$ ) resulting in a correlation between the two error terms defined by  $\text{corr}(\varepsilon_{jlm}, \mu_{jlm}) = \theta$ . In case  $\theta \neq 0$  OLS regression techniques produce biased results. We do not have data on the same farmer not having invested or otherwise an experimental setting with a control group not having invested. Hence, possible selection bias needs to be addressed differently.

The standard approach in impact evaluation is the counterfactual framework that goes back to Roy (1951) and Rubin (1974), and it is based on the idea that for each individual there exists an observed outcome in case of treatment  $Y_1$  and a counterfactual unobserved outcome  $Y_0$ . Thus, there exists an evaluation problem, since only one outcome can be observed for each individual. Individual treatment effects cannot be estimated and the analysis has to be subject to average treatment effects (Caliendo and Kopeinig, 2008).

In case of treatment taking multiple values, multivalued treatment effects are used. A binary treatment effect model has the treatment options 0 and 1; a finite multivalued treatment effect model for example has treatment values along a positive integer. Comparing to a binary treatment effect, a multi-values treatment effect implies, that a control group is not always clearly defined, new parameters of interest might be present linked to distinct phenomena like tipping points, and correct statistical inferences requires the joint estimation of all treatment effects (Cattaneo, 2010; 855-857). Since our main point of interest is the investment decision of farmers whether or not to invest in soil conservation measures, we do apply a binary treatment effect model that is using the average treatment effect.

Generally, the interest is on the average treatment effect (ATE) that can be formulated the following (see Rosenbaum and Rubin, 1983):

$$\tau_{ATE} = E(D = 1) - E(D = 0) \quad (6-4)$$

where  $Y_1$  is the outcome under investment ( $D = 1$ ) and  $Y_0$  the outcome under no investment ( $D = 0$ ). The ATE is the expected effect of investment (treatment) on an individual randomly drawn from the population (Wooldridge, 2010: 905).

However, the ATE also includes those not intended to be subject to treatment. Since there is heterogeneity in the impact across individuals, the most common parameter is the average treatment effect of the treated (ATT) defined the following (Caliendo and Kopeinig, 2008):

$$\tau_{ATT} = E(Y_1 - Y_0 | D = 1) \quad (6-5)$$

being the mean effect of those having invested (Wooldridge, 2010: 906). However, the counterfactual mean  $Y_0$  cannot be observed, and simply making use of those not having invested leads to selection bias as long as the distribution of covariates is not the same for both groups. Individuals do influence selection into treatment, i.e. they determine investment decisions and their decisions are related to expected outcome. The treatment effect being subject to selection bias can be formulated the following (Caliendo and Kopeinig, 2008):

$$E(D = 1) - E(D = 0) = \tau_{ATT} + E(D = 1) - E(Y_1 | D = 0). \quad (6-6)$$

Only in case  $E(D = 1) - E(D = 0)$  becomes zero that is in case  $Y_0$  is mean independent from investment  $D$ , the difference in means subject to treatment is an unbiased estimate and selection bias is zero. However, it is reasonable to assume that  $Y_0$  systematically differs between those having invested and those we observe that have not, since the outcome would also be different in case of no investment at all (Dehejia and Wahba, 2002; Wooldridge, 2010: 906 et seq.). In experimental settings, selection bias is approached using randomization, where control and treatment groups do not differ systematically (Imbens, 2010). Matching



overcomes the problem in non-experimental settings because selection bias is controlled for by building pairs of those with and without treatment with similar observable characteristics. The ATT is unbiased in case differences in any of the two pairs are assessed by the observables, while revenue is independent of assignment to investment conditional on covariates that are not influenced by investment (Rosenbaum and Rubin, 1983; Dehejia and Wahba, 2002).

Propensity score matching (PSM) is an improvement of matching on covariates and has been proposed by Rosenbaum and Rubin (1983, 1985). Matching on covariates becomes cumbersome since a large range of variables included and finding exact matches a demanding task (Dehejia and Wahba, 2002). Propensity score is a balancing score reducing matching to a one-dimensional problem, where individuals are compared whether having the same probability to invest given the observable covariates (Heckman *et al.*, 1997). The propensity score as the conditional probability to invest given the control variables  $Z$  is defined as follows (see Dehajia and Wahba, 2002; Caliendo and Kopeinig, 2008):

$$P(Z) = P(Z). \tag{6-7}$$

Two identifying assumptions for conducting PSM need to be met:

First, the conditional independence assumption (CIA), implying that differences in outcome of those subjected to treatment and those that are not, are only due to treatment as for other observables that influence both investment and outcome is controlled for, is defined as follows:

$$Y_1, Y_0 \perp\!\!\!\perp D | Z \tag{6-8}$$

where  $D$  denotes statistical independence and  $Z$  observable covariates that are not affected by treatment. The so-called unconfoundedness implies that all covariates, which influence both treatment and outcome, are observed by the researcher. If CIA holds, matching simulates an experiment and investment is random and uncorrelated with the outcome we want to measure. Differences in outcome are attributable to investment only. Thus, the CIA overcomes the issue of unobserved counterfactual observations, since it is assumed that the potential outcome of those who invest can be derived from the average actual outcome of those who do invest. Selection bias due to observables is removed, given the CIA holds, by conditioning on the propensity score (Imbens, 2004; Mendola, 2007; Caliendo and Kopeinig, 2008). Incorporating the CIA condition in (6-7) leads to (Imbens, 2004; Caliendo and Kopeinig, 2008):

$$Y(0)Y(1) \perp\!\!\!\perp | P(Z). \tag{6-9}$$

Second, the overlap condition is defined the following (Caliendo and Kopeinig, 2008):

$$0 < P(Z) < 1 \tag{6-10}$$

where P indicates the probability of investment given covariates in that individuals with the same Z values have a positive probability of both investing and not. Heckman *et al.* (1997) note the comparison of individuals is restricted to those with common support, which proves that only similar individuals are compared, and reasonable comparisons are made. The justification of matching is only given over the common support. The condition implies that the propensity score is bounded away from 0 and 1 with exclusion of the tails of the distribution p(Z). Rosenbaum and Rubin (1983) name both assumptions together “strong ignorability”.

Provided the CIA holds and assuming that there is overlap between the group of those who have invested and those who have not, the ATT based on the propensity score can be estimated the following:

$$\tau_{ATT} = E\{[D = 1, P(Z)] - E[Y_0|D = 0, P(Z)]\}. \tag{6-11}$$

The PSM estimator for ATT is therefore the average difference in outcomes over the common support weighted by the propensity score distribution of those having invested (Caliendo and Kopeinig, 2008). Due to the propensity score, given the assumptions are fulfilled, there is no bias left in estimation of treatment effects due to unobserved heterogeneity (Jalan and Ravallion, 2003).

### **Implementation of propensity score**

Any standard probability model is applicable to estimate the propensity score (Becker and Ichino, 2002). For the choice of variables, those included need to explain both investment and outcome at the same time. Yet, the variables are not allowed to be influenced by investment of the farmer, since they are the ones not changing over time or determined before investment. There is no mechanical algorithm that detects the set of variables being necessary to satisfy the CIA. On the one hand, a rich source of possible variables helps to satisfy the CIA. On the other hand, having too detailed information results in impossible matching, as those with specific characteristics do either always invest or not. Hence, missing data results in the problem of causal inference, but it is also required as variation is needed (Heckman *et al.*, 1998; Smith, 2000; Smith and Todd, 2005; Caliendo and Kopeinig, 2008).

### *Matching Algorithms*

A matching algorithm is chosen after having estimated the propensity score, a way of comparing the outcome of one farmer having invested on plot with a farmer not having invested on plot. A broad range of matching algorithms is applicable. Said algorithms are diverse, subject to definition of the counterfactual observation, the neighbor, treatment of common support and assignment of weights to counterfactual outcomes, and they mostly involve a

trade-off between quality of matching and variance (Caliendo and Kopeinig, 2008). Especially in small samples, the decision of which algorithm to choose plays a role. However, with large sample sizes they become similar in their results, as they then compare exact matches (Heckman *et al.* 1997; Smith, 2000). The most common ones applied are nearest-neighbor matching, kernel-based matching, stratified matching, radius matching and Mahalanobis metric matching (Faltermeier and Abdulai, 2009). A sound overview of algorithms can be found in both Smith and Todd (2005) and Caliendo and Kopeinig (2008). In practice, one should try several matching algorithms and the decision of which to choose can be based on how the distribution of propensity scores in both groups looks (Bryson *et al.*, 2002).

We apply two matching algorithms, the nearest neighbor matching (NNM) and an extension of the one, the Mahalanobis metric matching (MMM). The **nearest neighbor matching** is the most intuitive one. Two observations that are closest in terms of propensity score are matched, one from the treatment and one from the control group (Caliendo and Kopeinig, 2008). This neighborhood can be formulated the following:

$$C(i) = \min_j ||p_i - p_j||, \quad j \in E_0 \quad (6-12)$$

where  $C(i)$  is the set of observations not investing (control observations) matched to the treated observation  $i$  with the propensity score  $p_i$  and with  $p_j$  being the closest propensity score of the non-treated observation  $j$  and  $E_0$  is the set of indices for control group observations (Heckman *et al.*, 1997; Becker and Ichino, 2002; Smith and Todd, 2005). The nearest neighbor estimator can be described the following (Heckman *et al.*, 1997; Becker and Ichino, 2002):

$$\tau_{NN} = \frac{1}{n_{1i}} \sum_{i \in E_1 \cap S_p} (Y_{1i} - \sum_{j \in E_0} w_{ij} Y_{0j}) \quad (6-13)$$

where  $n_{1i}$  is the number of observations in the set  $E_1 \cap S_p$  with  $E_1$  being the set of indices of the treated observations and  $E_0$  the set of indices of the control group observations,  $S_p$  denotes the region of common support imposed and  $Y_{1i}$  and  $Y_{0j}$  are the outcomes in the two counterfactual situations of investment and no investment on plot. The weight  $w_{ij}$  attached to the control group observation in case of NNM is equal to one.

Several variations of the NNM are available, it can be used without and with replacement, where in case of non-treated observations can be used more than once as a match. This variant implies a trade-off between bias and variance. The bias will reduce due to higher matching quality; however, by reducing the number of non-treated observations the variance of the estimator increases (Caliendo and Kopeinig, Smith and Todd, 2005). Another option is to make use of more than one neighbor to obtain counterfactuals, implying less variance due to more information used. However, also increased bias, due to average poorer matches

(Smith and Todd, 2005). One way of avoiding poor matches is to apply caliper matching, where a tolerance level is imposed on the maximum distance of propensity scores (Cochran and Rubin, 1973). An observation from the comparison group is selected as a match for a treated observation that is within the propensity range defined by the caliper and has the closest distance in terms of propensity score that is  $|p_i - p_j| < \varepsilon$ ,  $j \in E_0$  where  $\varepsilon$  is the pre-specified caliper. The quality of matching increases, however, the variance of the estimates also increases (Sianesi, 2001; Caliendo and Kopeinig, 2008).

The **Mahalanobis metric matching** (MMM) is an extension of NNM that is in contrast to the other matching algorithms, a multivariate covariate matching reducing bias. Apart from matching on the propensity score, other covariates are added, which may be strongly related to both outcome and investment. By this, emphasis can be placed upon the other investment decisions that are interrelated and are assumed to exert a strong influence on outcome as well (Lechner, 2002; Caliendo and Kopeinig, 2008; Faltermeier and Abdulai, 2009). Generally, the application of too many covariates reduces the performance of the MMM and it is not advisable to use more than one continuous variable (Abadie and Imbens, 2006; Guo *et al.*, 2006). According to the MMM algorithm, the observation  $j$  with no investment with the minimum distance  $d(i, j)$  is chosen as the match for the observation  $i$  with investment and both are removed from the matching process. This procedure continues until all treated observations are matched. In case of calipers applied, the nearest counterfactual observation is within the predetermined common support region defined by the caliper. The Mahalanobis distances are calculated as follows (Rubin, 1980; Rosenbaum and Rubin, 1985):

$$d(i, j) = (u-v)^T C^{-1} (u-v) \tag{6-14}$$

where  $u$  and  $v$  are the values of the matching variables (including the propensity score) for observation  $i$  with investment on plot and observation  $j$  with no investment on plot, and  $C$  is the sample covariance matrix of the matching variables from the full set of farmers not having invested. The combination of metric matching with propensity score is promising since propensity score matching reduces the discrepancy along the propensity score and MMM reduces the distance along individual coordinates of  $Z$  (Rosenbaum and Rubin, 1985; Sekhon, 2008). Empirical results indicate that MMM is superior to other matching algorithms, in particular with calipers applied (Baser, 2006).

#### *Assessing the Matching Quality*

The main purpose of propensity score matching is not to predict why farmers invest, but to balance the distribution of observed covariates across groups of farmers having invested and groups of farmers not having invested on the plot. Matching quality is therefore determined by

the ability of matching to balance the relevant covariates that is dependent on the type and quality of control variables and matching procedure (Becker and Ichino, 2002; Caliendo and Kopeinig, 2008). A balancing test will provide information if reasonable counterfactual outcomes are constructed in that both groups are similar (Mendola, 2007; Lee, 2011).

Various balancing tests are included in the literature. All of the approaches coincide the comparison before and after matching to see if there are differences left after conditioning on the propensity score (Caliendo and Kopeinig, 2008). The most widely used is the standardized mean difference between treatment and control sample suggested by Rosenbaum and Rubin (1985). This estimate compares the difference in means before and after matching for each variable and is defined the following (Lee, 2011):

$$B(Z) = 100 \frac{\underline{Z}_T - \underline{Z}_C}{\sqrt{\frac{V_T(Z) + V_C(Z)}{2}}} \quad (6-15)$$

where  $\underline{Z}_T$  and  $\underline{Z}_C$  are the sample means for the treatment and control groups and  $V_T(Z)$  and  $V_C(Z)$  are the corresponding sample variances. Total bias is calculated by an unweighted average across all covariates and the reduction in bias is computed the following:

$$BR = 100 \left( 1 - \frac{B_{\text{after}}}{B_{\text{before}}} \right). \quad (6-16)$$

According to Rosenbaum and Rubin (1985), a standardized difference of 20% is considered to be large.

Additionally, Sianesi (2004) proposed to estimate the propensity score on the matched sample only and carry out a comparison between the pseudo  $R^2$  before and after matching. After matching, the pseudo  $R^2$  shall be quite low indicating no systematic differences in the distribution of covariates between those who invest and those who do not and, above all, the joint significance of the included covariates shall be rejected.

### *Sensitivity Analysis*

Even after matching there still might be hidden bias, since variables unobserved by the researcher affect both investment and outcome, with estimators not being robust to hidden bias, leading to misleading policy implications. Then, observations with the same observed covariates have different probabilities of being assigned to treatment (Rosenbaum, 2002: 106). Selection bias cannot be tested directly in nonexperimental settings; however, it can be addressed by sensitivity analysis. The change in effects estimated under the assumption of unconfoundedness is assessed by violating unconfoundedness (Caliendo and Kopeinig, 2008; Imbens and Wooldridge, 2009). One option is the bounding approach suggested by Rosenbaum (2002), with the inherent question to what extent unobservables make an

influence on selection into treatment to alter inference about treatment effects, i.e. how unobservables do change effects of investment on revenue per acre on plot, for observations with the same observable characteristics but different unobservable characteristics (Rosenbaum, 2010: 367). In order to answer this question, the probability of being subject to treatment is expressed simplistically (Rosenbaum, 2002: 107; Faltermeier and Abdulai, 2009):

$$\pi_i = \Pr(z_i) = F(\beta z_i + \gamma u_i) \quad (6-17)$$

where  $z_i$  is a vector of all observed variables that explain investment and  $u_i$  are the unobserved variables with  $\gamma$  denoting the effect on the investment decision estimated with  $F$  as a logistic distribution. In case of hidden bias  $\gamma$  is not zero, and two observations with the same observed covariates have different probabilities to invest. Rosenbaum (2002: 107) then considers the odds ratio to receive the treatment of two matched observations  $i$  and  $j$ :

$$\frac{\pi_i(1-\pi_j)}{\pi_j(1-\pi_i)} = \frac{\exp(\beta z_j - \gamma u_j)}{\exp(\beta z_i - \gamma u_i)} = \exp[\gamma(u_i - u_j)]. \quad (6-18)$$

The formula shows that two observations with the same covariates differ in their odds ratio of decision to invest, by a factor that includes the parameter  $\gamma$  and the difference in the respective unobserved covariates  $u$ . Rosenbaum (2002: 108) proposes to restrict the unobserved covariate  $u$  to be a dummy variable. Then, the odds ratio can be rewritten the following:

$$\frac{1}{\gamma} \leq \frac{\pi_i(1-\pi_j)}{\pi_j(1-\pi_i)} \leq \gamma \quad (6-19)$$

whereas  $\gamma = \exp(\gamma)$ . There does not exist any hidden bias if  $\gamma = 1$ , thus unconfoundedness is given. However, for  $\gamma \neq 1$  with even large values the association between investment and outcome is less restricted. The parameter describes the degree of departure from a study where no hidden bias is present at an outside estimate (Rosenbaum, 2010: 77). The sensitivity analysis considers several values of  $\gamma$  and the respective possible changes in inference. Values of being close to 1 already changing the inference to a great extent describes studies being sensitive to hidden bias. Bounds for significance levels and confidence intervals are derived by means of a Wilcoxon's signed-rank test statistic (Aakvik, 2001; Imbens and Wooldridge, 2009) that is defined as follows (Rosenbaum, 2002: 110):

$$T = t(D, r) = \sum_{s=1}^S d_s \sum_{i=1}^2 c_{si} D_{si} \quad (6-20)$$

where  $D$  is treatment assignment and is a binary variable that equals 1 if the farmer invests in the respective measure on the plot and 0 otherwise,  $r$  is the outcome for each observation in the  $s$  pairs, and  $c_{si}$  is binary ( $c_{si} = 1$  or  $c_{si} = 0$ ), both  $d_s > 0$  and  $c_{si}$  are a function of  $r$  and, hence, they are fixed under the null hypothesis of no effect of investment.

Under the assumption that a confounding variable exists, the test statistic  $T = t(D, r)$  for each possible  $(\gamma, u)$  is the sum of  $S$  independent variables and the  $s$ th variable is equal to  $d_s$  with a probability:

$$p_s = \frac{c_{s1} \exp(\gamma u_{s1}) + c_{s2} \exp(\gamma u_{s2})}{\exp(\gamma u_{s1}) + \exp(\gamma u_{s2})} \quad (6-21)$$

and is equal to zero with probability  $1-p_s$ . With  $p_s^+$  and  $p_s^-$  are defined as follows:

$$p_s^- = \begin{cases} 0 & \text{if } c_{s1} = c_{s2} = 0 \\ 1 & \text{if } c_{s1} = c_{s2} = 1 \\ \frac{\Gamma}{1+\Gamma} & \text{if } c_{s1} \neq c_{s2} \end{cases}$$

$p_s^+ = \text{and}$  (6-22)

Then, the unknown null distribution of  $T$  is bounded by two known distributions  $T^+$  and  $T^-$

The expectation and variance of  $T^+$  are as follows:

$$E(T^+) = \sum_{s=1}^S d_s p_s^+ \quad (6-23)$$

$$\text{Var}(T^+) = \sum_{s=1}^S d_s^2 p_s^+ (1-p_s^+). \quad (6-24)$$

The definitions for  $T^-$  are similar apart from using  $p_s^-$  instead of  $p_s^+$ . The formulas are employed in order to test the null hypothesis of no effect of investment. The bounds of this significance level is calculated for any specific by:

$$\begin{aligned} & (T - E(T^+)) / \sqrt{\text{Var}(T^+)} \text{ and} \\ & (T - E(T^-)) / \sqrt{\text{Var}(T^-)} \end{aligned} \quad (6-25)$$

where  $T$  is the Wilcoxon's signed-rank statistic. In case of  $\gamma = 1$  with no effect of unobservables on the assignment to treatment the bounds are equal to the estimated significance level of the matching estimator. However, an effect of unobservables is revealed by confidence intervals on the estimated effect getting wider, with also the significance levels of the test of no effect of investment on the outcome increasing (Rosenbaum, 2002: 105-112; DiPrete and Gangl, 2004).

## 6.4 Hypothesis

We hypothesize that investment in productivity-enhancing and soil conservation measures influences productivity positively. Due to self-selection being assumed (see for example Faltermeier and Abdulai, 2009), we will account for it within the empirical specification.

## 6.5 Results and discussion

### Variables included in the model

Variables included to estimate the propensity score by means of probit models shall influence both investment and outcome, but not be affected by investment (Caliendo and Kopeinig, 2008). For this reason, variables subject to endogeneity (see section 3.6.2) are not included in the matching process. We decided on a large range of regressors in order to reduce the possibility of unobservables influencing both investment and outcome. Yet, a ‘too good’ specification makes matching impossible (Dehejia and Wahba, 2002; Caliendo and Kopeinig, 2008). The main purpose of the propensity scores is not to determine investment, this has already been done (see section 3.6.2) to balance the covariates between those investing and those that do not (Augurzky and Schmidt, 2001). Interaction terms, like distance to the market and education, and higher-order terms, like plot size squared, are included in case differences in covariates between the two groups are still prevalent (Caliendo and Kopeinig, 2008).

The choice of variables is based on results determining investment decisions and productivity, and theory. Categories of variables are farm and household characteristics, plot-level characteristics, social capital and village dummies. The decision to invest in either of the investments is not independent of the other investment decisions as has been proven by the significance of the correlation coefficients in the multivariate probit model. Above all, those interrelated investment options are also likely to influence output. Thus, the remaining investment options are included as covariates within the matching process for each investment option. The definitions and sample characteristics of the variables used to estimate the propensity scores at plot-level are presented in table 6-1.

Since MMM allows us to include, apart from the propensity score, other covariates where emphasis shall be placed, we add, for each specification to the propensity score, the other three respective investment options. Otherwise, observations would be matched based on similar propensity scores, yet with investment in diverse interrelated measures on the plot (Lechner, 2002; Faltermeier and Abdulai, 2009).

Table 6-1: Descriptive statistics for variables used in the empirical analysis

Variable	Variable definition	Mean	S.D.
<i>Outcome variable</i>			
Yield	Value of output per acre (GHS*0.1)	46.10	72.43
<i>Treatment variables</i>			
Ditches	1 if farmer applies ditches on plot, 0 otherwise	0.42	0.49
Fert	1 if farmer applies fertilizer on plot, 0 otherwise	0.33	0.47
Manure	1 if farmer applies organic manure on plot, 0 otherwise	0.15	0.36
Multcrop	1 if farmer applies multiple cropping on plot, 0 otherwise	0.59	0.49
<i>Independent variables</i>			



Trees	1 if trees have been planted on plot, 0 otherwise	0.36	0.48
Pltsize	Plot size in acres	4.66	5.37
Pltsize2_100	Plot size in acres squared/100	0.51	2.01
Soilfert	1 if plot is on fertile soil, 0 otherwise	0.88	0.33
Slope	1 if slope on plot, 0 otherwise	0.35	0.48
Pltforest	1 if vegetation on plot is forest, 0 savanna	0.43	0.50
Age	Age of farmer (years)	48.39	12.84
Education	0=no education, 1= middle/JHS, 2=secondary/SHS	0.54	0.68
HH-size	Number of permanent household members	5.72	2.01
Yrsr	Years of residence in the village	20.73	15.62
Friend	1 if farmer has friends, 0 otherwise	0.74	0.44
Lvstckvlue	Value of livestock wealth (GHS*0.01)	7.53	13.33
TV	1 if farmer owns a TV, 0 otherwise	0.20	0.40
Bike	1 if farmer owns a bike, 0 otherwise	0.55	0.50
Fridge	1 if farmer owns a fridge, 0 otherwise	0.15	0.36
House	1 if farmer owns a house, 0 otherwise	0.52	0.50
Fbo	1 if farmer is member of an fbo, 0 otherwise	0.31	0.46
Nnoboa	1 if farmer is assisted by nnoboa, 0 otherwise	1.68	0.52
Extens	1 if farmer received assistance by extension officer, 0 otherwise	0.38	0.49
Moconstr	Principal component ,monetary constraint <sup>a</sup>	0.092	1.08
Prefft	Principal component 'constraint practical effort' <sup>a</sup>	-0.025	1.31
Distm	Distance to the nearest market (km)	6.883	5.08
Educ_distm	Interaction education and distance to the market	4.012	7.33
Safe	1 if farmer thinks community is safe to farm, 0 otherwise	0.902	0.30
Kintampo	1 if farmer resides in Kintampo, 0 otherwise	0.265	0.44
Kunso	1 if farmer resides in Kunso, 0 otherwise	0.163	0.37
Badukrom	1 if farmer resides in Badukrom, 0 otherwise	0.197	0.40
Awaropat	1 if farmer resides in Awaropat, 0 otherwise	0.274	0.44
Twimea	1 if farmer resides in Twimea, 0 otherwise	0.059	0.24
Fiaso	1 if farmer resides in Fiaso, 0 otherwise	0.041	0.20
Observations		441	

Ghanaian Cedis (GHS). Exchange rate: €1 = c 3,6 in 2014

<sup>a</sup> Components are constructed by principal component analysis in chapter 4

Source: Survey data

Table 6-1 shows manure is the least applied soil conservation measure with only 15% followed by mineral fertilizer with 33%. Ditches and multiple cropping are applied to a larger extent on 42% and 59% of plots respectively.

### 6.5.1 Descriptive Results

Tables 6-2 and 6-3 present descriptive statistics of household and plot characteristics by investment status.

Table 6-2: Household and plot characteristics of adopters and non-adopters summary statistics

Characteristics	Investment in ditches			Investment in mineral fertilizer		
	Nonadopter	Adopter	Diff.	Nonadopter	Adopter	Diff.
<i>Household characteristics</i>						
HH-Size	6,13	5,45	-0,68***	5,90	5,91	0,01
Age	45,41	49,67	4,26***	46,99	46,41	-0,58
Education	0,47	0,56	0,09**	0,47	0,58	0,09
Lvstckvlue	9,03	7,49	-1,54	8,19	9,33	1,14
Yrsr	20,34	19,03	-1,31	20,99	17,65	-3,34***
Friends	0,68	0,83	0,14***	0,69	0,80	0,11
Extens	0,36	0,40	0,04	0,36	0,41	0,05
Fbo	0,29	0,35	0,06*	0,30	0,34	0,04
Nnboa	0,37	0,37	0,00	0,37	0,38	0,01
TV	0,12	0,24	0,12***	0,13	0,23	0,10***
Bike	0,39	0,55	0,16***	0,42	0,49	0,07*
Fridge	0,11	0,15	0,04*	0,10	0,18	0,08
House	0,35	0,59	0,24***	0,40	0,49	0,09
Safe	0,83	0,95	0,12***	0,87	0,86	-0,01
Moconstr	0,01	0,22	0,21**	0,05	0,18	0,13
Prefft	-0,02	-0,12	-0,1	0,01	-0,20	-0,19*
<i>Plot characteristics</i>						
Pltsize	4,88	3,79	-1,09***	4,53	4,43	-0,10
Soilfert	0,88	0,88	0,00	0,89	0,84	-0,05
Slope	0,34	0,36	0,02	0,32	0,39	0,07
Pltforest	0,40	0,39	-0,01	0,44	0,32	-0,12**
Distm	6,63	6,36	-0,27	7,17	5,22	-1,95***
Trees	0,30	0,32	0,02	0,30	0,31	0,01

Note: The difference in output measured is  
*difference = mean (with investment) – mean (without investment)*,

with  $H_0$ : diff = 0 and  $H_1$ : diff  $\neq$  0; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Survey data

Table 6-3: Household and plot characteristics of adopters and non-adopters summary statistics

Characteristics	Investment in manure			Investment in multiple cropping		
	Nonadopter	Adopter	Diff.	Nonadopter	Adopter	Diff.
<i>Household characteristics</i>						
HH-Size	5,83	6,36	0,53**	5,80	6,02	0,22
Age	46,88	46,42	0,46	47,09	46,49	-0,60
Education	0,53	0,31	-0,22	0,56	0,44	-0,12**
Lvstckvlue	8,41	9,27	0,86	6,97	9,96	2,99***
Yrsr	20,35	17,77	-2,58	21,16	18,75	-2,41**

Friends	0,73	0,72	-0,01	0,69	0,76	-0,07**
Extens	0,37	0,39	0,02	0,36	0,39	0,03
Fbo	0,30	0,36	0,06	0,31	0,32	0,01
Nnboa	0,36	0,41	-0,05	0,35	0,40	0,05
TV	0,17	0,11	-0,06*	0,13	0,19	0,06
Bike	0,45	0,38	-0,07	0,46	0,43	-0,03
Fridge	0,13	0,07	-0,06**	0,09	0,15	0,06***
House	0,45	0,28	-0,17***	0,40	0,45	0,05
Safe	0,87	0,87	0,00	0,86	0,88	0,02
Moconstr	0,07	0,17	0,10	0,05	0,12	-0,07
Prefft	-0,10	0,23	0,33	-0,20	0,06	0,26**
<i>Plot characteristics</i>						
Pltsize	4,44	4,83	0,39	3,99	4,92	-0,93
Soilfert	0,87	0,90	0,03	0,86	0,89	0,03
Slope	0,32	0,48	0,16***	0,33	0,36	0,03
Pltforest	0,41	0,33	-0,08*	0,42	0,38	-0,04
Distm	6,83	4,88	-1,95***	7,21	5,97	-1,24***
Trees	0,32	0,25	-0,07	0,28	0,33	0,05

Note: The difference in output measured is  
*difference = mean (with investment) – mean (without investment)*,

with  $H_0$ : diff = 0 and  $H_1$ : diff  $\neq$  0; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Survey data

The t-statistics of the mean difference of household characteristics reveal that those farmers investing and those farmers that are not are partly different in their characteristics, supporting the notion that those farmers investing are systematically different and this relates to self-selection of farmers into investment. In addition, some differences with regard to plot characteristics between plots with and without investment emerge. For example, among plots with investment in mineral fertilizer, manure, and multiple cropping the distance to the market is shorter than among plots without investment. So, the benefit of investment seems to be higher with a market nearby where outputs can be purchased.

Table 6-4 reports descriptive statistics of differences in productivity by type of investment on the plot.

Table 6-4: Difference in yields on plot between investment and no investment

Investment option	Output with investment (GHS*0.1/acre)	Output without investment (GHS*0.1/acre)	Difference (GHS*0.1/acre)
Ditches	49.27	52.62	-3.35
Fertilizer	63.61	44.96	18.65**
Manure	52.66	51.18	1.48
Multiple Cropping	60.37	39.34	21.03**

Ghanaian Cedis (GHS). Exchange rate: €1 = c3.6 in 2014

Note: The difference in output measured is  
*difference = mean (with investment) – mean (without investment)*,

with  $H_0: \text{diff} = 0$  and  $H_1: \text{diff} \neq 0$ ; \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$   
Source: Survey data

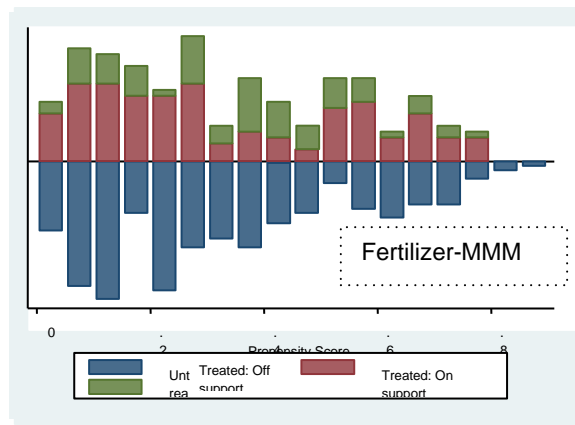
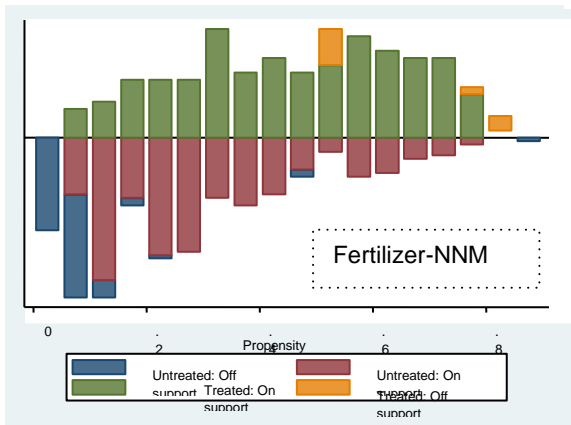
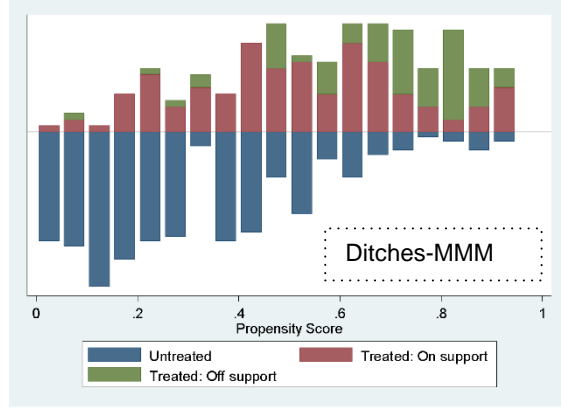
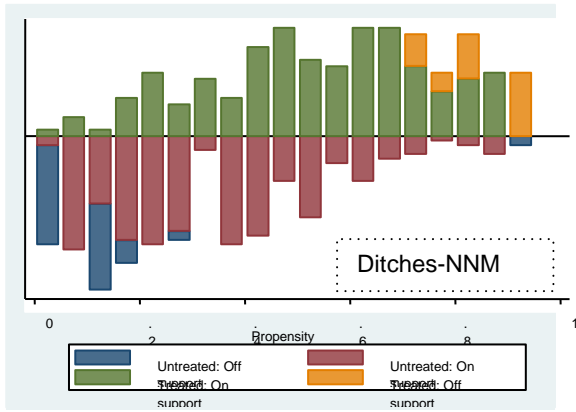
With regards to the outcome variable value of output per acre, there appear to be statistically significant differences between those observations with investment and those without. Output is significantly higher on plots where fertilizer and multiple cropping have been applied. However, the output on plots with investment in ditches is lower, albeit only to a small extent and significance. For investment in manure, we only observe a slightly higher output per acre of ₦14.8, which is not significant. Yet, a comparison of the means of output per acre by t-statistics does not account for the effect of other factors such as farm, household and plot characteristics and, as such, may alter the impact of investment in soil conservation measures on revenues per acre with the influence of other factors (Owusu *et al.*, 2011). In order to provide sound estimates of the impact of investment on revenues, we investigate the impact of the four investment options in the non-parametric framework propensity score matching accounting for selectivity bias. Hence, each investment is a treatment to be analyzed with respect to its impact on revenues per acre, the outcome variable.

### **6.5.2 Empirical results**

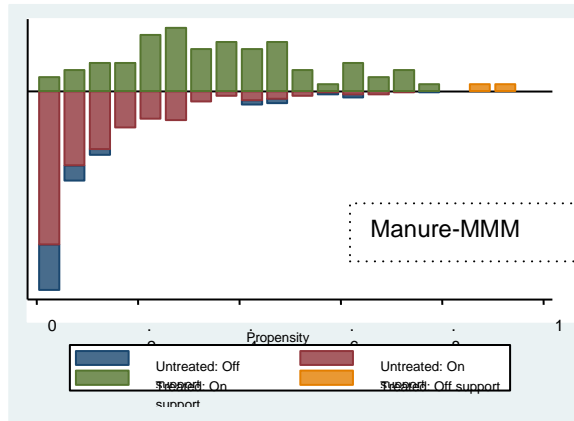
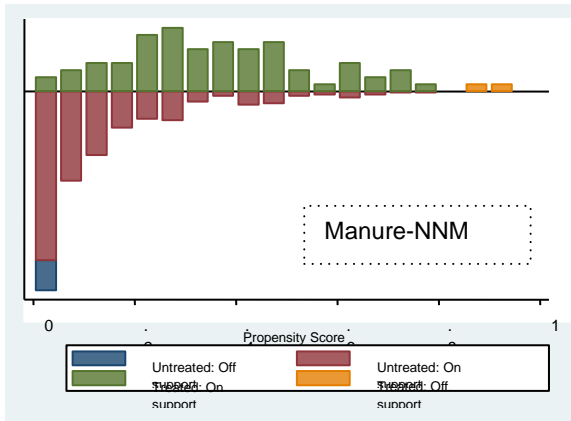
Propensity scores are estimated for each investment option by means of a probit model. The results of the propensity score estimates are reported in tables A9-A12 from the Annex. An interpretation of the propensity score estimates is not undertaken here since the main goal of propensity score matching is to balance the distribution of covariates across groups of farmers investing and groups of farmers not investing on the plot (Becker and Ichino, 2002; Caliendo and Kopeinig, 2008).

The overlap assumption implies that matching can only be performed in the region of common support (Caliendo and Kopeinig, 2008). Common support is imposed by making use of caliper determining the maximum distance of p-scores between one treated and one untreated observation. The distribution of propensity scores and the regions of common support are presented in figures 6-1. The bottom half shows the propensity scores distribution of those having invested, and the upper half the propensity scores of those not having invested with the y-axis presenting the density of the scores.

The graphs visualize the bias in the distribution of the propensity scores between groups with and without investment. They indicate the high relevance of proper matches and show that estimating the p-scores balance the untreated and treated groups very well.



Fertilizer-MMM



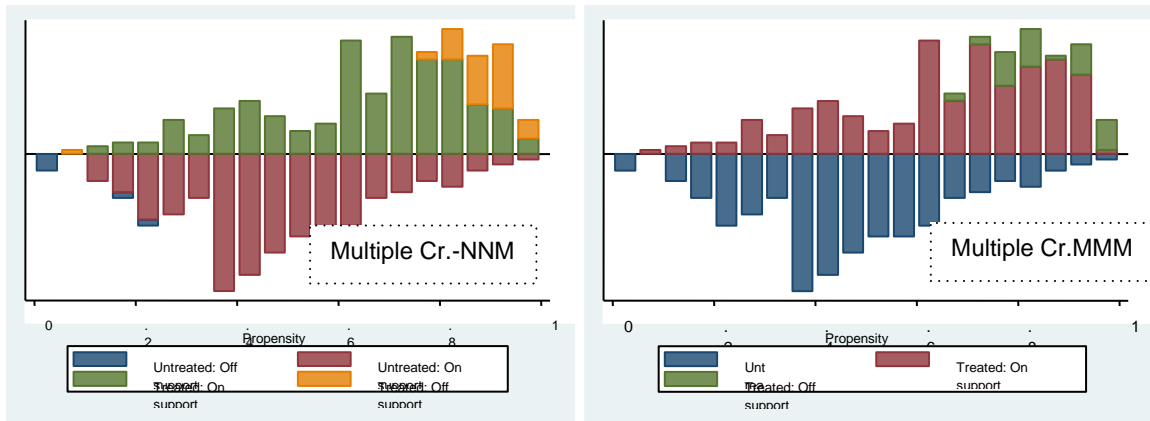


Figure 6-1: Propensity score distribution and common support for propensity score estimation

The results of the treatment effect ATT of each investment option on value of output per acre for both matching algorithms, NNM and MMM, with its respective caliper and number of treated and control observations on support used for matching, and the loss of observations due to common support condition are presented in table 6-5, while table 6-6 provides the indicators of matching quality.

Table 6-5: Average treatment effects of investment options and sensitivity analysis<sup>41</sup>

Investment	Matching Algorithm	ATT <sup>2</sup>	Caliper	Critical level of hidden bias $\Gamma$	No. treated No. controls On support	Loss of observations due to common support
Ditches	NNM	17.13**	0.01	1.3	166 219	75
	MMM <sup>1</sup>	24.45***	0.01	1.4	125 269	66
Fertilizer	NNM	21.43*	0.01	1.6	141 237	74
	MMM <sup>1</sup>	29.02***	0.01	1.6	119 303	30
Manure	NNM	12.31	0.1	-	70 313	22
	MMM <sup>1</sup>	11.44	0.08	-	70 279	56
Multiple Cropping	NNM	23.03***	0.01	1.4	228 182	52
	MMM <sup>1</sup>	27.00***	0.08	1.7	234 188	40

Note: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>1</sup> Conditioning variables apart from propensity score are the other three investment options respectively

<sup>2</sup> Outcome is output per acre in GHS\*0.1

<sup>41</sup> Units were randomly ordered before Matching algorithms are applied, in order to obtain consistent estimates, as otherwise, due to the matching algorithm a different order of data, leads to diverse results. In addition, given the relatively small sample size, matching is conducted with replacement (a given observation not having invested on the plot can get matched to more than one observation having invested on the plot).

Table 6-6: Indicators of covariate balancing, before and after matching

Investment	Matching Algorithm	Mean absolute bias before matching %	Mean absolute bias after matching %	Total (%) bias reduction	Pseudo R <sup>2</sup> (unmatched)	Pseudo R <sup>2</sup> (matched)	p-value of LR (unmatched)	p-value of LR (matched)
Ditches	NNM	22.73	8.00	64.80	0.223	0.043	0.000	0.582
	MMM	23.38	5.58	76.13	0.223	0.049	0.000	0.659
Fertilizer	NNM	22.82	8.47	62.88	0.174	0.058	0.000	0.202
	MMM	20.72	8.31	59.89	0.177	0.058	0.000	0.577
Manure	NNM	20.53	9.39	54.26	0.249	0.057	0.000	0.960
	MMM	21.28	9.63	54.75	0.248	0.078	0.000	0.771
Multiple Cropping	NNM	23.01	5.14	77.66	0.177	0.019	0.000	0.939
	MMM	23.82	7.79	67.30	0.172	0.040	0.000	0.135



Overall, estimates show a positive impact of each investment option on the plot on the outcome variable. In terms of causal effects and significance, the results of the NNM appear to be similar to those of the MMM. Investment in ditches, fertilizer and multiple cropping exert a positive and significant impact on value of output per acre.

In particular, plots with investment in ditches are characterized by a statistically higher output per acre of ₪171.3 in the case of NNM, and even a higher output when accounting for the other investment options by MMM of ₪244.5. Hindering soil erosion increases output significantly. The causal effect of investment in fertilizer is significant. It ranges between ₪214.3 (NNM) and ₪290.2 (MMM) and exerts the greatest effect on output within the analysis by increasing soil fertility in the short-run. Multiple cropping significantly increases output per acre by ₪230.3 in case of NNM and by ₪270.0 in case of MMM through, among other effects, hindering soil erosion and augmenting soil capital in the long-run. The findings are supported by similar results reported for soil conservation measures (Kassie *et al.* 2008), for fertilizer specifically for Ethiopia (Kassie *et al.* 2010) and for intensification technologies for Ghana (Faltermeier and Abdulai, 2009). All three studies control for possible self-selection bias by means of propensity score matching. Balancing the distribution of covariates does not lead to a statistically significant difference in output per acre between farmers having invested in manure on the plot and those that have not, even if both NNM and MMM estimates show a positive treatment effect, ATT=₪123.1 and ATT=₪114.4 respectively. One explanation might be that nutrient compositions of manure do not necessarily meet nutrient needs of crops on the plot (Vanlauwe and Giller, 2006).

Indicators of the matching quality are presented in table 6-6. The reduction in the mean absolute standardized bias is, in all cases, above 50% with a mean absolute bias after matching of always below 10, suggesting that the covariates are adequately balanced by propensity score estimation and each matching algorithm (Faltermeier and Abdulai, 2009). Next to the standardized bias, the pseudo- $R^2$  from the propensity score for each investment and the re-estimation of the propensity score after matching on the matched sample only as suggested by Sianesi (2004) is presented, together with the p-values of the likelihood ratio test of the joint significance of all the covariates in each probit model, before and after matching. In each model, the variance of the respective investment decision determined by the covariates declined substantially after matching. The joint significance of the covariates has to be rejected after matching in each case, whereas it is never rejected before matching. After matching, there is no systematic difference in the distribution of covariates between those farmers that have invested on plot and those that have not.

Table 6-5 also shows the results of the sensitivity analysis with the critical level of  $\Gamma$  at which the causal inference of significant investment effects is questionable. Sensitivity analysis only

makes sense in case the ATT is significant (Hujer *et al.*, 2004). The critical levels of gamma are obtained based on the assumption that the estimated effect of treatment overestimates the true effect since there might be positive unobserved selection that leads to an upward bias in the treatment effect that has been estimated (Becker and Caliendo, 2007). This confounding variable needs to have an equally strong effect on both selection into treatment and outcome (Faltermeier and Abdulai, 2009). Gamma values for investment in ditches, fertilizer and multiple cropping range between a lowest critical value of  $\Gamma=1.3$  for investment in ditches in case of NNM and a highest critical value of  $\Gamma=1.7$  for investment in multiple cropping in case MMM is applied. These results are in the range of previous studies and imply to be relatively robust to hidden bias, that is unobserved heterogeneity with  $\Gamma=1.3$  as the lowest value. A value of  $\Gamma=1.7$ , for example, indicates that in case observations that have the same Z vector differ in their odds of investment by a factor of 70%, then the confidence interval of the output effect would include a zero. In particular, it would require a hidden bias of  $\Gamma=1.7$  to reduce the positive effect of multiple cropping. It needs to be stressed that Rosenbaum bounds are a worst-case scenario and do not indicate unobserved heterogeneity in the dataset or insignificance of treatment effects (DiPetre and Gangl, 2004; Hujer *et al.*, 2004).

## 6.6 Summary and conclusions

The impact of investment on plot-level productivity is examined. The non-parametric approach propensity score matching was applied to account for selectivity bias, given the non-experimental nature of the data. Results of the standardized bias method prove that the propensity score is able to balance the distribution of covariates between farmers having invested on the plot and farmers not having invested on the plot.

Estimates reveal that investment in ditches, fertilizer and multiple cropping significantly increases value of output per acre on plot. The effect of investment in manure is positive, albeit insignificant. This might be due to manure not complying perfectly with nutrient requirements of crops.

Two main policy implications can be derived from the analysis. First, these investments seem to be worthy of supporting and disseminating among farmers to raise their productivity. In addition, these results reinforce the implications drawn from the analysis in Chapter 3. Secure tenure rights do influence productivity by means of increased investment. Farmers with secured rights are more likely to invest in soil conservation measures as found in Chapter 3, which, increases productivity. Therefore, providing secure tenure rights influences agricultural productivity positively, emphasizing the importance of secured tenure.

## Annex

### Estimation of propensity scores

Table 6-1: Estimation of propensity score for investment in ditches

Ditches	Coefficient	Std. Err.	Z-Value	Probability
Fert	-0.201	0.157	-1.28	0.201
Manure	0.623	0.224	2.78	0.005
Multcrop	0.206	0.150	1.37	0.170
Trees	-0.332	0.145	-2.29	0.022
Pltsize	-0.034	0.016	-2.18	0.029
Age	0.015	0.006	2.76	0.006
Education	0.022	0.109	0.21	0.838
HH-size	-0.083	0.035	-2.36	0.018
TV	0.534	0.195	2.74	0.006
Distm	-0.036	0.019	-1.95	0.051
Fbo	0.273	0.158	1.72	0.085
Safe	0.379	0.280	1.35	0.176
Moconstr	-0.007	0.064	-0.11	0.909
Lvstckvlue	-0.011	0.005	-2.36	0.018
Nnoboa	-0.243	0.118	-2.06	0.039
Kintampo	0.961	0.413	2.33	0.020
Kunso	1.167	0.469	2.49	0.013
Badukrom	1.540	0.405	3.81	0.000
Awaropat	0.296	0.404	0.73	0.464
Twimea	-0.600	0.496	-1.21	0.228
Constant	-0.988	0.536	-1.84	0.065
Observations	460			
Pseudo R <sup>2</sup>	0.223			

Table 6-2: Estimation of propensity score for investment in fertilizer

Fertilizer	Coefficient	Std. Err.	Z-Value	Probability
Ditches	-0.233	0.160	-1.46	0.145
Manure	-0.185	0.201	-0.92	0.357
Multcrop	0.543	0.152	3.57	0.000
Pltsize	0.001	0.013	0.11	0.915
Soilfert	-0.195	0.203	-0.96	0.337
Age	-0.007	0.006	-1.09	0.274
HH-size	0.039	0.037	1.04	0.299
Distm	0.007	0.021	0.32	0.750
Fridge	-0.103	0.208	-0.50	0.619
House	0.156	0.163	0.96	0.337
Extens	0.425	0.139	3.05	0.002
Yrsr	-0.010	0.005	-1.94	0.053
Friend	0.271	0.166	1.64	0.102
Lvstckvlue	-0.004	0.005	-0.73	0.464
Moconstr	-0.040	0.067	-0.59	0.553
Kintampo	0.735	0.359	2.05	0.040
Kunso	-0.684	0.440	-1.55	0.121
Badukrom	0.072	0.379	0.19	0.848
Awaropat	-0.350	0.355	-0.99	0.324
Twimea	0.066	0.410	0.16	0.873
Constant	-0.714	0.487	-1.47	0.143
Observations	452			
Pseudo R <sup>2</sup>	0.177			

\*For Mahalanobis matching the squared term of plot size is added

Table 6-3: Estimation of propensity score for investment in manure

Manure	Coefficient	Std. Err.	Z-Value	Probability
Ditches	0.530	0.226	2.35	0.019
Fert	-0.112	0.186	-0.60	0.549
Multcrop	-0.041	0.210	-0.20	0.843
Trees	0.054	0.188	0.29	0.775
Pltsize	0.206	0.099	2.08	0.037
Pltsize2_100	-1.416	0.736	-1.92	0.055
Soilfert	0.050	0.261	0.19	0.847
Slope	0.284	0.179	1.59	0.112
Pltforest	0.124	0.185	0.67	0.503
Bike	0.342	0.198	1.72	0.085
Education	0.032	0.155	0.21	0.835
Age	-0.016	0.043	-0.37	0.711
Age2_100	0.019	0.041	0.46	0.644
HH-size	-0.006	0.046	-0.13	0.895
Friend	-0.379	0.193	-1.96	0.050
Moconstr	0.473	0.132	3.58	0.000
Prefft	0.514	0.116	4.44	0.000
Kintampo	-1.372	0.396	-3.46	0.001
Badukrom	-1.000	0.386	-2.59	0.009
Awaropat	-1.471	0.356	-4.14	0.000
Twimea	0.281	0.359	0.78	0.433
Constant	-0.525	1.200	-0.44	0.662
Observations	405			
Pseudo R <sup>2</sup>	0.249			

\*Kunso predicts failure perfectly and it is dropped

Table 6-4: Estimation of propensity scores for investment in multiple cropping

Multiple Cropping	Coefficient	Std. Err.	Z-value	Probability
Ditches	0.303	0.149	2.03	0.043
Fert	0.552	0.151	3.66	0.000
Manure	0.413	0.214	1.93	0.054
Pltsize	0.042	0.029	1.43	0.152
Pltsize2_100	-0.026	0.075	-0.34	0.734
Pltforest	-0.035	0.136	-0.26	0.798
Age	-0.004	0.006	-0.81	0.415
Education	0.109	0.169	0.64	0.519
HH-size	0.021	0.035	0.61	0.545
Bike	-0.245	0.142	-1.72	0.085
Fridge	0.397	0.214	1.86	0.063
Distm	0.089	0.025	3.58	0.000
Educ_Distm	-0.057	0.021	-2.70	0.007
Safe	-0.112	0.231	-0.49	0.627
Moconstr	-0.049	0.062	-0.78	0.435
Lvstckvlue	0.007	0.005	1.22	0.221
Kintampo	-0.061	0.362	-0.17	0.865
Kunso	-1.001	0.425	-2.36	0.019
Badukrom	-0.304	0.374	-0.81	0.416
Awaropat	-0.875	0.351	-2.49	0.013
Twimea	0.464	0.438	1.06	0.289
Constant	-0.013	0.455	-0.03	0.978
Observations	462			
Pseudo R <sup>2</sup>	0.177			

## **7 Participation in off-farm activities**

### **7.1 Introduction**

Given the results of the investment specification in Chapter 3, indicating off-farm work and farm work to be interrelated and distinct by type of activity, it is imperative to gain deeper insight into these interrelationships similar to what has been done with social capital in Chapter 4, after having analyzed the interrelations to productivity in detail in Chapters 5 and 6. We determine participation in both wage and self-employment, contributing to scarce empirical literature differentiating between these two activities and, above all, increasing knowledge about the relationship between off-farm work and investment decisions. A better understanding of these interrelations is crucial for designing a policy that addresses welfare derived from both farm and off-farm activities for each individual. First, we present a review of extant empirical literature on the interrelations between participation in off-farm activities and investment on the farm and determinants of income diversification. Next, we provide a theoretical framework analyzing the decision of the farmer to participate in self-employment and/or wage employment. After having outlined the empirical specification, the next sections deal with descriptive and empirical results, analyzing the relationship between participation in off-farm work and investment and participation in self-employment and wage employment.

### **7.2 Literature review**

#### **7.2.1 Off-farm activities and investment in soil conservation measures**

Off-farm activities constitute an important aspect in the life of farmers, and omission of these when analyzing soil conservation measures could possibly lead to incorrect conclusions (Barrett *et al.*, 2005).

Progress in off-farm work ought to complement progress in agriculture as both are inter-related and inter-dependent (Owusu *et al.*, 2011). Reardon *et al.* (1994) rightly note that income from off-farm activities can be used to either hire labor or purchase farm technology that, itself, is a substitute for labor. In addition, working off-farm can be positively associated with more access to information concerning investment options (Wollni *et al.*, 2010). Agriculture, however, can only benefit from off-farm activities in cases where income obtained is actually used for investment in agriculture, and resources are not divided up at the expense of agriculture. Participation in off-farm activities also implies a withdrawal of family labor from the farm, and income might rather be used for consumption or investment in off-farm activities (Pfeiffer *et al.*, 2009). Hence, the influence of off-farm work on investment decisions cannot be stated a priori (Amsalu and Graaff, 2007).

Still, Taylor and Martin (2001) present the New Economics of Migration based on the assumption that off-farm decisions are made by families and not by individuals. Family members migrating provide liquidity and insurance overcoming lost labor on the farm. The latter can be tested by the effect of off-farm work on labor intensive investments, like building ditches. In contrast to this possible negative effect, income is received by migrants having better paid jobs. This effect cannot be measured by our data set, still, the higher income obtained might lead to an improved liquidity and reduced risk of investments. This can be tested empirically by the effect of off-farm work on cost-intensive investments like fertilizer. However, they argue that the positive effect of income from off-farm work largely depends on the type of investments and local circumstances; investments have to be profitable in order to pay-off.

Some empirical findings concerning the effect of off-farm activities on investment behavior indicate a positive influence. An overview of studies having examined the effect of off-farm activities on farm activities is provided by Davis *et al.* (2009). They conclude that there is mostly a positive impact of income from off-farm activities on purchased inputs and capital investments. Bababunde and Qaim (2010), while focusing on the effect of off-farm income on food security and nutrition in Nigeria, provide a chain of possible determinants that explain the significant positive effects with a higher off-farm income leading to more investment in fertilizer, pesticides, and hiring of farm labor. Oseni and Winters (2009) find a similar effect in Nigeria. The amount of crop expenses in general and hiring of labor and purchase of fertilizer, in particular, are fostered by participation in off-farm activities. They also explain that making use of a dummy variable representing participation in off-farm activities is more suitable than applying off-farm income in terms of decisions on the farm since it is the ability of participation that allows households to earn income.

Other empirical studies appear to be showing a negative influence of participation in off-farm work on investment on the farm. For instance, Kilic *et al.* (2009) in a study on Albania find a negative relationship. Income from off-farm activities is used as a substitute for farming and fewer resources are spent for input purchase and household farm labor. The study by Pfeiffer *et al.* (2009) on Mexico is partly in line with these results. They also reveal a negative effect on family labor resources, due to income obtained from off-farm employment. However, they observe a shift to input-intensive agricultural production, as more farm inputs are purchased by relaxed liquidity constraints. Huang *et al.* (2009) also observe a trade-off between allocation of labor to off-farm activities and agricultural production in China. The share of the household's time allocated to off-farm employment in 2001 negatively influenced the area planted with fruits five years later. Moreover, no positive effect on capital and labor intensities could be revealed. Deininger and Olinto (2001) analyze the influence of specialization of both farm and off-farm



activities on returns to labor, with households being engaged in multiple income-generating strategies obtaining lower returns to labor. They identify specialization by interacting labor supply with a binary variable that is equal to one, in case the household specializes, and zero otherwise, while returns to labor are estimated by total household expenditure as a proxy for household income.

Empirical analyses on the effect of off-farm activities on soil conservation measures are rare with ambiguous results concerning the influence of income diversification. The study by Holden *et al.* (2004) on Ethiopia, applies bio-economic modeling and analyzes conservation measures. They discovered that improved access to off-farm activities does reduce households' incentives to invest in conservation measures, enhancing soil erosion and land degradation. Thus, improved access to off-farm activities reduces resources spent on investments that are sustainable. Amsalu and Graaff (2007) investigate the determinants of investment in stone terraces and their continued use in Ethiopia by means of a bivariate probit model. Participation in off-farm work appears to be negatively associated with both adoption and continued use, the latter being significant. They argue that short-term benefits derived from off-farm work seem to be more attractive than long-term benefits, due to investment in conservation measures. This type of argument is also enforced by study results of Tenge *et al.* (2004) on Tanzania. Participation in off-farm activities is negatively and significantly associated with investment in soil and water conservation measures. However, in the study by Jara-Rojas *et al.* (2013), participation in off-farm work is not significantly related to investment in soil and water conservation measures in Chile, estimated by a bivariate probit model. On the other hand, Marenya and Barrett (2007) in their study on Kenya, reveal off-farm income is positively associated with investment in several natural resource management measures, such as agroforestry and application of chemical fertilizer, determined by means of a multivariate probit model. They state cash income is crucial for hiring labor and purchase fertilizer, which is not given by farm income alone.

A number of studies analyzing the relationship between off-farm activities and investment behavior on the farm applied instrumental variable approaches (see Kilic *et al.*, 2009; Oseni and Winters, 2009; Pfeiffer *et al.*, 2009). Participation in off-farm activities might be subject to endogeneity due to unobservable characteristics that influence both the decision to participate in off-farm work and the decision to invest. Possible unobservables might be ability or entrepreneurship (Kilic *et al.*, 2009). Instruments that have been applied to control for possible endogeneity of off-farm activities are very specific to the study area, such as foreign language knowledge and migration networks (Oseni and Winters, 2009). Pfeiffer *et al.* (2009) use, apart from migration networks and distance to the U.S. border, the instrument 'ratio of nonagricultural employment to economically active population', in order to account for employment

possibilities at the municipality level in Mexico, which is closely related to nonagricultural wage income.

### **7.2.2 Participation in off-farm activities**

Determinants of income diversification are generally differentiated into push and pull factors. Push factors are a result of missing income opportunities in agriculture since risk ought to spread by income diversification to compensate for income shocks *ex post* due to unforeseen failure and long-term constraints. Pull factors are also linked to some type of self-insurance, for risk is mitigated *ex ante* by deciding for an activity portfolio that is either low or negatively linked. Pull factors can be observed with a growing agricultural sector that provides beneficial linkages to the off-farm sector, such as provision of inputs and services for the farm sector (Ellis, 2000; Barrett *et al.*, 2001; Haggblade *et al.*, 2010). Thus, household's labor allocation to off-farm activities is driven by either productivity of agriculture being insufficient or relative returns outside agriculture being higher (Reardon, 1997).

Heterogeneous constraints and incentives have been considered in explaining the decision to participate in off-farm activities with household characteristics, such as availability of labor, money, and endowments, property rights in land and livestock and individual characteristics, like education (Abdulai and CroleRees, 2001; Barrett *et al.*, 2005), as main determinants. Within off-farm activities, it is differentiated between high-return and low-return activities, where for the first access it is facilitated by monetary means (household income), access to markets and social interaction (Barrett *et al.*, 2005).

Size and structure of the household influences the ability to diversify income (Reardon, 1997). A larger household size, especially the number of adults, is positively related to participation in off-farm work. Having a larger family size implies more adults still stay at the farm to meet the respective labor demands or they are driven into off-farm activities due to land constraints (Abdulai and CroleRees, 2001; Lay *et al.*, 2008). The number of children indicates the number of dependents that might influence participation in off-farm activities negatively, especially for women (Abdulai and Delgado, 1999).

Endowments and access to monetary means are related to participation in off-farm work in diverse ways. Land owned is a common determinant used, accounting for labor abundance and wealth (Abdulai and CroleRees; 2001; Barrett *et al.*, 2005). Off-farm activities linked to capital needed are more likely with households that have greater assets, such as land and livestock, whereas poorer households without noteworthy assets are more associated with lower-paid farm work (Reardon, 1997). Generally, those less favored in social and economic terms are less prone to high-return off-farm activities (Barrett *et al.*, 2001). However, valuable assets can reduce the likelihood of participation in off-farm work, since these function as a

proper source of income (Verpoorten, 2009). Deininger and Olinto also reveal asset ownership, such as land and livestock as a promoter of specialization in either farm or off-farm work in Colombia by making use of a probit regression. Assets serve as a self-insurance reducing the need to diversify. Land size owned is also negatively associated with participation in local off-farm activities in a cross-country analysis by Matsumoto *et al.* (2006) estimated by means of a multinomial probit model. Access to credit determines off-farm decisions differently. Lack of access to credit drives farmers into off-farm activities to obtain cash, as a substitute for credit, whereas access to credit can be a crucial factor in setting up a self-employed business (Reardon, 1997; Ellis, 2000; Escobal, 2001).

Individual determinants are mainly human capital, age, and gender. Human capital is coined as one major predictor of participation in off-farm activities. Education raises the likelihood to participate, mostly in those with higher returns, and also the supply of labor to off-farm activities (Abdulai and Delgado, 1999; Barrett *et al.*, 2001; Escobal, 2001; Jolliffe, 2004). Jolliffe (2004) in her study on Ghana shows that the average level of education of the household strongly supports both off-farm labor supply and off-farm profit. Age determines income diversification in a complex way. According to Abdulai and CroleRees (2001), at younger ages an increase in age increases the probability to participate in off-farm work, albeit with a certain maximum. In addition, a difference in access to off-farm activities by gender, especially in those with high-returns, has been outlined with women being disadvantaged. Women, mainly by being assigned duties at home, are restricted in their possibilities to participate in off-farm activities away from home. Social capital, as one attribute of the farmer, can also be beneficial in entering off-farm business (Ellis, 2000; Barrett *et al.*, 2001).

Other influential factors, which are neither controlled by the individual farmer nor are different across each individual farmer, have been outlined within the literature. Agroclimatic zones are perceived as important for explaining participation (see Reardon, 1997). Yet, according to the study by Yamono and Kijma (2010), soil fertility variables appear to be no significant determinants of off-farm income in Uganda. In addition, local conditions, such as infrastructure, population density and close distance to the market/city, are supposed to affect the capacity of farmers to shift from farm business to income diversification positively due to a reduction in various transaction costs (Abdulai and Delgado, 1999; Atamanov and van den Berg, 2012). For example, Matsumoto *et al.* (2006) reveal a larger distance to the market to be negatively associated with participation in local off-farm activities in Kenya, and link this result to the local labor market, which is thinner in remote areas. However, Yamono and Kijma (2010) do not find a meaningful relationship between market access and off-farm income in Uganda. They explain the insignificant effect in the tobit model by most local off-farm activities.

Having outlined main determinants of income diversification, we shed light on the fact that off-farm activities are a heterogeneous concept; diverse types differ in their characteristics and determinants, especially self-employment and wage employment (Woldenhanna and Oskam, 2001; Joliffe, 2014). Thus, by aggregating off-farm activities to one concept these differences are not observable (Barrett *et al.*, 2001; Woldenhanna and Oskam, 2001). Aggregating self-employment and wage employment comes at the cost of neglecting that self-employment is related to entrepreneurship and the latter not (Joliffe, 2004). Some empirical studies have disaggregated off-farm activities according to the type of activity, such as self-employment and wage employment. Those have determined participation in off-farm activities by binary choices, or the extent of activity by income or income shares (see e.g. Escobal, 2001; Ruben and van den Berg, 2001; Woldenhanna and Oskam, 2001; Isgut, 2004; Atamanov and van den Berg, 2012). Atamanov and van den Berg (2012) apply a multivariate probit model for explaining participation in different off-farm activities in the Kyrgyz Republic, due to choices to participate being related.

Extant empirical studies distinguishing among different types of off-farm activities, i.e. self-employment and wage employment, differ in their views about the two activities. Woldenhanna and Oskam (2001), when applying a multinomial logit model, find that self-employment is preferred over wage employment in Ethiopia, as the latter is indicated to be an activity determined by push factors, while self-employment is an activity linked to high returns. This finding is consistent with the observation by Bundervoet (2010) on Burundi, where unskilled wage employment is characterized by certain, yet low, income, whereas self-employment implies higher income, although with higher capital investment needed. Cunguara *et al.* (2011) also point out entry barriers with respect to self-employment in Mozambique, based on a positive effect of livestock on income obtained from self-employment. However, in a study on Honduras, self-employment is also related to females irrespective of education, where education plays a role in wage employment (Ruben and van den Berg, 2001). Another study by Escobal (2001) on Peru reveals that education is positively associated with both self-employment and wage employment, whereas the latter only holds on the premise of excluding working on another farm. With this category excluded, Isgut (2004) notes self-employment is less profitable than off-farm wage employment in Honduras. Lanjouw and Murgai (2009) find little evidence of a strong relationship between education and self-employment in India, by analyzing National Sample Survey data over time and using several multinomial logit models. The missing relationship is reasoned due to high heterogeneity of self-employment activities. Cunguara *et al.* (2011), additionally, differentiate between types of wage and self-employment when analyzing participation in off-farm work in Mozambique. They show a diverse effect of education by means of a multivariate sample selection model. Education is positively and significantly related to activities outside the farm sector, yet negatively and significantly with

participation in unskilled agricultural wage activities. According to these results, education also influences income obtained from skilled nonagricultural activities. A review of studies on Africa, by Reardon (1997), indicates a slightly higher share of income obtained by wage employment, compared to self-employment emphasizing the equal importance of wage employment.

As outlined above, empirical literature suggests that self-employment and wage employment are two diverse types of activity (Jolliffe, 2004), and we also assume determinants of these activities to be diverse, shedding light on the distinct nature of these two activities. In particular, this is an extension to the study by Jolliffe (2004) on Ghana disaggregating self-employment and wage employment.

### **7.3 Conceptual framework**

For analyzing the decision of the farmer to participate in off-farm activities, it is necessary to decide on either separability or nonseparability. The first concept implies that agricultural production of the household and consumption decisions are independent of each other (see Rosenzweig, 1980). The decision of the household concerning production and consumption can be analyzed in two stages. The farm household maximizes profits from agricultural production, subject to production constraints, and its full income constraint, with farm profits included, is part of its utility maximization from consumption. Market wages reflect the value of family labor exogenously. Family labor supply is only influenced by production decisions since changes in farm profits exert an income effect (Skoufias, 1994; Abdulai and Regmi, 2000). This assumption implies perfect labor markets, perfect substitutability of family and hired labor, no transaction costs and production decisions of the household, not being influenced by preferences (Bardhan and Udry, 1999: 7; Abdulai and Regmi, 2000).

Nonseparability arises due to imperfect markets, since hiring labor on the farm and participation in off-farm activities is subject to constraints. Family and hired labor differ in their efficiency, and preferences of the farmer influence the decision to work on and off-farm (Lopez, 1986; Singh *et al.*, 1986; Deolalikar and Vijverberg, 1987; Benjamin, 1992). With market failure, labor is nontradable for some households, for the price is determined internally and not by the market (Sadoulet and Janvry, 1995: 150). As a result, the decision to work off-farm and to what extent is not independent of labor requirements of the farm. Barrett *et al.* (2008) even indicate that in the face of various market failures the decision of households deviates from the respective equilibrium in a predictable manner due to risk, transaction costs, and preferences. The shadow wage, instead of the market wage, determines the respective decisions of the household that is the price that would equalize supply and demand of the farmer in case of market existence. The shadow wage is an endogenous function of characteristics and preferences of the household, production technology, fixed inputs and market prices (Singh *et*

*al.*, 1986; Jacoby, 1993; Barrett *et al.*, 2008). Nonseparability implies that exogenous factors influencing agricultural production choices also influence labor supply of the household. One can distinguish between direct effects that happen through changes in the households' shadow profits, and indirect effects that happen through changes in the shadow wages of labor of the family. The latter effect only occurs in a nonseparable model (Skoufias, 1994; Abdulai and Regmi, 2000).

A unitary household model is used. The household allocates time among leisure, farm work and off-farm work that is self-employment and wage employment<sup>42</sup>. The farm household is assumed to maximize utility (7-1) over consumption of goods and leisure:

$$\max U = U(C; Z_u) \quad (7-1)$$

where  $U$  is the farm household's utility function, the vector  $C$  summarizes manufactured goods and home-produced goods ( $C_c$ ) and leisure ( $C_l$ ) and  $Z_u$  are exogenous utility shifters (individual and household characteristics). We assume goods produced on the farm and goods that are purchased are perfect substitutes. The utility function of the household is assumed to be monotone, increasing and concave in each of its arguments, and twice differentiable.

The technology of farm production is given by a twice differentiable, concave production function:

$$Y = Y(X, R, Z_y) \quad (7-2)$$

where  $Y$  is the output produced on the farm, the vector  $X$  consists of variable inputs  $X_v$ , family farm labor  $X_1^f$  and hired labor  $X_h$ ,  $R$  is a vector of fixed factors such as capital and land, and  $Z_y$  are exogenous production shifters (household characteristics).

The farm household is subject to a time constraint:

$$T_t = X_1^f + X_1^s + X_1^w + C_l \quad (7-3)$$

where  $T_t$  is total time available,  $X_1^s$  is time allocated to self-employment in case the farmer is self-employed, and  $X_1^w$  is time allocated to wage employment in case the farmer participates in wage employment,  $X_1^f$  and  $C_l$  are defined as above. Since the farmer might not participate in self-employment and/or wage employment, but cannot work less than zero hours off-farm and also on the farm, we impose a nonnegativity constraint on  $X_1^f$ ,  $X_1^s$  and  $X_1^w$  that is:

---

<sup>42</sup> Even if in the data set there is only a small number of farmers (5) that participates in self-employment and wage employment at the same time, farmers have the possibility to participate in both types.

$$X_1^f, X_1^s, X_1^w \geq 0. \quad (7-4)$$

Next, the farmer is subject to a budget constraint, indicating that total expenditure of the farmer (left-hand side) must not exceed his total income (right-hand side):

$$P_c C_c \leq P_y Y(\cdot) - P_v X_v - W_h X_h + W_s X_1^s + W_w X_1^w + E \quad (7-5)$$

where  $P_c$  is the price of consumption goods purchased in the market,  $P_y$  is the farm output price and  $P_v$  is the price of variable inputs used for agricultural production. From agricultural income, in addition to variable input costs, hired labor costs, indicated by the amount of hired labor  $X_h$  and its respective wage rate  $W_h$ , are subtracted. The household's income is accumulated by time allocated to self-employment multiplied by the wage  $W_s$  and time allocated to wage employment multiplied by the wage  $W_w$ . The vector  $E$  represents non-labor income such as transfers, land rent and assets not related to farming. Equation 7-6 indicates the sum of incomes with costs already subtracted,  $I_A$  is farm income,  $I_W$  income from wage employment,  $I_S$  income from self-employment and  $I_O$  other income.

Substituting (7-3) and (7-4) into (7-5) it follows:

$$P_c C_c + W C_l \leq P_y Y(\cdot) - P_v X_v - W_h X_h + W T_t + E. \quad (7-6)$$

The so-called 'full-income' constraint states that the value of consumption of both goods and leisure must not exceed the value of household's endowments with farm profits included (Bardhan and Udry, 1999: 9).

The household's decision problem can be formulated by making use of equation (7-1), (7-3) and (7-5):

$$L(\cdot) = U(C; Z_u) + \lambda(T_t - X_1^f - X_1^s - X_1^w - C_l) + \mu(P_y Y(\cdot) - P_v X_v - W_h X_h + W_s X_1^s + W_w X_1^w + E - P_c C_c) \quad (7-7)$$

where  $\lambda$  is the Lagrange multiplier linked to the inequality constraints on the work of each labor type and  $\mu$  is the Lagrange multiplier linked to the income inequality constraint. We maximize this Lagrangian function  $L(\cdot)$  with respect to  $X_1^f$ ,  $X_1^s$ ,  $X_1^w$ ,  $X_h$  and  $X_f$  and the multipliers  $\lambda$  and  $\mu$ :

$$\frac{\delta L}{\delta X_1^f} = -\lambda + \mu P_y \left( \frac{\delta Y}{\delta X_1^f} \right) = 0 \quad (7-8)$$

$$\frac{\delta L}{\delta X_i} = -\lambda + \mu W_i = 0, \quad i = s, w \quad (7-9)$$

$$\frac{\delta L}{\delta X_h} = \mu P_y \left( \frac{\delta Y}{\delta X_h} \right) - \mu W_h = 0 \quad (7-10)$$

$$\frac{\delta L}{\delta X_v} = \mu P_y \left( \frac{\delta Y}{\delta X_v} \right) - \mu P_v = 0 \quad (7-11)$$

$$\frac{\delta L}{\delta \lambda} = T_t - X_1^f - X_1^s - X_1^w - C_1 = 0 \quad (7-12)$$

$$\frac{\delta L}{\delta \mu} = P_y Y(\cdot) - P_v X_v - W_h X_h + W_s X_1^s + W_w X_1^w + E - P_c C_c = 0. \quad (7-13)$$

We can rewrite the first-order conditions (7-8), (7-9), (7-10) and (7-11) to:

$$P_y \left( \frac{\delta Y}{\delta X_i^f} \right) = \left( \frac{\delta U}{\delta C_1} \right) / \mu = \lambda / \mu \geq W_i, \quad i = s, w \quad (7-14)$$

$$P_y \left( \frac{\delta Y}{\delta X_h} \right) = W_h \quad (7-15)$$

$$P_y \left( \frac{\delta Y}{\delta X_v} \right) = P_v. \quad (7-16)$$

Equation (7-14) provides conditions for the optimal time allocation for farm work, off-farm work, and leisure. A farm household equates the marginal value of leisure with the marginal value of farm work and this equalization shall not be smaller than the off-farm wage. The term  $\lambda / \mu$  represents the shadow wage that is equal to the market wage in case of complete markets; optimal hours of self-employment and wage employment may be above zero (Huffman, 1991: 96).

Equation (7-15) suggests that the farm household will hire labor up to the point where the marginal product of hired labor is equal to the wage rate, and (7-16) implies that inputs will be used up to the point where the marginal product of inputs is equal to the price of inputs.

The model above assumes complete markets. In addition, production and consumption decisions of the household are separable, and the value of marginal product of off-farm labor participation by type of off-farm activity is equal to an exogenously determined market wage (Singh *et al.*, 1986). As indicated above under nonseparability, the decision to work off-farm and to what extent is not independent of labor requirements of the farm and the shadow wage, instead of the market wage, determines the labor decisions of the household (Singh *et al.*, 1986; Jacoby, 1993). Thus, we introduce market failure in the model as a market labor constraint:  $X_1^i \leq M$ , where  $M$  is the maximum number of hours a farmer can work in the labor market. Given this assumption, it follows with  $i = s, w$ :

$$\frac{\partial U / \partial C_1}{\partial U / \partial C_c} = W_i^* \quad (7-17)$$

$$W_i > \frac{\partial Y}{\partial X_i^f} = \frac{\partial Y}{\partial X_i^i} = W_i^* \quad \text{if } X_1^i = M \quad (7-18)$$



Condition (7-17) indicates the equilibrium condition for the households' utility maximization. Households will equate the marginal rate of substitution between consumption and leisure and the "shadow wage rate"  $W_i^*$ . Equation (7-18) suggests that the shadow wage will be less than the off-farm wage, given labor market is incomplete and off-farm labor constraints are binding. Barrett *et al.* (2008) indicate that the difference between the market wage and the marginal revenue product of labor is predictable based on household characteristics and endowments that is allocative inefficiency. Therefore, there is a difference between the shadow wage and the marginal revenue product of labor being of relevance in the empirical specification.

Applying nonseparability and making use of a shadow wage, the non-linear budget constraint can be replaced by an artificial linear constraint. The household maximization problem of equation (7-1) under the linear budget constraint can then be re-written as:

$$\max U = U(C; Z_u) \quad (7-19)$$

Rewriting equation (7-6) subject to:

$$P_c C_c + W_i^* C_l \leq P_y Y(\cdot) - P_v X_v - W_h X_h + W_i X_i^i(Z) + E \quad (7-20)$$

where the value of the household's total consumption of goods and leisure may not exceed the household's total shadow income  $Y^*$ .

Structural demand functions for leisure and corresponding structural labor supply function are given as with  $i = s, w$ :

$$C_l^* = C_l(W_i^*, Y^*; Z) \quad (7-21)$$

$$T_l^* = T_l(W_i^*, Y^*; Z) \quad (7-22)$$

where  $T_l^*$  equals total hours of work of the household in farm and off-farm activities (wage and/or self-employment)

$$T_l^* = T_t - C_l^* = X_l^{f*} + X_l^{i*} \quad \text{if } X_l^{i*} > 0 \quad (7-23)$$

$$T_l^* = T_t - C_l^* = X_l^{f*} \quad \text{if } X_l^{i*} = 0 \quad (7-24)$$

#### Testing nonseparability

We assess nonseparability by means of the well-known Benjamin (1992) test for differing efficiencies of family and hired labor. The underlying question of this test is whether the combination of hired and family labor affects total labor supply on the farm.

$$\log L = \beta \log W^* + \gamma \log Z + (1-\alpha) \frac{L^H}{L} + \varepsilon \quad (7-25)$$

where  $L$  is total labor supply,  $W^*$  is the shadow wage,  $Z$  are household preferences, and  $\frac{L^H}{L}$  is the fraction of hired labor on the farm. The objective of testing for differing efficiencies of family and hired labor is tested by  $(1-\alpha) = 0$ . We account for possible endogeneity of shadow wage by applying 2SLS<sup>43</sup>.

The test consists of 3 main steps. First, an agricultural production function (Cobb-Douglas) is estimated, second the shadow wage is derived (marginal product of labor), third separability is tested by estimating farm supply (Skoufias, 1994). We account for possible endogeneity of the shadow wage.

The Cobb-Douglas production function can be found in table 7-1.

Table 7-1: Cobb-Douglas production function

Independent variables	Log of farm output
Log hired labour male hours	0.0663*** (0.023)
Log hired labour female hours	0.0134 (0.030)
Log family labour male hours	0.042 (0.032)
Log family labour female hours	0.046 (0.031)
Log land size	0.888*** (0.110)
Log implements	0.188 (0.132)
Livestock dummy	0.368** (0.173)
Age	-0.001 (0.004)
Male	0.239 (0.185)
Education	0.089 (0.090)
Fbo	-0.394*** (0.141)
District	-0.548*** (0.154)
Log Inputs amount*	0.045 (0.042)
Log fertilizer amount*	0.055 (0.074)
Log pesticides amount*	0.122**

<sup>43</sup> Information on estimation of shadow wage can be found in the Annex.

Constant	(0.052) 3.969*** (0.458)
$\chi^2$ -statistic for overidentification	0.484
[p-values]	[0.922]
Observations	375
Adj. R <sup>2</sup>	0.398

Note: Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

\*Instrumented, Instruments used are village farm wage rates for male and females, share of land under ownership, share of children, share of elderly, distance to the market

Estimation of shadow wage:  $W^* = \frac{\alpha \hat{Y}}{F}$ ,

where  $\hat{Y}$  is predicted value of outcome and F are total hours of family labor.

The wage might be subject to endogeneity and estimation can be found in the Appendix<sup>44</sup>.

Table 7-2: Benjamin test 2SLS

Independent variables	Log Farm labor
Log wage*	-0.288*** (0.093)
Log fertilizer amount	0.272*** (0.065)
Log Fraction_hlabour	-0.055 (0.082)
Share_madults	0.033 (0.236)
Share_fadults	0.111 (0.328)
Share_elderly	-0.653 (1.102)
Log Inputs amount	0.039 (0.032)
Log Pesticides amount	-0.006 (0.065)
Log Implements	0.154** (0.075)
Log Land area	0.037*** (0.010)
Age	-0.002 (0.004)
Education	-0.106 (0.081)
District	0.027 (0.127)
Constant	4.724*** (0.36)

Observations	238
Adjusted R <sup>2</sup>	0.285

Note: \* predicted value, Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The results of the instrumental variable estimation reveal the effect of the fraction of hired labor to be insignificant. Therefore, the hypothesis of  $(1-\alpha) = 0$  cannot be rejected implying separability. In addition, the other two labor variables share of male adults on the farm and share of female adults on the farm are also not significant. The result is in line with the assumption of separability applied by Abdulai and Delgado (1999) on farmers in Northern Ghana, however, contradictory to the test of separability applied by Jolliffe (2004) on Ghanaian farmers. Still, Jolliffe (2004) bases her decision on the joint significance of household characteristics, neglecting the effect of fraction of hired labor.

Another test is the one proposed by Le (2010) representing a generalized test on separability combining both the Benjamin and Jacoby test (1993) that tests the equality of market wage and shadow wage. In this study we also apply the approach of Le's generalized test in the context of Ghana:

$$\log(pQ/L) = -\log(\sigma) + \beta \log(w) + \alpha Z + \xi \tag{7-26}$$

where  $(pQ/L)L$  is value of farm output per labour,  $w$  is the market wage and  $Z$  are household preferences, The objective of testing for separability is tested by  $\beta=1$  and  $\alpha=0$ . We account for possible endogeneity of market wage by 2SLS.

Table 7-3: Le's Generalized test 2SLS

Independent Variables	Log(Value of Output/Farm labour)
Log Wage*	2.588** (0.820)
Share_elderly	3.556 (3.196)
Share_fadults	-0.688 (1.062)
Share_madults	0.334 (0.782)
Log Fert_amount	-0.029 (0.174)
Log Pest_amount	0.159 (0.125)
Log Inputs_amount	0.044 (0.109)
Log Implements	-0.388 (0.230)
Pltsize_all	0.064** (0.027)
District	-0.632 (0.419)

Constant	0.971 (0.759)
$\chi^2$ (4) -statistic [p-value]	4.08 [0.395]
Observations	369
Adjusted R <sup>2</sup>	0.890

Note: \* predicted value; instruments: education, population density proxied by two villages kintampo and awaropat (according to Le and Jacoby) ; Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

The results of the instrumental variable estimation reveal the effect of wage is significantly different from 1 and the preference shifters are insignificant. The joint Wald test of  $\beta=1$  and  $\alpha=0$  can also not be rejected with the  $\chi^2$  -statistic of 4.08 [0.395]. The test statistic is smaller than the upper critical value of 11.14 and larger than the lower critical value of 0.48. Separability requires that the coefficient on log wage is 1 and the coefficients on the preference shifters are 0. Le's test is a combination of two individual tests, where the first uses the relationship between production decisions and preferences and the second uses the relationship between shadow wages and market wages. Le's test is based on a generalized specification of the shadow wage  $\log(w^*) = \beta \log(w) + \alpha A$ , with  $w^* = w$  under separability (Le, 2010). As indicated above in case of nonseparability, the decision to work off-farm and to what extent is not independent of labor requirements of the farm and the shadow wage.

As already indicated, the results are contradictory to Joliffe (2004) in Northern Ghana, However, this test has not yet been applied in the respective study and only considers one part of separability. Both tests do not reject separability, indicating independence of production and consumption decision of rural households in Ghana.

## 7.4 Empirical specification

We want to estimate the decision of the farmer  $j$  to participate in self-employment,  $i = s$ , and/or wage employment,  $i = w$ . Following the theoretical model in section 7.3, in case the market wage ( $W_{ij}^m$ ,  $i = s, w$ ) of a household's off-farm time is greater than the respective shadow value ( $W_{ij}^r$ ,  $i = s, w$ ) of time on the farm, we observe positive hours of self-employment (wage employment). We define the empirical reservation wage and off-farm wage equations the following (Huffman, 1991: 99; Abdulai and Delgado, 1999):

$$W_{ij}^r = \beta_1 Z_{rij} + \varepsilon_{rij}, i = s, w \quad (7-27a)$$

$$W_{ij}^m = \beta_2 Z_{mij} + \varepsilon_{mij}, i = s, w \quad (7-27b)$$

where  $Z_{rij}$  and  $Z_{mij}$  are exogenous explanatory variables (individual and household characteristics) that influence reservation and off-farm wages, and  $\varepsilon_{rij}$  and  $\varepsilon_{mij}$  are error terms.

We define an indicator  $N_{ij}$  for the farmer  $j$  to participate in self-employment (wage employment):

$$N_{ij}^* = \begin{cases} 1 & \text{if } W_{ij}^m > W_{ij}^r \\ 0 & \text{otherwise} \end{cases}, i = s, w \quad (7-28)$$

Due to  $\varepsilon_{rij}$  and  $\varepsilon_{mij}$  being random variables, the probability of participating in self-employment (wage employment) for farmer  $j$  can be written as:

$$\begin{aligned} pr(N_{ij}^* = 1) &= pr(W_{ij}^m > W_{ij}^r) \\ &= pr(\varepsilon_{rij} - \varepsilon_{mij} < \beta_2 Z_{mij} - \beta_1 Z_{rij}) \\ &= F_v(\beta Z_{ij}) \end{aligned} \quad (7-29)$$

where  $v_{ij}$  is the difference of  $\varepsilon_{rij} - \varepsilon_{mij}$ , and  $\beta Z_{ij}$  of  $\beta_2 Z_{mij} - \beta_1 Z_{rij}$ , and  $F(\cdot)$  is a cumulative distribution function for the random variable  $v$ . Variables that increase the reservation wage, reduce the probability to be engaged in off-farm activities, and variables that increase the off-farm wage increase the probability to participate in off-farm activities (Huffman, 1991: 99). We estimate the probability to be self-employed and the probability to participate in wage employment jointly, since these decisions are likely to be interrelated (see Atamanov and van den Berg, 2012). For this reason, we account for correlation ( $\rho$ ) in the unobservable variables across the two equations (Wooldridge, 2010: 442). Under the null hypothesis  $\rho$  is equal to zero and the model comprises independent probit specifications. Separate estimation of these equations is provided herein below. However, in case of significance of  $\rho$  a bivariate probit model shall be used (Greene, 2008: 820).

## 7.5 Hypothesis

Off-farm activities, i.e. self-employment and wage employment, are assumed to exert an influence on farmers' decision to invest in soil conservation measures. These effects can be either positive or negative and can vary according to the type of investment (see Davis *et al.*, 2009). Due to differing natures of self-employment and wage employment (Woldenhanna and Oskam, 2001), diverse effects on investment behavior are likely.

## 7.6 Results and discussion

### 7.6.1 Descriptive Results

Table 7-4 presents descriptive statistics of off-farm activities of the farmer.

Table 7-4: Off-farm activities

Variable	Definition	Mean	S.D.
Selfempl	1 if farmer is self-employed, 0 otherwise	0.26	0.42
Wageempl	1 if farmer participates in wage employment, 0 otherwise	0.25	0.43
Selfhrs	Hours spent per day on self-employment	6.55	4.63
Wagedays	Number of days used for wage employment per month	18.03	11.34
Income_selfempl	Income from self-employment in 2009 (GHS)	359.62	855.33
Income_wage	Income from wage employment in 2009 (GHS)	902.77	1140.21

Ghanaian Cedis (GHS). Exchange rate: €1 = ₵3.6 in 2014

Source: Survey data

Out of the 49% of farmers participating in off-farm activities, nearly equal shares are self-employment and wage employment, with a low share of farmers (5) being engaged in both types of off-farm activities. Self-employment includes activities such as selling food, having a retail shop or charcoal production, whereas wage employment includes working for private employers or government, and working on another farm as hired help. Those who are self-employed spend an average of nearly seven hours per day at work, indicating a large amount of this valuable resource —time— is spent there. Wage employment implies working, on average, 18 days per month. For those participating in off-farm activities, income from wage employment is highest with on average ₵900 per year, whereas self-employment only accounts for an average yearly income of ₵360<sup>45</sup>. However, for wage-employment we observe a high variance, with those working on another farm having the lowest income, and those working for the government having well-paid off-farm opportunities.

In Chapter 3, we included off-farm activities in the investment specification. Now, we want to refer to the linkages between participation in off-farm activities and investment in soil conservation measures again by means of descriptive statistics and additionally with breaking down off-farm activities into self-employment and wage employment.

<sup>45</sup> Some even made no income, as the costs of the business were higher than income generated. Income referred to is net income.

Table 7-5: Cross-tabulation self-employment and incidence of investment

	Ditches =0	Ditches =1	Fertilizer =0	Fertilizer =1	Manure =0	Manure =1	Mult. Crop. =0	Mult. Crop. =1
Selfempl=0								
Frequency	387	192	405	174	494	85	273	308
Expected Frequency	393	186	399	179	487	92	276	305
Selfempl=1								
Frequency	128	51	117	61	143	35	87	91
Expected Frequency	122	57	123	55	150	28	84	93

Table 7-6: Cross-tabulation wage employment and incidence of investment

	Ditches =0	Ditches =1	Fertilizer =0	Fertilizer =1	Manure =0	Manure =1	Mult. Crop. =0	Mult. Crop. =1
Wageempl=0								
Frequency	401	205	429	177	516	90	290	318
Expected Frequency	412	194	418	188	510	96	288	320
Wageempl=1								
Frequency	114	38	93	58	121	30	70	81
Expected Frequency	103	49	104	47	127	24	72	79

In table 7-5 we observe that those being self-employed are expected to invest less in fertilizer and manure when comparing the expected frequencies with what they do underlining the positive results of off-farm activities on investment choices in the investment specification. Although, labor intensive conservation practices such as ditches and multiple cropping are less prevalent with self-employed farmers than expected. In table 7-6, being engaged in nonagricultural wage employment and at the same time investing in mineral fertilizer and multiple cropping is more often observed than expected. In the investment specification, we do find a strong relationship between off-farm activities and investment options. Money earned seems to be used for buying fertilizer and crops for multiple cropping. So, we partly reinforce the results obtained from the investment specification and shed some more light on the complexity of off-farm activities.

#### Variables included in the model

The decision of the farmer to participate in off-farm work is measured by two dummy variables that take the value 1 for working off-farm and zero otherwise. Variables included in the model



explaining participation in self-employment and wage employment, are based on previous research (see section 7.2) and are presented in table 7-5.

Individual characteristics are included, such as age, years of formal education, and gender. Education represents human capital and can be beneficial for both, off-farm activities and farm business. Gender reveals differences between the two types of activity and indicates possible disadvantages for women (Abdulai and Delgado, 1999; Ellis, 2000; Ruben and van den Berg, 2001). Social capital is represented by membership of an fbo. Given the positive effect of an fbo on investment behavior of the farmer, the effect on off-farm activities is examined, since social capital might enhance access to off-farm activities (Ellis, 2000). Number of people with money the farmer knows to get assistance from in cases of need is used to proxy for access to monetary means.

Household characteristics included are size of land the farmer is cultivating, ownership of land, value of cattle the farmer owns and household composition. Land size is linked to labor abundance. Ownership of land and cattle represent wealth of the farmer, having been pointed out to be crucial for access to some types of off-farm activities. Household composition controls for the possible role the number of dependents and adults in the household play in decision making of the farmer (Reardon, 1997; Barrett *et al.*, 2005; Lay *et al.*, 2008).

Variables related to location are distance to the market and district of the farmer. The first represents possible transaction costs of access to labor and the latter regional labor market conditions (Abdulai and Delgado, 1999).

In the estimation, the problem of omitted variable bias might appear. Variables that are not included in the model but are correlated to independent variables produce biased and inconsistent estimates. Since we include variables based on previous research and cover a wide range of determinants, we can be confident in not being exposed to the problem of omitted variable bias.

Table 7-7: Descriptive statistics for variables used in the empirical analysis

Variable	Variable definition	Mean	S.D.
<i>Dependent variables</i>			
Selfempl	1 if farmer is self-employed, 0 otherwise	0.27	0.44
Wageempl	1 if farmer participates in wage employment, 0 otherwise	0.25	0.43
<i>Independent variables</i>			
Age	Age of farmer (years)	47.36	13.15
Educyrs	Years of formal education of farmer	3.84	4.89
Male	1 if farmer is male, 0 otherwise	0.85	0.36
Landsize	Size of land farmer is cultivating (acres)	6.95	9.19
Owner_land	1 if farmer owns (restricted and unrestricted ownership) land, 0 otherwise	0.51	0.50
Children6	Number of children under 6 years old	0.60	0.77
Children14	Number of children between 6 and 14 years old	2.02	1.50
HH-size	Number of household members above 14 years old	3.58	1.69
Cattle	Value of cattle (GHS*0.01)	2.88	12.74
Fbo	1 if farmer is member of an fbo, 0 otherwise	0.30	0.46
Monasall	Number of individuals who would assist farmer with money if needed	1.22	2.18
Distm	Distance to the nearest market (km)	6.39	4.80
District	1 if farmer resides in district Kintampo North, 0 Techiman	0.57	0.50
Observations		326	

Ghanaian Cedis (GHS). Exchange rate: €1 = c3.6 in 2014

Source: Survey data

### 7.6.2 Empirical Results

The results of the maximum likelihood bivariate probit model of the farmer's decision to participate in self-employment and/or wage employment are presented in table 7-8. The marginal effects of the regressors on the probability to participate in each type of off-farm activity, calculated at the mean of the regressors, are also presented in the table<sup>46</sup>. We employ heteroscedasticity-robust standard errors.

The log-likelihood ratio statistic is 65.91 and is significant at the 1% level, suggesting that the independent variables taken together influence the decision of the farmer to participate in off-farm activities<sup>47</sup>. The cross-equation correlation coefficient is -0.628 and is statistically significant at the 1% level. This shows that it is more efficient to estimate the decision to participate in both types of off-farm activities jointly, since both decisions are not statistically independent. Unobservables that enhance participation in self-employment reduce the probability to participate in wage employment

<sup>46</sup> The delta method has again been applied to estimate the standard errors, due to nonlinearity of the model. The marginal effect is the marginal probability for each outcome only, and not conditional on the other outcome.

<sup>47</sup> We test multicollinearity of the explanatory variables (see table in the Annex), test statistics reveal no problem of highly correlated variables.

Table 7-8: Bivariate probit estimates and marginal effects of decision to work off-farm

Variables	Selfempl	Marginal effects	Wageempl	Marginal effects
Age	-0.017*** (0.007)	-0.005 (0.002)	-0.006 (0.007)	-0.002 (0.002)
Educyrs	0.028* (0.017)	0.009 (0.005)	0.013 (0.017)	0.004 (0.005)
Male	-0.727*** (0.217)	-0.259 (0.078)	0.822*** (0.294)	0.189 (0.044)
Landsize	-0.010 (0.011)	-0.003 (0.003)	-0.006 (0.011)	-0.002 (0.002)
Owner_land	0.321* (0.168)	0.100 (0.051)	-0.113 (0.170)	-0.034 (0.050)
Children6	0.228 (0.142)	0.072 (0.045)	-0.030 (0.143)	-0.009 (0.042)
Children14	-0.064 (0.075)	-0.020 (0.024)	0.030 (0.071)	0.009 (0.022)
HH-size	0.007 (0.051)	0.002 (0.017)	0.017 (0.052)	0.005 (0.015)
Cattle	-0.003 (0.010)	-0.001 (0.002)	0.011* (0.006)	0.003 (0.002)
Fbo	-0.267 (0.184)	-0.080 (0.051)	0.391** (0.177)	0.123 (0.057)
Monasall	0.081** (0.035)	0.025 (0.001)	-0.085** (0.0426)	-0.025 (0.012)
Distm	-0.001 (0.017)	-0.0004 (0.006)	-0.039** (0.0193)	-0.012 (0.066)
District	0.074 (0.174)	0.023 (0.053)	-0.040 (0.171)	-0.012 (0.050)
Constant	0.469 (0.459)		-0.994** (0.480)	
Cross-equation correlation				
$\rho_{SW}$		-0.628***		
Log-likelihood ratio statistic <sup>a</sup>		65.91 > $\chi^2_{0.01}[26]$		
Observations	326		326	

Note: Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

<sup>a</sup> The log-likelihood ratio statistic is given by  $LR = 2(L_{\Omega} - L_{\omega})$  where  $L_{\Omega}$  is the unrestricted maximum likelihood and  $L_{\omega}$  is the restricted maximum likelihood with an asymptotic  $\chi^2(k)$  distribution where k is the number of restrictions.

Individual characteristics influence the decision of the farmer to participate in off-farm activities. The variable age is negative for off-farm activities but only significant for self-employment<sup>48</sup>, according to findings by Ruben and van den Berg (2001) and Lay *et al.* (2008). Formal years

<sup>48</sup> We also test on a possible life cycle effect (see Abdulai and CroleRees, 2001). Since we do not find one, this was not included in the model. In addition, ethnicity has been mentioned as one factor explaining participation in non-farm work (see Abdulai and Delgado, 1999). However, after including ethnic identity with this not significant variable, results deteriorated.

of education are positively associated with both off-farm activities but only significant for self-employment, as it has been pointed out by other empirical studies (Abdulai and Delgado, 1999; Escobal, 2001). Specifically, additional education increases the 'wage' for self-employment more than it increases the reservation wage for farm activities (Abdulai and Delgado, 1999). This is an important finding and reveals that the role of education needs to be analyzed in detail and cannot be considered for the aggregate off-farm work as has been done by Jolliffe (2004) in Ghana. However, Woldenhanna and Oskam (2001) did not find any significant positive effect of education on both types of off-farm activities for Nigeria. This might be due to policy and NGO interventions in the off-farm labor market (Berhanu *et al.*, 2007).

Self-employment is more likely among female farmers and wage employment among male farmers. The activities representing self-employment and wage employment seem to differ in their gender suitability, with no evidence of women being disadvantaged with respect to off-farm activities. The findings are consistent with results reported by Ruben and van den Berg (2001) for Honduras.

Assets determine the decision of the farmer to participate in off-farm activities. Ownership of land is positively and significantly associated with self-employment, possibly due to wealth that is necessary to set up a business. Off-farm activities that are capital intensive are mainly undertaken by wealthier households with a stock of assets (Reardon, 1997). The value of cattle, the highest value livestock, is positive and significant for wage employment. Wage employment covers a broad range of job options, some of them are linked to high income and certainly only accessible by wealthier households. The finding is in line with empirical results by Lay *et al.* (2008) in regard to participation in high-return activities in Kenya. However, findings by Ruben and van den Berg (2001) suggest livestock limits access to off-farm activities on account of the constant care needed. Membership of an fbo is a positive significant predictor of wage employment. The fbo might act as a broker in order to find wage employment possibilities, especially those working on another farm, enhancing access.

Access to monetary assistance shows diverse results, as indicated in the literature with respect to access to credit (Reardon, 1997; Ellis, 2000). The variable number of people with money the farmer knows to get assistance from in case of need, also constituting a social network, appears to be positive and significantly different from zero for self-employment due to set-up costs. The result is to be compared to Escobal (2001), who similarly finds that access to credit facilitates access to self-employment. However, the variable is negative and significant for wage employment. Therefore, monetary constraints are overcome and monetary assistance is substituted by wage employment. These results underline the categorization of self-employment and wage employment by Woldenhanna and Oskam (2001). The first is linked to high returns and pull factors, whereas the latter is linked to push factors. Yet, the asset cattle

that appears to be a positive and significant determinant of wage employment suggests this category to be a heterogeneous one. Farm wage employment is used by poor households to stabilize income, whereas off-farm wage employment is linked to households that diversify income. For that to be feasible, resources need to be available to compensate for the family member not working on the farm (Ruben and van den Berg, 2001) <sup>49</sup>.

Demographic variables of the household are not significant determinants of participation in off-farm activities. Number of children with no negative effect suggests other family members look after their children in case the parents spend time off-farm (Matshe and Young, 2004). These results are consistent with findings from several other empirical studies (e.g. Abdulai and CroleRees, 2001; Lay *et al.*, 2008).

Location matters for wage employment, distance to the market is negatively and significantly associated with wage employment. In less remote areas, off-farm opportunities increase and participation is more likely, whereas remote areas increase costs of participation (Abdulai and CroleRees, 2001). However, being close to the market also enhances farm profitability, since agricultural products can be sold more easily (Lay *et al.*, 2008). The positive significant effect on wage employment indicates that the latter effect does not override the first. For self-employment, distance is not significant and suggests that remoteness is not hindering farmers from becoming self-employed, and it is more probable that regional infrastructure plays an important role (Canagarajah *et al.*, 2001), due to data limitations not addressed here. The same diverse effect for closeness to urban areas on each type of off-farm activity has been found by Isgut (2004) for Honduras.

## **7.7 Summary and conclusions**

This chapter analyzes both the influence of participation in off-farm activities on investment behavior, and the determinants of participation in self-employment and wage employment. The first objective is analyzed by means of descriptive analysis. Participation in off-farm activities is analyzed under the assumption of separability after having tested for the separability hypothesis. Self-employment and wage employment are determined by a bivariate probit model differing in their determinants.

The descriptive analysis underlines the results of the investment specification in Chapter 3. Self-employment is negatively related to some investment decisions, whereas wage employment is positively related to investment decisions. Results of the bivariate probit model indicate that younger, female and better educated farmers that own land and receive financial

---

<sup>49</sup> The differentiation between farm wage employment and non-farm wage employment is not feasible, since the share of those belonging to the first category is too small to draw inferences from.

assistance are more likely to be self-employed. Monetary assistance is negatively associated with wage employment, suggesting this activity is one of the means of overcoming cash constraints, whereas, in cases of self-employment, it might act as a precondition possibly due to start-up costs. However, ownership of cattle significantly increases the likelihood to participate in wage employment, which suggests wage employment is a heterogeneous concept.

The empirical findings lend support to the notion that entry barriers exist for both types of off-farm activities for households that have few, if any, other assets. Membership of an fbo makes participation in wage employment more likely, probably due to fbos acting as a broker in order to find employment possibilities. A smaller distance to the market has also been found to facilitate access to wage employment, which can be explained by more off-farm opportunities in less remote areas.

Information of this chapter is essential for policy makers in order to foster both self-employment and wage employment by accounting for interrelations to investment on the farm.

## Annex

Table 7-1: First – stage estimation shadow wage in order to account for possible endogeneity

Independent variables	Shadow wage (predicted value)
Wage_nonfarm_village*	-0.660*** (0.210)
Log fertilizer amount	2.273*** (0.440)
Log Fraction_hlabour	2.430*** (0.449)
Share_madults	-1.147 (2.053)
Share_fadults	-0.0910 (2.881)
Share_elderly	4.953 (10.461)
Log Inputs amount	-0.565** (0.277)
Log Pesticides amount	-3.128 (0.362)
Log Implements	0.610 (0.642)
Log Land area	0.278** (0.084)
Age	-0.062* (0.036)
Education	-0.719 (0.722)
District	0.325 (1.192)
Constant	9.025*** (02.702)
Observations	238
Adjusted R <sup>2</sup>	0.2302

\*average off-farm income on the village level; Benjamin uses population density that is not available in our data set, we used in line with Le (10) the commune wage rate.

Table 7-2: Variance inflation factors bivariate probit

Variable	VIF <sup>a</sup>
Age	1.19
Educyrs	1.17
Male	1.06
Landsize	1.11
Ownership_land	1.15
Children6	1.98
Children14	1.87
HH-size	1.23
Cattle	1.05
Fbo	1.11
Monasall	1.05
Distm	1.10
District	1.21
Mean VIF	1.25

<sup>a</sup>The VIF is defined as:  $VIF_j = \frac{1}{1-R_j^2}$  where  $R_j^2$  is the  $R^2$  belonging to the regression of the  $j$ th explanatory variable on the remaining explanatory variables

All individual VIF values and the mean VIF are far below 10, a value where one has to worry about multicollinearity.



## **8 Conclusions from the study**

### **8.1 Summary of findings**

Tenure arrangements have gained attention as a way to understand investment in soil conservation measures. The presented study provides some important policy implications. We observe a negative effect of rentership on investment with positive long-term effects and positive effects attributed to the increase in length of time a farmer has been using a plot. Providing farmers with secured tenure arrangements and extending temporary rights would facilitate investment in soil conservation measures, in turn, increasing agricultural productivity. Investment in institutions, such as fbos and extension services, that enhance access to information and assistance, and communicate the positive effects of soil conservation measures on revenues, could be promising in light of the empirical results.

The main goal of the study has been to gain insight into the impact of land tenure arrangements on farmers' investment decisions in soil conservation measures. Results of the multivariate probit model which explain investment decisions at plot-level, while controlling for endogeneity of tenure arrangements, social capital, and off-farm activities, reveal that farmers who rent land are less likely to invest in manure, a soil improving investment option with positive long-term effects. Farmers on sharecropping contracts and under fixed-rentership are more likely to invest in fertilizer, a short-term investment option decreasing soil quality over time. The number of years the plot is under use by the cultivator is positively associated with all investment options, supporting the notion of tenure security as an important factor when investing in soil conservation measures.

Investment is driven by social networks. Being part of information networks as well as networks related to other types of assistance is positively related to nearly all investment options. These results are consistent with the theoretical framework which suggests that the positive effect of social networks occurs through a reduction in transaction costs.

Off-farm employment increases the likelihood of investment in fertilizer, manure and multiple cropping. Income obtained from off-farm activities might be used to overcome monetary and labor constraints, therefore enhancing investment.

The crucial role of human capital for progress in the agricultural sector is indicated by education revealing a nonlinear pattern.

Generally, the results support the call for improved tenure security for farmers. This can be done in different ways, for example, by land registration programs or offering long-term contracts to tenants. Long-term contracts seem to be especially appealing based on our study results. The effects of social networks and off-farm work along with statements by farmers revealing access to credit and inputs as major obstacles of investment show that several factors influence investment. Solving the issue of tenure security alone is not enough. Investments in institutions which provide information and social interaction, like fbos or extension officers, and in institutions which provide access to credit and off-farm employment, need to be considered in order to enhance sustainability in agriculture.

A descriptive analysis is used to further explore the relationship between social capital and investment decisions. Several different types of social capital appear to be positively associated with investment in soil conservation measures. Additionally, principal component analysis is applied in order to structure constraints on investment of the farmer, assessed by a Likert-Scale, and to complement the quantitative analyses. The five extracted components represent diverse aspects of the constraints: lack of expertise, liquidity, practical assistance, tenure security and profitability of investment. We compare these constraints by different levels of social capital and across different tenure arrangements. Social capital is positively linked to feeling less constrained. Having trust in the community and participation in several social networks is partly negatively associated to different types of constraints. The comparison of these components between tenure arrangements reveals differences in constraints. As expected, farmers on sharecropped and fixed-rented plots feel more tenure constrained compared to farmers on plots that are owner-cultivated. The same relation holds true for unprofitable options.

Plot-level productivity is determined through an instrumental variable approach. We uncover no evidence that both tenure arrangements and social capital are significant determinants of productivity. Having a mobile phone increases productivity, which indicates the relevance of communication in raising productivity. Individual and household characteristics only matter to a minor extent for productivity. Credit is no significant determinant of productivity, which might be due to the low number of observations of farmers having access to credit. A household fixed effects model has also been applied, in order to control for unobservables at the household-level influencing productivity. However, tenure arrangements, again, do not significantly influence productivity.

The impact of investment on plot-level productivity is examined by the non-parametric approach, propensity score matching, in order to account for selectivity bias. Estimates reveal that investment in ditches, fertilizer and multiple cropping, significantly increase revenues per acre on plot. The effect of investment in manure is positive, but insignificant.

The decision of the farmer to participate in self-employment and wage employment is determined by a bivariate probit model. Self-employment and wage employment differ in their determinants. Results indicate that younger, female and better educated farmers that own land and receive financial assistance are more likely to be self-employed. Monetary assistance is negatively associated with wage employment, suggesting this activity is one of the means of overcoming cash constraints. However, ownership of cattle significantly increases the likelihood to participate in wage employment, which indicates wage employment is a heterogeneous concept. These findings lend support to the notion that entry barriers exist for both types of off-farm activities for households that have few assets. Membership of an fbo makes participation in wage employment more likely, probably due to an fbo acting as a broker in order to find employment possibilities. A smaller distance to the market has also been found to facilitate access to wage employment, which can be explained by more off-farm opportunities in urban areas.

## **8.2 Conclusions and policy implications**

Tenure arrangements are a significant driver of investment decisions and secured tenure arrangements would foster sustainable growth in agriculture. Extending temporary rights would facilitate investment, as the years the plot is under use by the cultivator increases likelihood to invest in soil conservation measures.

Similarly, social capital is positively associated with investment. Hence, promoting soil conservation measures might provide a leverage point to policy makers. One option is investment in institutions facilitating information and assistance, for instance helping farmers building fbos.

Off-farm activities do influence investment decisions positively, there is further need to analyze the effect of these activities in different parts of the population in order to build the right incentive structures. While education is only positive and significant above the average number of years of education, it still underpins the crucial role of human capital. Investment in education provides a payoff in the form of decision making on the farm.

Taking into consideration the results of the impact analysis, those farmers investing on their plot and in measures with long-term effects do obtain higher revenues than those who do not invest. These results can be used as a powerful message to communicate to farmers. Given the positive influence of social capital, this could be achieved by means of social networks like fbos or also just within farmer communities. Social networks can facilitate spreading the positive effects of soil conservation measures.

The determinants of self-employment and wage employment show that human capital is also important for access to off-farm work, especially self-employment. Since for both types of off-farm activities, the ownership of assets enhances participation, access to off-farm activities could be facilitated for those with few assets. One way could be improved education in order to compensate for limited capital ownership. Results clearly suggest that access to monetary means fosters self-employment participation, which brings the relevance of credit access to the fore. Qualitative analysis suggests a widespread lack of access to credit. Provision of monetary means on a small-scale, for example through microcredit, could be a way to stimulate both investment and productivity on the farm as well as participation in off-farm activities, given this makes sense from a macroeconomic perspective.

### **8.3 Suggestion for future research**

Investment decisions should not only be viewed from the economic perspective. One fruitful collaboration would be a project with agricultural science to go into detail with respect to biophysical processes. Investment in soil conservation measures could be optimized by viewing it from different relevant perspectives and with different expertise.

Tenure arrangements should be analyzed over a period of time. The theoretical framework for investment is based on a dynamic perspective, yet cross-sectional data is used due to time and resource constraints. In order to assess the effects of tenure over time, panel data would be best.

Future research should focus on the amount of investment in determining the effect of land tenure arrangements. It is crucial to understand the effect of tenure, not only on the decision to invest, but to also whether the investment was optimal. The theoretical framework captures the amount of investment, yet in the empirical analysis only binary data is used.

Social capital linked to access to information turned out to be crucial for investment. Further research is needed to analyze the economic impacts of social learning and how to leverage it best. Detailed information on flows of information and social interaction connected to it would be beneficial in setting-up the right social structures for social learning.

With respect to determinants of off-farm activities, infrastructure and location have been proven to be important. However, data about infrastructure and location was limited within the data set since this was not the main focus of the study. Concentrating on off-farm activities, additional locational information would probably assist in explaining the decision of the farmer to be engaged in off-farm activities.

Macroeconomic research is needed to understand the implications of, on the one hand increasing off-farm activities off-farm activities growing, and on the other hand the need for sustainable growth in agriculture. Research needs to focus on understanding how to incentivize different parts of the population in different ways to sustainably grow agriculture while growing the overall economy at the same time.

## References

- Aakvik, A. (2001) Bounding a matching estimator: the case of a Norwegian training program. *Oxford Bulletin of Economics and Statistics* 63 (1), 115-143.
- Abadie, A. and Imbens, G.W. (2006) Large Sample Properties of Matching Estimators for Average Treatment Effects. *Econometrica* 74 (1), 235-267.
- Abdulai, A. and Delgado, C.L. (1999) Determinants of Nonfarm Earnings of Farm-Based Husbands and Wives in Northern Ghana. *American Journal of Agricultural Economics* 81 (1), 117-130.
- Abdulai, A. and Regmi, P.P. (2000) Estimating labour supply of farm households under nonseparability: empirical evidence from Nepal. *Agricultural Economics* 22 (3), 309-320.
- Abdulai, A. and CroleRees, A. (2001) Determinants of income diversification amongst rural households in Southern Mali. *Food Policy* 26 (4), 437-452.
- Abdulai, A., Owusu, V. and Goetz, R. (2011) Land Tenure Arrangements and Investment in Land Measures: Theoretical and Empirical Analysis. *Journal of Development Economics* 96 (1), 66-78.
- Abdulai, A. and Goetz, R. (2014). Time-related Characteristics of Tenancy Contracts and Investment in Soil Conservation Practices. *Environmental Resource Economics* 59 (1); 87-109.
- Abdulai, A. and Huffman, W.E. (2005). The Case of Crossbred Cow Technology in Tanzania. *American Journal of Agricultural Economics* 87 (3), 45-659.
- Abdulai, A. and Huffman, W.E. (2014). The Adoption and Impact of Soil and Water Conservation Technology: An Endogenous Switching Regression Application. *Land Economics* 90 (1); 26-43.
- Acock, A.C. (2008) *A Gentle Introduction to STATA*. Lakeway Drive, Texas: Stata Press.
- Adam, F. and Roncevic, B. (2003) Social capital: recent debates and research trends. *Social Science Information* 42 (2), 155-183.
- AgriInfo (2011) *Crop rotation and its factors and advantages*. Available at: <http://agriinfo.in/?page=topic&superid=1&topicid=490>. (Accessed: 10 April 2012).

- Agwe, J., Morris, M. and Fernandez, E. (2007) *Africa's Growing Soil Fertility Crisis: What Role for Fertilizer?* Agriculture and Rural Development Notes. World Bank. Available at: <http://siteresources.worldbank.org/INTARD/Resources/fertilizernote.pdf>. (Accessed: 20 May 2012).
- Agyeman, V.K., Marfo, K.A., Kasanga, K.R., Danso, E., Asara, A.B., Yeboah, O.M. and Agyeman, F. (2003) Revising the taungya plantation system: Non-revenue sharing proposals from Ghana. *Unasyiva* 212 (54), 40-47.
- Aker, J.C. (2011) Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. *Agricultural Economics* 42 (6), 631-647.
- Ali, D.A., Dercon, S. and Gautam, M. (2011) Property rights in a very poor country: tenure insecurity and investment in Ethiopia. *Agricultural Economics* 42 (1), 75-86.
- Ali, A., Abdulai, A. and Goetz, R. (2012) Impacts of tenancy arrangements on investment and efficiency: evidence from Pakistan. *Agricultural Economics* 43 (6), 1-13.
- Amanor, K.S. (1999) *Global Restructuring and Land Rights in Ghana. Forest Food Chains, Timber and Rural Livelihoods*. Vol. 108. Uppsala: Nordiska Afrikainstitutet.
- Amare, M., Asfaw, S. and Shiferaw, B. (2012) Welfare impacts of maize-pigeonpea intensification in Tanzania. *Agricultural Economics* 43 (1), 27-43.
- Amsalu, A. and Graaff de, J. (2007). Determinants of adoption and continued use of stone terraces for soil and water conservation in an Ethiopian highland watershed. *Ecological Economics* 62, 294-302.
- Arcand, J.-L., Ai, C. and Ethier, F. (2007) Moral hazard and Marshallian inefficiency: Evidence from Tunisia. *Journal of Development Economics* 83 (2), 411-455.
- Arnot, C.D., Luckert, M. K. and Boxall, P.C. (2011) What is Tenure Security? Conceptual Implications for Empirical Analysis. *Land Economics* 87 (2), 297-311.
- Atamanov, A. and van den Berg, M. (2012) Participation and returns in rural nonfarm activities: evidence from the Kyrgyz Republic. *Agricultural Economics* 43 (4), 457-469.
- Atwood, D.A. (1990) Land Registration in Africa: The Impact on Agricultural Production. *World Development* 18 (5), 659-671.
- Augurzky, B. and Schmidt, C. (2001) The propensity score: a means to an end. *Discussion Paper No. 271*, IZA.

- Austin, G. (2005) *Labour, Land and Capital in Ghana. From Slavery to Free Labour in Asante, 1807-1956*. New York: University of Rochester Press.
- Bababunde, R.O. and Qaim, M. (2010) Impacts of off-farm income on food security and nutrition in Nigeria. *Food Policy* 35 (4), 303-311.
- Backhaus, K., Erichson, B., Plinke, W. and Weiber, R. (2006) *Multivariate Analysemethoden. Eine anwendungsorientierte Einführung*. Berlin: Springer.
- Bandiera, O. and Rasul, I. (2006) Social Networks and Technology Adoption in Northern Mozambique. *The Economic Journal* 116 (514), 869-902.
- Banerjee, A.V. and Ghatak, M. (2004) Eviction threats and investment incentives. *Journal of Development Economics* 74 (2), 469-488.
- Bardhan, P. and Udry, C. (1999) *Development Microeconomics*. Oxford: Oxford University Press.
- Barrett, C.B., Reardon, T. and Webb, P. (2001) Nonfarm income diversification and household livelihood strategies in rural Africa: concepts, dynamics, and policy implications. *Food Policy* 26 (4), 315-331.
- Barrett, C.B., Place, F., Aboud, A. and Brown, D.R. (2002a) The Challenge of Stimulating Adoption of Improved Natural Resource Management Practices in African Agriculture. In: Barrett, C.B., Place, F. and Aboud, A., eds., *Natural Resources Management in African Agriculture. Understanding and Improving Current Practices*. Wallingford: CABI Publishing. 1-22.
- Barrett, C.B., Lynam, J., Place, F., Reardon, T. and Aboud, A. (2002b) Towards Improved Natural Resource Management in African Agriculture. In: Barrett, C.B., Place, F. and Aboud, A., eds., *Natural Resources Management in African Agriculture. Understanding and Improving Current Practices*. Wallingford: CABI Publishing. 287-296.
- Barrett, C.B., Bezuneh, M., Clay, D.C. and Reardon, T. (2005) Heterogeneous constraints, incentives and income diversification in rural Africa. *Quarterly Journal of International Agriculture* 44 (1), 37-60.
- Barrett, C.B., Sherlund, S.M. and Adesina, A.A. (2008) Shadow wages, allocative inefficiency, and labour supply in smallholder agriculture. *Agricultural Economics* 38 (1), 21-34.
- Barrett, C.B., Bellemare, M.F. and Hou, J.Y. (2010) Reconsidering Conventional Explanations of the Inverse Productivity-Size Relationship. *World Development* 38 (1), 88-97.



- Baser, O. (2006) Too Much Ado about Propensity Score Models? Comparing Methods of Propensity Score Matching. *Value in Health* 9 (6), 377-385.
- Baum, C.F. (2006) *An Introduction to Modern Econometrics Using Stata*. Brighton, Massachusetts: Stata Press.
- Becker, S.O. and Ichino, A. (2002) Estimation of average treatment effects based on propensity scores. *The Stata Journal* 2 (4), 358-377.
- Beekman, G. and Bulte, E.H. (2012) Social norms, tenure security and soil conservation: Evidence from Burundi. *Agricultural Systems* 108, 50-63.
- Bellemare, M.F. (2013). The productivity impacts of formal and informal land rights: Evidence from Madagascar. *Land Economics* 89 (2), 272-292.
- Benjamin, D. (1992) Household Composition, Labor Markets, and Labor Demand: Testing for Separation in Agricultural Household Models. *Econometrica* 60 (2), 287-322.
- Bennett-Lartey, S.O. and Oteng-Yeboah, A.A. (2008) *Ghana Country Report on the State of Plant Genetic Resources for Food and Agriculture*. Available by the FAO. Available at: <http://www.fao.org/docrep/013/i1500e/Ghana.pdf>. (Accessed: 27 June 2012).
- Berhanu, W., Colman, D. and Fayissa, B. (2007) Diversification and Livelihood Sustainability in a Semi-Arid Environment: A Case Study from Southern Ethiopia. *Journal of Development Studies* 43 (5), 871-889.
- Berry, S. (1993) *No Condition is Permanent. The Social Dynamics of Agrarian Change in Sub-Saharan Africa*. Madison: University Wisconsin Press.
- Berry, S. (2009) Building for the Future? Investment, Land Reform and the Contingencies of Ownership in Contemporary Ghana. *World Development* 37 (8), 1370-1378.
- Besley, T. (1995) Property Rights and Investment Incentives: Theory and Evidence from Ghana. *The Journal of Political Economy* 103 (5), 903-937.
- Bland, J.M. and Altman, D.G. (1997) Cronbach's alpha. *Statistics notes. BMJ* 314: 572.
- Borgatti, S.P., Mehra, A., Brass, D.J. and Labianca, G. (2009) Network Analysis in the Social Sciences. *Science* 323 (5916), 892-895.
- Bouma, J., Bulte, E. and van Soest, D. (2008) Trust and cooperation: social capital and community resource management. *Journal of Environmental Economics and Management* 56 (2), 155-166.

- Brasselle, A.-S., Gaspart, F. and Platteau, J.-P. (2002) Land tenure security and investment incentives: puzzling evidence from Burkina Faso. *Journal of Development Economics* 67 (2), 373-418.
- Brock, W.A. and Durlauf, S.N. (2007) Identification of binary choice models with social interactions. *Journal of Econometrics* 140 (1), 52-75.
- Brown, B.L., Hendrix, S.B., Hedges, D.W., Smith, T.B. (2012) *Multivariate Analysis for the Biobehavioral and Social Sciences. A Graphical Approach*. Hoboken, New Jersey: Jon Wiley and Sons Inc..
- Bruni, A. (2009) Meaningful distinctions within a concept: relational, collective, and generalized social capital. *Social Science Research* 38 (2), 251-265.
- Bryson, A., Dorsett, R. and Purdon, S. (2002) *The Use of Propensity Score Matching in the Evaluation of Active Labour Market Policies*. Working Paper No. 4, Policy Studies Institute and National Centre for Social Research, London: Crown Copyright.
- Bühl, A. and Zöfel, P. (2005) *SPSS 12 Einführung in die moderne Datenanalyse unter Windows*. München: Pearson Studium.
- Bundervoet, T. (2010) Assets, Activity Choices, and Civil War: Evidence from Burundi. *World Development* 38 (7), 955-965.
- Byerlee, D., Janvry de, A. and Sadoulet, E. (2009) Agriculture for Development: Toward a New Paradigm. *Annual Review of Resource Economics* 1, 15-31.
- Cattaneo, M.D. (2010) Multi-valued treatment effect. In Durlauf, S.N. & Blume, L.E. (eds.), *New Palgrave Dictionary of Economics*, Palgrave Macmillan, pp. 855–857.
- Canagarajah, S., Newman, C. and Bhattamishra, R. (2001) Non-farm income, gender, and inequality: evidence from rural Ghana and Uganda. *Food Policy* 26 (4), 405-420.
- Caliendo, M. and Kopeinig, S. (2008) Some Practical Guidance for the Implementation of Propensity Score Matching. *Journal of Economic Surveys* 22 (1), 31-72.
- Cappellari, L. and Jenkins, S.P. (2003) Multivariate probit regression using simulated maximum likelihood. *The STATA Journal* 3 (3), 278-294.
- CC DARE (2010) *Ghana-National Climate Change Adaptation Strategy*. Available at: <http://www.ccdare.org/Outputs/Ghana/tabid/6904/Default.aspx>. (Accessed: 28 June 2012).

- Chand, S. and Yala, C. (2009). Land Tenure and Productivity: Farm-level Evidence from Papua New Guinea. *Land Economics* 85 (3), 442-453.
- Central Intelligence Agency (2018) *The World Factbook. Africa: Ghana*. Available at: <https://www.cia.gov/library/publications/the-world-factbook/geos/gh.html>. (Accessed: 20 January 2018).
- Cochran, W. and Rubin, D. (1973) Controlling Bias in Observational Studies: A Review. *Sankhya, Series A* 35, 417-446.
- Coleman, J.S. (1988) Social Capital in the Creation of Human Capital. *The American Journal of Sociology* 94, 95-120.
- Combes, P.-P., Lafourde, M. and Mayer, T. (2005) The trade-creating effects of business and social networks: evidence from France. *Journal of International Economics* 66 (1), 1-29.
- Conley, T.G. and Udry, C.R. (2010) Learning about a New Technology: Pineapple in Ghana. *American Economic Review* 100 (1), 35-69.
- Costello, A.B. and Osborne, S.W. (2005) Best Practices in Exploratory Factor Analysis: Four Recommendations for Getting the Most From Your Analysis. *Practical Assessment, Research and Evaluation* 10 (7), 1-9.
- Cramb, R.A. (2006) The Role of Social Capital in the Promotion of Conservation Farming: The Case of 'Landcare' in the Southern Philippines. *Land Degradation and Development* 17 (1), 23-30.
- Cronbach, L.J. (1951) Coefficient alpha and the internal structure of tests. *Psychometrika* 16 (3), 297-334.
- Cunguara, B., Langgyintu, A. and Darnhofer, I. (2011). The role of nonfarm income in coping with the effects of drought in southern Mozambique. *Agricultural Economics* 42, 701-7013.
- Davidson, R. and MacKinnon, J.G. (1993) *Estimation and Inference in Econometrics*. Oxford: University Press.
- Davidson, R. and MacKinnon, J.G. (2004) *Econometric Theory and Methods*. Oxford: University Press.
- Davis, B., Winters, P., Reardon, T. and Stamoulis, K. (2009) Rural nonfarm employment and farming: household-level linkages. *Agricultural Economics* 40 (2), 119-123.

- Dehejia, R.H. and Wahba, S. (2002) Propensity Score-Matching Methods for Nonexperimental Causal Studies. *The Review of Economics and Statistics* 84 (1), 151-161.
- Deininger, K. and Chamorro, J.S: (2004). Investment and equity effects on land regularization: the case of Nicaragua. *Agricultural Economics* 30, 101-116
- Deininger, K. and Jin, S. (2006) Tenure security and land-related investment: Evidence from Ethiopia. *European Economic Review* 50 (5), 1245-1277.
- Deininger, K. and Ali, D.A. (2008) Do Overlapping Land Rights Reduce Agricultural Investment? Evidence From Uganda. *American Journal of Agricultural Economics* 90 (4), 869-882.
- Deininger, K., Ali, D.A. and Yamano, T. (2008) Legal Knowledge and Economic Development: The Case of Land Rights in Uganda. *Land Economics* 84 (4), 593-619.
- Deininger, K. and Olinto, P. (2001). Rural nonfarm employment and income diversification in Colombia. *World Development* 29 (3), 455-465.
- Diao, X. (2010) *Economic Importance of Agriculture for Sustainable Development and Poverty Reduction: Findings from a Case Study on Ghana*. Global Forum on Agriculture 29-30 November 2010. Policies for Agricultural Development, Poverty Reduction and Food Security. OECD Headquarters, Paris. Available at: <http://www.oecd.org/tad/agriculturalpoliciesandsupport/46341169.pdf>. (Accessed: 16 August 2012).
- Di Falco, S.; Yesuf, M.; Kohlin, G. and Ringler, C. (2012). Estimating the Impact of Climate Change on Agriculture in Low Income Countries: Household Level Evidence from the Nile Basin, Ethiopia. *Environmental Resource Economics* 52,457-478.
- DiPrete, T.A. and Gangl, M. (2004) Assessing Bias in the Usual Estimation of Causal Effects: Rosenbaum Bounds on Matching Estimators and Instrumental Variables Estimation with Imperfect Instruments. *Sociological Methodology* 34 (1), 5-86.
- Deolalikar, A. B. and Vijverberg, W. P.M. (1987) A Test of Heterogeneity of Family and Hired Labour in Asian Agriculture. *Oxford Bulletin of Economics and Statistics* 49, 291-303.
- Dowling, J. M. and Chin-Fang, Y. (2007) *Modern Developments in Behavioral Economics*. Singapore: World Scientific Publishing Co..
- Dufhues, T., Buchenrieder, G. and Dinh Quoc, H. (2012) Social capital and loan repayment performance in Northern Vietnam. *Agricultural Economics* 43 (3), 277-292.

- Durlauf, S. and Fafchamps, M. (2005) Social Capital. *In: Aghion, P. and Durlauf, S., eds., Handbook of Economic Growth*. Amsterdam: Elsevier B.V..1639-1699.
- Economic Commission for Africa (ECA) (2004) *Land tenure systems and their impacts on food security and sustainable development in Africa*. Addis Ababa: Publications Economic Commission for Africa.
- Ellis, F. (2000) The Determinants of Rural Livelihood Diversification in Developing Countries. *Journal of Agricultural Economics* 51 (2), 289-302.
- Embassy of the Republic of Ghana (2013). Brong Ahafo Region. Available at: <http://www.ghanaembelin.de/en/about-ghana/regions-in-ghana/brong-ahafo-region/index.html>. (Accessed: 02. October 2013.)
- Escobal, J. (2001) The Determinants of Nonfarm Income Diversification in Rural Peru. *World Development* 29 (3), 497-508.
- Fafchamps, M. (2004) *Social capital and development*. Department of Economics, Discussion Paper Series. Available at: <http://www.economics.ox.ac.uk/Research/wp/pdf/paper214.pdf>. (Accessed: 15 September 2009).
- Fafchamps, M. (2006) Development and Social Capital. *Journal of Development Studies* 42 (7), 1180-1198.
- Fafchamps, M. and Minten, B. (1999) Relationships and Traders in Madagascar. *The Journal of Development Studies* 35 (6), 1-35.
- Fafchamps, M. and Minten, B. (2002) Returns to social network capital among traders. *Oxford Economic Papers* 54 (2), 173-206.
- Fafchamps, M. and Lund, S. (2003) Risk-sharing networks in rural Philippines. *Journal of Development Economics* 71 (2), 261-287.
- Faltermeier, L. and Abdulai, A. (2009) The impact of water conservation and intensification technologies: empirical evidence for rice farmers in Ghana. *Agricultural Economics* 40 (3), 365-379.
- Feder, G., Onchan, T., Chalamwong, Y. and Hongladarom, C. (1988) *Land Policies and Farm Productivity in Thailand*. Published for the World Bank. Baltimore: The Johns Hopkins University Press.

- Fenske, J. (2010a) Land Tenure and Investment Incentives: Evidence from West Africa. *Journal of Development Economics* 95 (2), 137-156.
- Fenske, J. (2010b) L'Etranger: Status, Property Rights, and Investment Incentives in Cote d'Ivoire. *Land Economics* 86 (4), 621-644.
- Field, J. (2003) *Social capital*. Abingdon: Routledge.
- Field, A. (2005) *Discovering Statistics Using SPSS*. London: SAGE Publications.
- Food and Agricultural Organization (2012) *Good Environmental Practices in Bioenergy Feedstock Production. Environment and Natural Resources Management*. Working Paper No. 49. Available at: <http://www.fao.org/docrep/015/i2596e/i2596e00.pdf>. (Accessed: 30 September 2012).
- Foster, A.D. and Rosenzweig, M.R. (1995) Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture. *The Journal of Political Economy* 103 (6), 1176-1209.
- Fukuyama, F. (1996). *Trust. The social virtues and the creation of prosperity*. Free Press Paperbacks.
- Gavian, S. and Fafchamps, M. (1996) Land Tenure and Allocative Efficiency in Niger. *American Journal of Agricultural Economics* 78 (2), 460-471.
- Geest, K., Vrieling, A. and Dietz, T. (2010). Migration and environment in Ghana: a cross-district analysis of human mobility and vegetation dynamics. *Environment and Urbanization* 22 (10), 107-124.
- Genius, M., Koundouri, P., Nauges, C., and Tzouvelekas V. (2013) Information Transmission in Irrigation Technology Adoption and Diffusion: Social Learning, Extension Services and Spatial Effects. *American Journal of Agricultural Economics* 96 (1), 328-344.
- George, D. and Mallery, P. (2003) *SPSS Windows step by step. A simple guide and reference 11.0 update*. Boston: Allyn and Bacon.
- Gittel, R. and Vidal, A. (1998) *Community Organizing: Building Social Capital as a Development Strategy*. Thousand Oaks: Sage Publications.

- Gliem, J.A. and Gliem, R.R. (2003) *Calculating, interpreting, and reporting Cronbach's alpha reliability coefficient for Likert-type scales*. Midwest Research to Practice Conference in Adult, Continuing, and Community Education. Available at: <http://www.alumniosu.org/midwest/proceeding.html>. (Accessed: 18 June 2012).
- Gocking, R.S. (2005) *The History of Ghana*. Westport: Greenwood Press.
- Goldstein, M. and Udry, C. (2008) The Profits of Power: Land Rights and Agricultural Investment in Ghana. *Journal of Political Economy* 116 (6), 982-1022.
- Gong, Y., Bull, G. and Baylis, K. (2010). Participation in the world's first clean development mechanism project: The role of property rights, social capital and contractual rules. *Ecological Economics* 69,1292-1302.
- Government of Ghana Official Portal (2013). *Introduction Brong Ahafo*. Available at: <http://www.ghana.gov.gh/index.php/about-ghana/regions/brong-ahafo>. (Accessed: 02. October 2013)
- GSS (Ghana Statistical Service) (2013) *Ghana Living Standards Survey Round 6 (GLSS 6)* [http://www.statsghana.gov.gh/docfiles/glss6/GLSS6\\_Main%20Report.pdf](http://www.statsghana.gov.gh/docfiles/glss6/GLSS6_Main%20Report.pdf) (accessed 30 January 2017)
- Granovetter, M.S. (1973) The strength of weak ties. *American Journal of Sociology* 78 (6), 1360-1380.
- Greene, W.H. (2008) *Econometric Analysis*. New York: Upper Saddle River.
- Grootaert, C. and Bastelaer van, T. (2002) *The Role of Social Capital in Development. An Empirical Assessment*. Cambridge: Cambridge University Press.
- Guo, S., Barth, R.P. and Gibbons, C. (2006) Propensity score matching strategies for evaluation substance abuse services for child welfare clients. *Child and Youth Services Review* 28 (4), 357-388.
- Haggblade, S., Hazell, P. and Reardon, T. (2010) The Rural Non-farm Economy: Prospects for Growth and Poverty Reduction. *World Development* 38 (10), 1429-1441.
- Hagos, F. and Holden, S. (2006). Tenure security, resource poverty, public program, and household plot-level conservation investments in the highlands of northern Ethiopia. *Agricultural Economics* 34 (XX), 183-196.
- Hamilton, L.C. (2009) *Statistics with STATA. Updated for version 10*. Belmont: Brooks/Cole.

- Hayami, Y. (2009) Social Capital, Human Capital and the Community Mechanism: Toward a Conceptual Framework for Economists. *Journal of Development Studies* 45 (1), 96-123.
- Hayes, J. Roth, M. and Zepeda, L. (1997) Tenure Security, Investment and Productivity in Gambian Agriculture: A Generalized Probit Analysis. *American Journal of Agricultural Economics* 79 (2), 369-382.
- Heckman, J.T., Ichimura, H. and Todd, P.E. (1997) Matching as an Econometric Evaluation Estimator: Evidence from Evaluating a Job Training Programme. *Review of Economic Studies* 64 (4), 605-654.
- Heckman, J.T., Ichimura, H. and Todd, P.E. (1998) Matching as an Econometric Evaluation Estimator. *Review of Economic Studies* 65 (2), 261-294.
- Holden, S., Shiferaw, B. and Pender, J. (2001) Market Imperfections and Land Productivity in the Ethiopian Highlands. *Journal of Agricultural Economics* 52 (3), 53-70.
- Holden, S. and 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.
- Holden, S., Shiferaw, B. and Pender J. (2004) Non-farm income, household welfare, and sustainable land management in a less-favoured area in the Ethiopian highlands. *Food Policy* 29 (4), 369-392.
- Holden, S.T., Otsuka, K. and Place, F.M. (2009) Understanding Land Markets. In: Holden, S.T., Otsuka, K. and Place, F.M., eds., *The Emergence of Land Markets in Africa. Impacts on Poverty, Equity and Efficiency*. Washington D.C.: Resources for the Future. 18-54.
- Huang, J., Wu, Y. and Rozelle, S. (2009) Moving off the farm and intensifying agricultural production in Shandong: a case study of rural labor market linkages in China. *Agricultural Economics* 40 (2), 203-218.
- Huffman, W.E. (1991) Agricultural Household Models: Survey and Critique. In: Findeis, J.L., Hallberg, M.C. and Lass, D.L., eds., *Multiple Job Holding Among Farm Families*. Ames, Iowa: State University Press. 79-111.
- Hujer, R., Caliendo, M. and Thomson, S.L. (2004) New evidence on the effects of job creation schemes in Germany – a matching approach with threefold heterogeneity. *Research in Economics* 58 (4), 257-302.



Infonet- Biovision (2011) *Crop rotation*.

Available at: <http://www.infonet-biovision.org/default/ct/251/soilFertilityManagement>.  
(Accessed: 8 April 2012).

International Monetary Fund (2009) *Ghana-Poverty Reduction Strategy Paper - Annual Progress Report - Joint Staff Advisory Note*. IMF Country Report No. 09/238. Available at: <http://siteresources.worldbank.org/INTPRS1/Resources/383606-1092340662634/cr09238.pdf><http://siteresources.worldbank.org/INTPRS1/Resources/383606-1092340662634/cr09238.pdf>. (Accessed: 25 June 2012).

International Monetary Fund (2012) *Ghana: Fifth Review Under the Three-Year Arrangement Under the Extended Credit Facility and Request for Modification of Performance Criteria*. Staff Report; Staff Supplements; Press Release on the Executive Board Discussion; and Statement by the Executive Director for Ghana. Available at: <http://www.imf.org/external/pubs/ft/scr/2012/cr1236.pdf>. (Accessed: 27 June 2012).

International Rice Research Institute (2003) *Organic Materials and Manures*

Available at:

[http://www.knowledgebank.irri.org/factsheetsPDFs/Nutrient\\_Management/fs\\_orgMatMaure.pdf](http://www.knowledgebank.irri.org/factsheetsPDFs/Nutrient_Management/fs_orgMatMaure.pdf). (Accessed: 10 January 2013).

Imbens, G.W. (2004) Nonparametric Estimation of Average Treatment Effects under Exogeneity: A Review. *The Review of Economics and Statistics* 86 (1), 4-29.

Imbens, G.W. (2010) Better Late than Nothing: Some Comments on Deaton (2009) and Heckman and Urzua (2009). *Journal of Economic Literature* 48 (2), 399-423.

Imbens, G.W. and Wooldridge, J.M. (2009) Recent Developments in the Econometrics of Program Evaluation. *Journal of Economic Literature* 47 (1), 5-86.

Isgut, A.E. (2004) Non-farm Income and Employment in Rural Honduras: Assessing the Role of Locational Factors. *The Journal of Development Studies* 40 (3), 59-86.

Isham, J. (2002) The Effect of Social Capital on Fertilizer Adoption: Evidence from Rural Tanzania. *Journal of African Economics* 11 (1), 39-60.

Jackson, M.O. (2008) *Social and Economic Networks*. Princeton: Princeton University Press.

Jacoby, H.G. (1993) Shadow Wages and Peasant Family Labour Supply: An Econometric Application to the Peruvian Sierra. *The Review of Economic Studies* 60 (4), 903-921.

- Jacoby, H.G. and Minten, B. (2007) Is Land Titling in Sub-Saharan Africa Cost-Effective? Evidence from Madagascar. *The World Bank Economic Review* 21 (3), 461-485.
- Jacoby, H.G. and Mansuri, G. (2008) Land Tenancy and Non-Contractible Investment in Rural Pakistan. *Review of Economic Studies* 75 (3), 763-788.
- Jacoby, H.G. and Mansuri, G. (2009) Incentives, supervision, and sharecropper productivity. *Journal of Development Economics* 88 (2), 232-241.
- Jalan, J. and Ravallion, M. (2003) Does piped water reduce diarrhea for children in rural India? *Journal of Econometrics* 112 (1), 153-173.
- Jara-Rojas, R., Bravo-Ureta, B., Engler, A. and Diaz, J. (2013). An analysis on the joint adoption of water conservation and soil conservation in Central Chile. *Land Use Policy* 32, 292-301.
- Jensen, R. (2007) The Digital Divide: Information (Technology), Market Performance, and Welfare in the South Indian Fisheries Sector. *The Quarterly Journal of Economics* 122 (3), 879-924.
- Jolliffe, D. (2004) The impact of education in rural Ghana: examining household labour allocation and returns on and off the farm. *Journal of Development Economics* 73 (1), 287-314.
- Jolliffe, I.T. (2002) *Principal Component Analysis*. New York: Springer.
- Jöreskog, K.G. (1999) *How large can a standardized coefficient be?* In the help file of the LISREL program. Available at: <http://www.ssicentral.com/lisrel/techdocs/HowLargeCanaStandardizedCoefficientbe.pdf> (Accessed: 26 June 2012).
- Kassie, M. and Holden, S. (2007) Sharecropping efficiency in Ethiopia: threats of eviction and kinship. *Agricultural Economics* 37 (2-3), 179-188.
- Kassie, M., Pender, J., Mahmud, Y., Köhlin, G., Bluffstone, R. and Mulugeta, E. (2008) Estimating returns to soil conservation adoption in the northern Ethiopian highlands. *Agricultural Economics* 38 (2), 213-232.
- Kassie, M., Zikhali, P., Pender, J. and Köhlin, G. (2010) The Economics of Sustainable Land Management Practices in the Ethiopian Highlands. *Journal of Agricultural Economics* 61 (3), 605-627.

- Kassie, M., Teklewold, H., Marenja, P., Jaleta, M. and Erenstein, O. (2014). Production Risks and Food Security under Alternative Technology Choices in Malawi: Application of a Multinomial Endogenous Switching Regression. *Journal of Agricultural Economics*
- Kato, E.; Ringler, C.; Yesuf, M. and Bryan, E. (2011). Soil and water conservation technologies: a buffer against production risk in the face of climate change? Insights from the Nile basin in Ethiopia. *Agricultural Economics* 42 (5), 593-604.
- Katz, E.G. (2000). Social Capital and Natural Capital: A Comparative Analysis of Land Tenure and Natural Resource Management in Guatemala. *Land Economics* 76 (1), 114-132.
- Key, N., Sadoulet, E. and Janvry de, A. (2000) Transaction Costs and Agricultural Household Supply Response. *American Journal of Agricultural Economics* 82 (2), 245-259.
- Kilic, T., Carletto, C., Miluka, J. and Savastano, S. (2009) Rural nonfarm income and its impact on agriculture: evidence from Albania. *Agricultural Economics* 40 (2), 139-160.
- Kintampo North Municipal Assembly (2013). *Kintsampo North*. Available at: [http://kintamponorth.ghanadistricts.gov.gh/?arrow=dnf&\\_id=37&r=10&rlv=geology](http://kintamponorth.ghanadistricts.gov.gh/?arrow=dnf&_id=37&r=10&rlv=geology). Accessed: 02.October 2013.
- Knörzer, H., Graeff-Hönninger, S., Guo, B., Wang, P. and Claupein, W. (2009) The Rediscovery of Intercropping in China: A traditional Cropping System for Future-Chinese Agriculture - A Review. In: Lichtfouse, E., ed., *Climate Change, Intercropping, Pest Control and Beneficial Microorganisms*. New York: Springer. 13-44.
- Knox, A., Meinzen-Dick, R. and Hazell, P. (2002) Property Rights, Collective Action, and Technologies for Natural Resource Management: A Conceptual Framework. In: Meinzen-Dick, R., Knox, A., Place, F. and Swallow B., eds., *Innovation in Natural Resource Management - The Role of Property Rights and Collective Action in Developing Countries*. Washington D.C.: The International Food Policy Research Institute. 12-44.
- Kothari, A. (2004) *Ghana - Community Based Rural Development Project: environmental and social management framework*. World Bank. Available at: [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2008/05/16/000334955\\_20080516045803/Rendered/PDF/E18910EA0P11111700BOX0327375B01PUBLIC1.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2008/05/16/000334955_20080516045803/Rendered/PDF/E18910EA0P11111700BOX0327375B01PUBLIC1.pdf). (Accessed: 23 June 2012).
- Kousar, R. and Abdulai, A. (2013). *Impacts of rural non-farm employment on household welfare in Pakistan*. Paper prepared for presentation at the 2nd AIEAA Conference

"Between Crisis and Development: which Role for the Bio-Economy" 6-7 June, 2013 Parma, Italy.

Kremer, M. and Miguel, E. (2007) The Illusion of Sustainability. *The Quarterly Journal of Economics* 122 (3), 1007-1065.

Krishnan, P. and Sciubba, E. (2009) Link and Architecture in Village Networks. *The Economic Journal* 119 (537), 917-949.

Lanjouw, P. and Murgai, R. (2009). Poverty decline, agricultural wages, and nonfarm employment in rural India: 1983-2004. *Agricultural Economics* 40, 243-263.

Lay, J., Mahmoud, T. O. and M'Mukaria, G.M. (2008) Few Opportunities, Much Desperation: The Dichotomy of Non-Agricultural Activities and Inequality in Western Kenya. *World Development* 36 (12), 2713-2737.

Le, K.T. (2010). Separation hypothesis tests in the agricultural household model. *American Journal of Agricultural Economics* 92 (5), 1420-1431.

Lechner, M. (2002) Some practical issues in the evaluation of heterogeneous labour market programmes by matching methods. *Journal of Royal Statistical Society A* 165 (1), 59-82.

Lee, L. (1992) Amemiya's generalized least squares and test of overidentification in simultaneous equation models with qualitative limited dependent variables. *Econometric Reviews* 11 (3), 319-328.

Lee, W.-S. (2011) Propensity score matching and variations on the balancing test. *Empirical Economics*. doi: 10.1007/s00181-011-0481-0.

Liebman, M. and Dyck, E. (1993) Crop Rotation and Intercropping Strategies for Weed Management. *Ecological Applications* 3 (1), 92-122.

Lopez, R.E. (1986) Structural Models of the Farm Household that Allow for Interdependent Utility and Profit-Maximization Decisions. *In: Singh, I., Squire, L. and Strauss, J., eds., Agricultural Household Models. Extensions, Applications and Policy*. London: The John Hopkins University Press. 306-327.

Maddala, G.S. (1997) *Limited Dependent and Qualitative Variables in Econometrics*. New York: Cambridge University Press.

Manski, C.F. (1993) Identification of Endogenous Social Effects: The Reflection Problem. *Review of Economic Studies* 60 (3), 531-542.

- Manski, C.F. (2000) Economic Analysis of Social Interactions. *Journal of Economic Perspectives* 14 (3), 115-136.
- Marenya, P.P. and Barrett, C.B. (2007) Household-level determinants of adoption of improved natural resources management practices among smallholder farmers in western Kenya. *Food Policy* 32 (4), 515-536.
- Markussen, T. (2008) Property Rights, Productivity, and Common Property Resources: Insights from Rural Cambodia. *World Development* 36 (11), 2277-2296.
- Matshe, I. and Young, T. (2004) Off-farm labour allocation decision in small-scale rural household in Zimbabwe. *Agricultural Economics* 30 (3), 175-186.
- Matusmoto, T., Kijima, Y. and Yamano, T. (2006). The role of local nonfarm activities and migration in reducing poverty: evidence from Ethiopia, Kenya and Uganda. *Agricultural Economics* 35, 449-458.
- Meinzen-Dick, R., DeGregorio, M. and McCarthy, N. (2004) Methods for studying collective action in rural development. *Agricultural Systems* 82 (3), 197-214.
- Mendola, M. (2007) Agricultural technology adoption and poverty reduction: A propensity-score matching analysis for rural Bangladesh. *Food Policy* 32 (3), 372-393.
- Ministry of Food and Agriculture, Republic of Ghana (2013). *Districts Brong Ahafo Region*. Available at: [http://mofa.gov.gh/site/?page\\_id=1345](http://mofa.gov.gh/site/?page_id=1345). (Accessed: 02 October 2013).
- Moffitt, R. A. (2004). Introduction to the Symposium on the Econometrics of Matching. *The Review of Economics and Statistics* 86 (1), 1-3.
- Morris, M., Kelly, V.A., Kopicki, R.J. and Byerlee, D. (2007) *Fertilizer Use in African Agriculture. Lessons Learned and Good Practice Guidelines*. The International Bank for Reconstruction and Development. World Bank. Available at: [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2007/03/15/000310607\\_20070315153201/Rendered/PDF/390370AFR0Fert101OFFICIAL0USE0ONLY1.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2007/03/15/000310607_20070315153201/Rendered/PDF/390370AFR0Fert101OFFICIAL0USE0ONLY1.pdf) (Accessed: 21 June 2012).
- Mutsaers, H.J.W., Ezumah, H.C. and Osiru, D.S.O. (1993) Cassava-based intercropping: a review. *Field Crop Research* 34 (3-4), 431-457.
- Nahapiet, J. and Ghoshal, S. (1998) Social Capital, Intellectual Capital and the Organizational Advantage. *Academy of Management Review* 23 (2), 242-266.

- National Development Planning Commission (2005) *Growth and Poverty Reduction Strategy (GPRS II) (2006-2009)*. Available at:  
[http://siteresources.worldbank.org/INTPRS1/Resources/GhanaCostingofGPRS\\_2%28Nov-2005%29.pdf](http://siteresources.worldbank.org/INTPRS1/Resources/GhanaCostingofGPRS_2%28Nov-2005%29.pdf). (Accessed: 27 June 2012).
- National Development Planning Commission (2010) *Medium-Term National Development Policy Framework. Ghana Shared Growth and Development Agenda (GSGDA) 2010-2013*. Volume I: Policy Framework. Available at:  
<http://www.ndpc.gov.gh/GPRS/Final%20Draft%20Policy%20Framework%20092010.pdf>. (Accessed: 27 June 2012).
- Njuki, J.M., Mapila, M. T., Zingore, S. and Delve, R. (2008) The Dynamics of Social Capital in Influencing Use of Soil Management Options in the Chinyanja of Southern Africa. *Ecology and Society* 13 (2), 9.
- Olasantan, F.O., Ezumah, H.C. and Lucas, E.O. (1996) Effects of intercropping with maize in the micro-environment, growth and yields of cassava. *Agriculture, Ecosystems and Environment* 57 (2-3), 149-158.
- Oseni, G. and Winters, P. (2009) Rural nonfarm activities and agricultural crop production in Nigeria. *Agricultural Economics* 40 (2), 189-201.
- Ostrom, E. (1994) Constituting social capital and collective action. *Journal of Theoretical Politics* 6 (4), 527-562.
- Otsuka, K., Quisumbing, A.R., Payongayong, E. and Aido, J.B. (2003) Land tenure and the management of land and trees: the case of customary land tenure areas of Ghana. *Environment and Development Economics* 8 (1), 77-104.
- Owusu, V., Abdulai, A. and Abdul-Rahman, S. (2011) Non-farm work and food security among farm households in Northern Ghana. *Food Policy* 36 (2), 108-118.
- Pande, R. and Udry, C. (2005) *Institutions and Development: A View from Below*. Yale University Economic Growth Center Discussion Paper No. 928. Available at:  
[http://papers.ssrn.com/sol3/papers.cfm?abstract\\_id=864044](http://papers.ssrn.com/sol3/papers.cfm?abstract_id=864044). (Accessed 28 June 2012).
- Pande R. and Udry, C. (2007) Institutions and Development: A View from Below. In: Blundell, R., Newey, W. and Persson, T., eds., *Advances in Economics and Econometrics: Volume 2*. Cambridge: Cambridge University Press. 349-411.
- Paldam, M. (2000) Social Capital: One Or Many? Definition and Measurement. *Journal of Economic Surveys* 14 (5), 629-653.

- Pender, J. and Fafchamps, M. (2006) Land lease markets and agricultural efficiency in Ethiopia. *Journal of African Economics* 15 (2), 251-284.
- Peters, P.E. (2004) Inequality and Social Conflict Over Land in Africa. *Journal of Agrarian Change* 4 (3), 269-314.
- Pfeiffer, L., Lopez-Feldman, A. and Taylor, J.E. (2009) Is off-farm income reforming the farm? Evidence from Mexico. *Agricultural Economics* 40 (2), 125-138.
- Pichler, F. and Wallace, C. (2007) Patterns of Formal and Informal Social Capital in Europe. *European Sociological Review* 23 (4), 423-435.
- Pimentel, D., Harvey, C., Resosudarmo, P., Sinclair, K., McNair, D., Crist, S., Shpritz, L., Fitton, L., Saffouri, R. and Blair, R. (1995) Environmental and Economic Costs of Soil Erosion and Conservation Benefits. *Science* 267 (5201), 1117-1123.
- Place, F. (2009) Land Tenure and Agricultural Productivity in Africa: A Comparative Analysis of the Economics Literature and Recent Strategies and Reforms. *World Development* 37 (8), 1326-1336.
- Place, F. and 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. 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. and Swallow, M. (2002) Assessing the Relationships between Property Rights and Technology Adoption in Smallholder Agriculture: Issues and Empirical Methods. In: Meinzen-Dick, R., Knox, A., Place, F. and Swallow B., eds., *Innovation in Natural Resource Management - The Role of Property Rights and Collective Action in Developing Countries*. Washington D.C.: The International Food Policy Research Institute. 45-72.
- Powlson, D.S., Gregory, P.J., Whalley, W.R., Quinton, J.N., Hopkins, D.W., Whitmore, A.P., Hirsch, P.R. and Goulding, K.W.T. (2011) Soil management in relation to sustainable agriculture and ecosystem services. *Food Policy* 36 (1), 72-87.
- Pretty, J. (2003) *Social capital and connectedness: Issues and implications for agriculture, rural development and natural resource management in ACP countries*. CTA Working Document Number 8032. Wageningen. The ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA).

- Pretty, J. and Ward, H. (2001) Social capital and the Environment. *World Development* 29 (2), 209-222.
- Pretty, J. and Buck, L. (2002) Social Capital and Social Learning in the Process of Natural Resource Management. *In: Barrett, C.B., Place, F. and Aboud, A., eds., Natural Resources Management in African Agriculture. Understanding and Improving Current Practices.* Wallingford: CABI Publishing. 23-34.
- Putnam, R. D. (2002) *Democracies in Flux - The Evolution of Social Capital in Contemporary Society.* New York: Oxford University Press.
- Pyndick, R.S. and Rubinfeld. D.L. (1998) *Econometric Models and Economic Forecasts.* Singapore: McGraw Hill.
- Reardon, T. (1997) Using Evidence of Household Income Diversification to Inform Study of the Rural Nonfarm Labor Market in Africa. *World Development* 25 (5), 735-747.
- Reardon, T., Crawford, E. and Kelly, V. (1994) Links Between Nonfarm Income and Farm Investment in African Households: Adding the Capital Market Perspective. *American Journal of Agricultural Economics* 76 (5), 1171-1176.
- Rijn van, F., Bulte, E. and Adegunle, A. (2012) Social capital and agricultural innovation in Sub-Saharan Africa. *Agricultural Systems* 108, 112-122.
- Rivers, D. and Vuong, Q.H. (1988) Limited Information Estimators and Exogeneity Tests for Simultaneous Probit Models. *Journal of Econometrics* 39 (3), 347-366.
- Roodman, D. (2009) *Cmp: Stata module to implement conditional (recursive) mixed process estimator.* Center for Global Development Working Paper No. 168. Available at: <http://dspace.cigilibrary.org/jspui/bitstream/123456789/23864/1/Estiamting%20fully%20observed%20recursive%20mixed-process%20models%20with%20cmp.pdf?1>. (Accessed: 21 June 2012).
- Rosenbaum, P.R. (2002) *Observational Studies.* New York: Springer.
- Rosenbaum, P.R. (2010) *Design of Observational Studies.* New York: Springer.
- Rosenbaum, P.R. and Rubin, D.B. (1983) The central role of the propensity score in observational studies for causal effects. *Biometrika* 70 (1), 41-55.
- Rosenbaum, P.R. and Rubin, D.B. (1985) Constructing a Control Group Using Multivariate Matched Sampling Methods that Incorporate the Propensity Score. *The American Statistician* 39 (1), 33-38.



- Rosenzweig, M.R. (1980) Neoclassical theory and the optimizing peasant: an econometric analysis of market family labour supply in a developing country. *The Quarterly Journal of Economics* 94 (1), 31-55.
- Roth, M. and Haase, D. (1998) *Land Tenure Security and Agricultural Performance in Southern Africa*. BASIS Southern Africa Program Publication, Land Tenure Center, University of Wisconsin-Madison. Available at: <http://www.ies.wisc.edu/ltc/live/bassaf9806a.pdf>. (Accessed: 22 June 2012).
- Roy, A.D. (1951) Some Thoughts on the Distribution of Earnings. *Oxford Economics Paper* 3 (2), 135-146.
- Royal Horticultural Society (2011) *Soil types*. Available at: <http://apps.rhs.org.uk/advicesearch/profile.aspx?PID=179>. (Accessed: 17 November 2011).
- Ruben, R. and van den Berg, M. (2001) Nonfarm Employment and Poverty Alleviation of Rural Farm Households in Honduras. *World Development* 29 (3), 549-560.
- Ruben, R., Krusemann, G. and Kuyenhoven, A. (2006) Strategies for sustainable intensification in East African highlands: labour use and input efficiency. *Agricultural Economics* 34 (2), 167-181.
- Rubin, D.B. (1974) Matching to Reduce Bias in Observational Studies. *Biometrics* 29 (1), 159-183.
- Rubin, D.B. (1980) Bias Reduction Using Mahalanobis Metric Matching. *Biometrics* 36 (2), 293-298.
- Rudd, M.A. (2000) Live long and prosper: collective action, social capital and social vision. *Ecological Economics* 34 (1), 131-144.
- Sabatini, F. (2008) Social Capital and the Quality of Economic Development. *Kyklos* 61 (3), 466-499.
- Sadoulet, E. and de Janvry, A. (1995) *Quantitative Development Policy Analysis*. London: The John Hopkins Press. Ltd..
- Saint-Macary, C., Keil, A., Zeller, M., Heidhues, F. and Thi My Dung, P. (2010) Land titling policy and soil conservation in the northern uplands of Vietnam. *Land Use Policy* 27 (2), 617-627.

- Sanginga, P.C., Kamugisha, R.N. and Martin, A.M. (2007) The Dynamics of Social Capital and Conflict Management in Multiple Resource Regimes: A Case of the Southwestern Highlands of Uganda. *Ecology and Society* 12 (1), 6.
- Sarpong, G.A. (2006) *Improving Tenure Security for the Rural Poor. Ghana - Country Case Study. Towards the improvement of tenure security for the poor in Ghana: Some thoughts and observations.* LEP Working Paper 2, FAO, Rome. Available at: <ftp://ftp.fao.org/docrep/fao/010/k0783e/k0783e00.pdf>. (Accessed: 23 October 2009).
- Sekhon, J. S. (2008) The Neyman-Rubin Model of Causal Inference and Estimation via Matching Methods. In: Box-Steffensmeier, J.M., Brady, H.E. and Collier, D., eds., *The Oxford Handbook of Political Methodology*. Oxford: Oxford University Press. 271-299.
- Shaban, R.A. (1987) Testing Competing Models of Sharecropping. *Journal of Political Economy* 95 (5), 893-488.
- Sianesi, B. (2001) *Implementation propensity score estimators with STATA*. Prepared for UK Stata Users Group, VII Meeting London, May 2001.  
Available at: <http://www.cba.ua.edu/assets/docs/jlee/ec671/psmatch.pdf>. (Accessed: 14 June 2012).
- Sianesi, B. (2004) An evaluation of the Swedish system of active labour market programmes in Sweden. *The Review of Economics and Statistics* 86 (1), 133-155.
- Singh, I., Squire, L. and Strauss, J. (1986) A Survey of Agricultural Household Models: Recent Findings and Policy Implications. *The World Bank Review* 1 (1), 149-179.
- Sjaastad, E. and Bromley, D.W. (1997). Indigenous Land Rights in Sub-Saharan Africa: Appropriation, Security and Investment Demand. *World Development* 25 (4), 549-562.
- Skoufias, E. (1994) Using Shadow Wages to estimate Labor Supply of Agricultural Households. *American Journal of Agricultural Economics* 76 (2), 215-227.
- Smith, J. (2000) A Critical Survey of Empirical Methods for Evaluating Active Labour Market Policies. *Schweizerische Zeitschrift für Volkswirtschaft und Statistik* 136 (3), 1-22.
- Smith, R.E. (2004) Land Tenure, Fixed Investment, and Farm Productivity: Evidence from Zambia's Southern Province. *World Development* 32 (10), 1641-1661.
- Smith, R.J. and Blundell, R.W. (1986) An Exogeneity Test for a Simultaneous Equation Tobit Model with an Application to Labor Supply. *Econometrica* 54 (3), 679-685.

- Smith, J.A. and Todd, P.E. (2005) Does Matching overcome LaLonde's critique of Nonexperimental estimators? *Journal of Econometrics* 125 (1-2), 305-353.
- Sobel, J. (2002) Can we trust social capital? *Journal of Economic Literature* 40 (1), 139-154.
- Stiefel, D. and Minten, B. (2008) Isolation and productivity. *Agricultural Economics* 39 (1), 1-15.
- Sumner, D.R., Doupnik, B. and Boosalis, M.G. (1981) Effects of Reduced Tillage and Multiple Cropping on Plant Diseases. *Annual Review Phytopathology* 19, 167-187.
- Taylor, J.E. and Martin, P.L. (2001). Human Capital: Migration and Rural Population Change. In: Gardner, B.L. and Rauser, G.C. eds., *Handbook of Agricultural Economics*. New York: Elsevier Science.
- Tenge, A. J., De Graaff, J. and Hella, J. P. (2004). Social and economic factors affecting the adoption of soil and water conservation in West Usambara Highlands, Tanzania. *Land Degradation and Development* 15, 99-114.
- Titeca, K. and Vervisch, T. (2008) The Dynamics of Social Capital and Community Associations in Uganda: Linking Capital and its Consequences. *World Development* 36 (11), 2205-2222.
- Todaro, M.P. and Smith, S.C. (2009) *Economic Development*. Harlow, England: Pearson Education.
- Udry, C. (2009) *Networks, Local Institutions and Agriculture in Africa: Notes Towards a Research Program*. Available at: <http://www.econ.yale.edu/~cru2/pdf/aqdev.pdf>. (Accessed: 07 September 2009).
- Udry, C. (2012) Land Tenure. In: Aryeetey, E., Devarajan, S., Kanbur, R. and Kasekende, L., eds., *The Oxford Companion to the Economics of Africa*. New York: Oxford University Press. 410-415.
- Udry, C. and Conley, T. (2004) *Social Networks in Ghana*. Yale University Economic Growth Center Discussion Paper No. 888. Available at: <http://ssrn.com/abstract=555699>. (Accessed: 03 December 2009).
- UNDP (2015). *Ghana Millennium Development Goals. 2015 Report*. Available at: [file:///C:/Users/daniela.lueth/Downloads/UNDP\\_GH\\_2015%20Ghana%20MDGs%20Report.pdf](file:///C:/Users/daniela.lueth/Downloads/UNDP_GH_2015%20Ghana%20MDGs%20Report.pdf) (Accessed: 20 January 2018).
- UNDP (2018). *UNDP Ghana – About Ghana*. Available at:

<http://www.gh.undp.org/content/ghana/en/home/countryinfo/> (Accessed: 20 January 2018).

- Uphoff, N. (2000) Understanding social capital: learning from the analysis and experience of participation. *In: Dasgupta, P. and Serageldin, I., eds., Social Capital. A Multifaceted Perspective.* Washington D.C.: World Bank. 215-249.
- Vanlauwe, B. and Giller, K.E. (2006). Popular myths around soil fertility management in Sub-Saharan Africa. *Agriculture Ecosystems and Environment* 116 (1-2), 34-46.
- Verpoorten, M. (2009). Household coping in war and peacetime: Cattle sales in Rwanda, 1991-2001. *Journal of Development Economics* 88, 67-86.
- Wannasai, N. and Shrestha, R.P. (2008). Role of land tenure security and farm household characteristics on land use change in the Prasae Watershed, Thailand. *Land Use Policy* 25 (X), 214-224.
- Weligamage, P., Shumway, C.R. and Blatner, K.A. (2014). Water access, farm productivity, and farm household income: Sri Lanka's Kirindi Oya irrigation system. *Agricultural Economics* 45, 1-13.
- Willy, D.K. and Holm-Müller, K. (2013). Social influence and collective action effects on farm level soil conservation effort in rural Kenya. *Ecological Economics* 90, 94-103.
- Woldenhanna, T. and Oskam, A. (2001) Income diversification and entry barriers: evidence from the Tigray region of northern Ethiopia. *Food Policy* 26 (4), 351-365.
- Wollni, M., Lee, D.R. and Thies, J.E. (2010) Conservation agriculture, organic marketing, and collective action in the Honduras hillsides. *Agricultural Economics* 41 (3-4), 373-384.
- Woodhouse, P. (2003) African Enclosures: A Default Mode of Development. *World Development* 31 (10), 1705-1720.
- Woolcock, M. (2001) The Place of Social Capital in Understanding Social and Economic Outcomes. *Canadian Journal of Policy Research* 2 (1), 11-17.
- Woolcock, M. (2010). The Rise and Routinization of Social Capital, 1988-2008. *Annual Review of Political Sciences* 13, 469-487.
- Woolcock, M. and Narayan, D. (2000) Social Capital: Implications for Development Theory, Research and Policy. *The World Bank Research Observer* 15 (2), 225-249.
- Wooldridge, J.M. (2010). *Econometric Analysis of Cross Section and Panel Data.* Cambridge, Massachusetts: MIT Press.

- Wooldridge, J.M. (2014). Quasi-maximum likelihood estimation and testing for nonlinear models with endogenous explanatory variables. *Journal of Econometrics* 182, 226-234.
- World Bank (2010) *Ghana - Ghana Agriculture DPL2*. Project Information Document. Available at: <http://go.worldbank.org/K0FNWCSIH0>. (Accessed: 06 April 2010).
- World Bank (2011a) *Africa Development Indicators 2011*. Available at: [http://data.worldbank.org/sites/default/files/adi\\_2011-web.pdf](http://data.worldbank.org/sites/default/files/adi_2011-web.pdf). (Accessed: 25 June 2012).
- World Bank (2011b) *Ghana - Land Administration Project*. Available at: <http://documents.worldbank.org/curated/en/2011/12/15590436/ghana-land-administration-project>. (Accessed: 25 June 2012).
- World Bank (2012) *Ghana - Country Brief*. Available at: <http://go.worldbank.org/QAKWTY7640>. (Accessed: 29 June 2012).
- World Data Bank (2018). *World Development Indicators*. <http://databank.worldbank.org/data/views/reports/tableview.aspx>. (Accessed: 20. January 2018).
- World Bank (2018). *Country Brief- Ghana*. [http://data.worldbank.org/country/ghana#cp\\_gep](http://data.worldbank.org/country/ghana#cp_gep). (Accessed: 20. January 2018).
- World Population Review (2017). *Ghana Population 2018*. <http://worldpopulationreview.com/countries/ghana-population>. (Accessed: 20. January 2018).
- Yamono, T. and Kijima, Y. (2010). The associations of soil fertility and market access with household income: Evidence from rural Uganda. *Food Policy* 35, 51-59.
- Zanello, G. (2012) Mobile Phones and Radios: Effects on Transaction Costs and Market Participation for Households in Northern Ghana. *Journal of Agricultural Economics* 63 (3), 694-714.

# Annex

## Field Questionnaire

### Section 1 Personal History

#### 1.1. Personal characteristics

1	Serial number of household head	Male	Female
2	Position in household <b>(A)</b>		
3	What ethnic group do you belong? <b>(B)</b>		
4	Religion		
5	Hometown		
6	District of hometown		
7	Place of residence (village)		
8	District of residence		
9	Years of residence in the village		
10	Distance to the nearest market		
11	Age (yrs)		
12	Where born <b>(C)</b>		
13	Education level <b>(D)</b>		

\* Interview both husband and wife if needs be.

#### 1.2. Household characteristics

1	Number of household members	1	2	3	4	5	6	7	8
2	List and indicate position of all permanent household members residing with you now <b>(E)</b>								
3	Age (yrs)								
4	Education level <b>(Same as D)</b>								
5	What job is he/she engaged in now? <b>(F)</b>								

## Section 2. Plot-level Characteristics

### 2.1. Current plot characteristics

1	Plot number	P01	P02	P03	P04	P05	P06
2	Vegetation (01=forest, 02=savanna)						
3	What is the size of plot (acres)						
4	Distance of plot from home (km)*						
5	What is the means of transportation to plot (01=walk, 02=bicycle, 03=motor bike,04= car)?						
6	Type of slope <b>(G)</b>						
7	Indicate the expected soil quality by ranking them <b>(H)</b>						
8	What is the nature of soil on your plot? (01= sand, 02=clay, 03=loam, 04= sandy loam, 05=other (specify)?)						

\* For both tenant and landlord.

### 2.2. Tenure arrangements and duration on plot

1	Plot number	P01	P02	P03	P04	P05	P06
	Are you a tenant or an owner? (1= tenant, 2 =owner)						
	If owner, how many plots do you own?						
	How did you become the owner? <b>(I)</b>						
	How many plots have you released to tenants?						
	How many plots are you cultivating this year?						
	Who inherits the plot (s) when you pass away? <b>(J)</b>						
2	What tenure contract exists between you and your landowner/tenant? <b>(K)</b>						
	Is it a paper contract? (1=yes, 2=no)						
3	If share cropping, indicate following detailed agreements						
	How long have you cultivated this plot?						

		What is the contract duration on plot if any (years)?							
		Have you renewed the contract on plot before?	1=yes, 2=no						
			If yes, how many times have you renewed the contract on plot?						
		How are costs of inputs (seeds, fertilizer) shared between you and your landowner/tenant? <b>(L)</b>							
		Do you prevent your tenant (Are you prevented by your landowner) from planting any particular tree or crop on plot?	1=yes, 2=no						
			If yes, why the restrictions?						
4	If rented (hired) land, indicate the following detailed agreements	Duration of tenure on plot (years)							
		How long have you cultivated this plot?							
		Amount paid/collected (GH¢).							



		Are you restricted from planting any particular tree or crop on plot?	1=yes, 2=no						
			If yes, why the restrictions?						
5	If taungya, indicate the following detailed agreements	Duration of tenure on plot (years)							
		How long have you cultivated this plot?							

NB: Please ask questions on tenants and owners differently.

### 2.3. Previous plot characteristics

1	Plot number	P01	P02	P03	P04	P05	P06
2	What was the nature of vegetation before you started farming on the land? (1=forest, 2=savanna)						
3	How long have you cultivated the plot since acquisition?						
4	Was the plot under fallow before you started using it?	1=yes, 2=no					
		If yes, how long was the plot put to fallow before you started cultivating it?					
		If no, how long has the plot been put to use					

		before you started cultivating it?						
		Crops grown on plot before you started using it? <b>(M)</b>						
5	Were there trees on the plot when you started using it?	1=yes, 2=no						
		If yes, what type of trees? <b>(N)</b>						
6	Have you cut some trees since you started farming on the plot?	1=yes, 2=no						
		If yes, approximately how many trees have you removed from the plot?						

#### 2.4. Investments on Plots

1	Plot number	P01	P02	P03	P04	P05	P06
2	Are you aware of any <b>soil conservation</b> method? (1=yes, 2=no)						
(i)	What method do you use in controlling <b>soil erosion</b> on your plot? <b>(O)</b>						
	How long have you practiced this erosion control method?						
	What quantity of investments have you undertaken on plot (in GH¢)?						
(ii)	What <b>agronomic method</b> do you use on your plot? <b>(P)</b>						

	How long have you practiced this agronomic method?						
	What quantity of investments have you undertaken on plot (in GH¢)?						
(iii)	What <b>soil management</b> practice do you use on your plots? <b>(Q)</b>						
	How long have you practiced this soil management method?						
	What quantity of investments have you undertaken on plot (in GH¢)?						
(iv)	What <b>cultivation method</b> do you practice on your plot? <b>(R)</b>						
	How long have you practiced this cultivation method?						
	What quantity of investments have you undertaken on plot (in GH¢)?						
3	Have you planted <b>trees</b> on your plot (s)? (1= yes, 2= no)						
	Area (acres) planted with trees?						
	What types of trees have you planted? <b>(Same as N)</b>						
	What year did you plant the trees?						
	What are the most important reasons for planting the tree <b>(S)</b>						
	How were seedlings obtained? <b>(T)</b>						
	How do you maintain the trees? <b>(U)</b>						

2.5. Future investments on plot (in five years time)

plot No.	No. of years you intend using plot	What land preparation techniques would you adopt when the tenure on plot is renewed?	What crops are you going to cultivate in case you decide to renew your tenure on plot?	How are you going to restore fertility on plot when you decide to renew your tenure?
P01				
P02				
P03				
P04				
P05				
P06				

## 2.6. Land Preparation

plot No.	Do you practice slash and burn? (1=yes,2=no)	Mention any other land preparation method you use on your plots?	Do you intercrop or rotate your crops with legumes? (1=yes, 2=no)	Mention other farming systems you have been using on plot.
P01				
P02				
P03				
P04				
P05				
P06				

## 2.7. Input Use

plot No.	Major rainy season (2009)			Minor rainy season (2009)		
	Input <b>(V)</b>	Quantity (units)	Amount paid (GH¢)	Type of input <b>(V)</b>	Quantity (units)	Amount paid (GH¢)

P01						
P02						
P03						
P04						
P05						
P06						

2.8.1 Hired Labor Input (Adult male)

Major rainy season (March-July, 2009)												
plot No.	Land Preparation			Sowing			Weed Control			Harvesting		
	No	Days	Wage	No	Days	Wage	No	Days	Wage	No	Days	Wage
P01												
P02												
P03												
P04												
P05												
P06												
Minor rainy season (September-November, 2009)												
plot No.	Land Preparation			Sowing			Weed Control			Harvesting		
	No	Days	Wage	No	Days	Wage	No	Days	Wage	No	Days	Wage
P01												
P02												
P03												
P04												
P05												
P06												

Note: Wages in GH¢

2.8.2 Hired Labor Input (Adult female)

Major rainy season (March-July, 2009)												
plot No.	Land Preparation			Sowing			Weed Control			Harvesting		
	No	Days	Wage	No	Days	Wage	No	Days	Wage	No	Days	Wage
P01												
P02												
P03												
P04												
P05												
P06												
Minor rainy season (September-November, 2009)												
plot No.	Land Preparation			Sowing			Weed Control			Harvesting		
	No	Days	Wage	No	Days	Wage	No	Days	Wage	No	Days	Wage
P01												
P02												
P03												
P04												
P05												
P06												

### 2.8.3. Family Labor Input (Adult male)

Major rainy season (March-July, 2009)								
plot No.	Land Preparation		Sowing		Weed Control		Harvesting	
	No	Days	No	Days	No	Days	No	Days
P01								
P02								
P03								
P04								

P05								
P06								
Minor rainy season (September-November, 2009)								
plot No.	Land Preparation		Sowing		Weed Control		Harvesting	
	No	Days	No	Days	No	Days	No	Days
P01								
P02								
P03								
P04								
P05								
P06								

#### 2.8.4. Family Labor Input (Adult female)

Major rainy season (March-July, 2009)								
plot No.	Land Preparation		Sowing		Weed Control		Harvesting	
	No	Days	No	Days	No	Days	No	Days
P01								
P02								
P03								
P04								
P05								
P06								
Minor rainy season (September-November, 2009)								
plot No.	Land Preparation		Sowing		Weed Control		Harvesting	
	No	Days	No	Days	No	Days	No	Days
P01								
P02								

P03								
P04								
P05								
P06								

2.9. Crop cultivation

1	Plot number			P01	P02	P03	P04	P05	P06
2	Crops grown <b>(Same as M)</b>	Major rainy season (2009)	crop 1						
			crop 2						
			crop 3						
	Minor rainy season (2009)	crop 1							
		crop 2							
		crop 3							
3	Area of crop cultivated (acres)	Major rainy season (2009)	crop 1						
			crop 2						
			crop 3						



		Minor rainy season (2009)	crop 1						
			crop 2						
			crop 3						
4	Have you observed any decline in crop yields?(1= yes, 2= no)								
	If yes, what do you think are the causes of this problem?								
5	Are there any differences between crops you grow and that of the landowner/tenant?	1=yes, 2=no							
		If yes, mention some of the differences in farming systems.							
6	Did you receive any technical assistance from an extension officer in 2009?	1=yes, 2=no							
		If yes, how many times in 2009?							

### Section 3. Household Income and Assets (Wealth)

#### 3.1. Household ownership of implements/tools/assets

1	Implements/tools/assets	1	2	3	4	5	6
2	What types of implements/tools do you use in your farm? <b>(W)</b>						
	How many of those implements do you have?						
	How did you acquire them? <b>(X)</b>						
	What year did you acquire them?						
	What is the unit cost of the implement (in GH¢)?						
3	Which of the following assets do you have? <b>(Y)</b>						
	How did you acquire them? <b>(Same as (X))</b>						

### 3.2. Income from crop/tree/fruit sales

1	Serial number of head							
2	Type of crop/trees/fruits	Maize (bags)	Yam (100 average tubers)	Cassava (bags/taxi boot)	Plantain (bunches)	Groundnut/ Beans (bags)	Vegetable* (box/crates)	Trees/Fruits (logs/quantity)
3	What quantity of crop/tree/fruit was harvested in 2009?	P01						
		P02						
		P03						
		P04						

		P05							
		P06							
		P01							
		P02							
		P03							
		P04							
		P05							
		P06							
4	What quantity of the crop/ tree/	P01							

	fruit was sold in 2009?								
		P02							
		P03							
		P04							
		P05							
		P06							
	What is the unit price (GH¢) of crop/tree/fruit sold in 2009?								
5	What quantity of the crop was stored in 2009?	Major rainy season							
		Minor rainy season							
6	What quantity of crop did the household consume in 2009?								

3.2. Income from crop/tree/fruit sales (continued)

	Type of crop/ trees/ fruits		Maize (bags)	Yam (100 average tubers)	Cassava (bags/ taxi boot)	Plantain (bunches)	Ground nut/ Beans (bags)	Vegetable* (box/ crates)	Trees/ Fruits (logs/qty)
7	How do you sell your farm produce? (market channels) <b>(Z)</b>	P01							
		P02							
		P03							
		P04							
		P05							
		P06							
8	What type of marketing costs do you incur? <b>(AA)</b>	P01							
		P02							
		P03							
		P04							
		P05							
		P06							
9	What is the value of the marketing costs (GH¢)?	P01							
		P02							
		P03							

		P04							
		P05							
		P06							
10	What are the main problems with marketing of the farm produce?	P01							
		P02							
		P03							
		P04							
		P05							
		P06							

### 3.3. Livestock ownership

1	Serial no. of head							
2	What types of animals do you own? (tick)	Cattle	sheep	goat	pigs	chicken	guinea fowls	
3	What quantity did you have at the beginning of 2009?							
4	What quantity did you have at the end of 2009?							
5	What is the unit price (GH¢) of animal in 2009?							
	Did a veterinary officer attend to your animals in 2009? (1=yes, 2=no)							

### 3.4. Non-farm Business Activities

1	Serial number of household head*	Male	Female
---	----------------------------------	------	--------

2	Self-employment	Type of business? <b>(AB)</b>		
		How much time (in hours) is spent on the work each day?		
		How was capital obtained for the business? <b>(Same as X)</b>		
		What were the costs (GH¢) of this business in 2009?		
		What was the total income (GH¢) in 2009?		
3	Non-agricultural wage employment  (e.g. drivers, truck pushers, watchman, etc.)	Actual job <b>(AC)</b>		
		Number of days used for this work per month		
		Monthly wage (GH¢)		
		How was payment made? <b>(AD)</b>		
		Value of payment in kind (GH¢)		
		Value of payment in cash (GH¢)		
4	Off-farm agricultural employment  (e.g. hired labor etc.)	Actual job <b>(Same as AC)</b>		
		Daily wage (GH¢)		

	Number of days used for this work per month		
	How was payment made? <b>(Same as AD)</b>		
	Value of payment in kind (GH¢)		
	Value of payment in cash (GH¢)		

\* Interview both male and female

## Section 4. Social Capital, Networks and Cooperation

### 4.1 Social networks

1	<b>Informal social networks</b>	Male	Female
	Do you have friends apart from your relatives? (1=yes, 2=no)		
	How often do you visit your friends per week?		
	How many farmers live in a radius of five kilometers around your home?		
	How often do you talk to them per week?		
2	<b>Networks for specific purposes</b>		
	Do you have someone who assists you practically in your farming activities (through nnoboa)? (1=yes, 2=no)		
	If yes, how many do help you?		
	Do you know someone who assists you with money in case of need? (1=yes, 2=no)		
	If yes, how many individuals would assist you? Differentiate between 1= family, 2= friends, neighbors, 3= traders, 4=other (specify) (Use the numbers and state number of individuals for each!)		
	Does someone assist you with trading? (1=yes, 2=no)		



	If yes, who does help you?		
	Mention the form of assistance		
3	<b>Information networks</b>		
	How many neighbors do use soil conservation methods and soil-improving practices?		
	If more than none, do you discuss the methods with some of them? (1=yes, 2=no)		
	What is the main experience of those who use soil conservation methods and soil-improving practices? (1=very bad, 2=bad, 3=don't know, 4=good, 5=very good)		
	How many individuals you know do use soil conservation methods and soil-improving practices? 1=family, 2=friends, 3=religious networks (Indicate the number of individuals for each)		
	If more than none, do you discuss the methods with some of them? (1=yes, 2=no)		
	What is the main experience of those who use soil conservation methods and soil-improving practices? (1=very bad, 2=bad, 3=don't know, 4=good, 5=very good)		
	Are you getting advice about your farming business? <ul style="list-style-type: none"> <li>● family (1=yes, 2=no)</li> <li>● friends (1=yes, 2=no)</li> <li>● neighbors (1=yes, 2=no)</li> <li>● others (specify) (1=yes, 2=no)</li> </ul>		
	If yes, mention the type of advice		
	Do you have a mobile phone? (1=yes, 2=no)		
	If yes, (and if applicable) how does it help you in your farming business?		

#### 4.2. Social capital from participation in social activities

		Male	Female
1	<b>Participation in religious activities</b>		

	Do you belong to any religious organization? (1=yes, 2=no)		
	If yes, what group?		
	What informed you to join the group?		
	Do you hold any position in the group? (1=yes, 2=no)		
	Does joining this group assist you in your farming activities?		
	If yes, mention this form of assistance!		
2	<b>Participation in farmer based organizations (FBO) activities</b>		
	Are you a member of any FBO? (1=yes, 2=no)		
	If yes, how many organizations are you a member of?		
	How many ethnic groups are present in your organization(s)? If more than one organization, indicate for each!		
	Does joining the organization (s) assist you in your farming business?		
	If yes, mention the form of assistance!		
	Do you hold any position in any of the organizations? ( 1=yes, 2=no)		
	Have the members of the organization (s) received some training towards improving your farming activities? (1=yes,2=no)		
	If yes, what kind of training have you received?		

#### 4.3. Social capital at the village level

	Serial number of household head	
--	---------------------------------	--

		Male	Female
1	Do you think the community in which you farm is safe for you to undertake your farming activities? (1=yes, 2=no)		
2	Generally, do you think the people in the village or community where you farm can be trusted? (1=yes, 2=no)		
3	Generally, how do you rank the cooperative behavior in the community? (4=very good, 3=good, 2=average, 1=poor)		
4	How do you rank the educational systems in the community where you farm? (4=very good, 3=good, 2=average, 1=poor)		
5	Do you think being a member of the community offer you opportunity to access credit from the community credit lenders?  (1=yes, 2=no)		
6	Do you vote for local politics? (1=yes, 2=no)		

\*Interview both male and female

#### 4.4.Trust and cooperation in tenancy arrangements and assistance

	Serial number of household head		
		Male	Female
1	How often do you meet your landowner/tenant in a year?		
2	For sharecroppers, do you trust your owner/tenant to accept/pay his/her share of output? (4=very high 3=high, 2=average, 1=poor)		
3	For fixed-rent tenants;  Do you trust your owner to allow you to vacate the rented plot promptly? (4=very high, 3=high, 2=average, 1=poor)		

	Do you trust your owner to extend the tenure duration, if you want to? (4=very high, 3=high, 2=average, 1=poor)		
	For owners of fixed plots; Do you trust your tenant to vacate the rented plot promptly? (4=very high, 3=high, 2=average, 1=poor)		
4	Have your owner/tenant assisted you with a loan for your farming activities before? (1=yes, 2=no)		
5	If yes, have you defaulted in the repayment of the loan agreement before? (1=yes, 2=no)		
6	How do you rank the assistance extension agents give to you in improving your cultivation techniques? (4=very high, 3=high, 2=average, 1=poor)		
7	How do you rank the assistance extension agents give to you in improving the investments you undertake on your plot(s)? (4=very high, 3=high, 2=average, 1=poor)		

\*Interview both male and female

## Section 5. Perceived Needs

### 5.1. Constraints on investment

Which of the following issues hinder you from investing in soil conservation methods and soil-improving practices? Determine the extent of constraint!

		Very High	High	Low	Very Low	None
1	Socio- economic issues					
	Lack of access to inputs					
	High prices of inputs					
	Lack of access to credit					
	Lack of land					
	Insecurity in extension of tenure duration					
	High effort of applying practices					
	Lack of practical help					

	Lack of implements and/ or tools to apply practices					
	Lack of remunerative options to gain benefits from investment					
	Insecurity in reaping benefits of investment					
	Lack of good experiences from others					
	High social pressure					
	High complexity of applying combination of practices					
	Lack of support from family/friends to invest					
	Low increase in (short-term) productivity in comparison to cost increase of production due to investment					
2	Structural issues					
	Lack of information on possible practices					
	Lack of knowledge on how to apply practices					
	Lack of advice/ guidance on how to apply practices					
3	Other (Specify)					

5.2. Necessary Changes

What have to be changed for you to invest in soil conservation methods and soil-improving practices? Please name three and start with the most crucial in order to indicate the order of importance

- 1).....  
.....  
2).....

3).....  
.....

## CODES

### Section 1: Personal History

#### A (Position)

- 01=husband
- 02=wife
- 03=brother
- 04=sister
- 05=son
- 06=daughter
- 07=other (specify)

#### C (Where born)

- 01=this village
- 02=out of this district
- 03=my hometown
- 04=foreign country
- 05=other (specify)

#### E (Position)

- 01=husband
- 02=wife
- 03=son
- 04=daughter
- 05=brother
- 06=sister
- 07=nephew
- 08=other (specify)

### Section 2: Plot-level Characteristics

#### G (Type of slope)

- 01=flat
- 02=mild slope
- 03=severe slope
- 04=other (specify)

#### I (Plot ownership)

- 01=inherited maternal family
- 02=inherited paternal family
- 03=husband family land
- 04=hired/rented land
- 05=sharecropping
- 06=free/gift
- 07=stool land (lease/grant from chief)
- 08=personally owned land (purchased)

#### K (Tenure arrangement)

- 01=sharecropping (*abunu*)
- 02=sharecropping (*abusa*)
- 03=hired (rented)
- 04=purchased (owned)
- 05=free (gift)

#### B (Ethnic group)

- 01=Frafra
- 02=Kusasi
- 03=Busanga
- 04=Kasena Nankani
- 05=Builsa (Kangyaga)
- 06=Gurunshie (Kasena)
- 07=Asante
- 08=Brong
- 09=other (specify)

#### D (Education Level)

- 01=none
- 02=primary
- 03=middle/JHS
- 04=secondary/college/SHS
- 05=other (specify)

#### F (Job)

- 01=student/pupil
- 02=looking after the family farm
- 03= non-agricultural wage employment
- 04=agricultural wage employment
- 05=self-employed
- 06=unemployed
- 07=other (specify)

#### H (Expected fertility)

- 01=very fertile
- 02=fertile
- 03=not fertile
- 04=other (specify)

#### J (Inheritance of plot)

- 01=children
- 02=brother/sister
- 03=uncle/aunt
- 04=husband/wife
- 05=others (specify)

#### L (Share of costs of inputs)

- 01=migrant tenant bear all the cost
- 02=landowner bear all the cost
- 03=cost is shared equally
- 04=migrant tenant pays two-thirds
- 05=landowner pays two thirds

06=lease (grant) from chief  
07=taungya  
08=other (specify)

06=other (specify)

### **M (Crops grown)**

01=maize  
02=sorghum  
03=millet  
04=yams  
05=cassava  
06=cocoyam  
07=pepper

08=tomato  
09=okro  
10=garden eggs  
11=cowpea  
12=groundnuts  
13=plantain  
14=other (specify)

### **N (Type of trees)**

01=teak  
02=cashew  
03=oil palm  
04=mahogany ("odum")

05=orange  
06=mango  
07=other (specify)

### **O (Erosion control)**

01=terraces  
02=ditches  
03=wind breaks  
04=earth dams  
05= other (specify)

### **P (Agronomic practices)**

01=multiple cropping  
02=mulching  
03=crop rotation  
04=cover crops  
05=others (specify)

### **Q (Soil management practices)**

01=deep ploughing  
02=compost  
03=farm manure  
04=green manure  
05= other (specify)

### **R (Cultivation practices)**

01=minimum tillage  
02=zero tillage  
03=ridging across slope  
04=ridging along slope  
05=others (specify)

### **S (Reasons for planting trees)**

01=to check soil erosion  
02=to prevent declines in yields of crops  
03=part of tenure agreement

04=to earn income  
05=to have secure tenure of plot  
06=other (specify)

### **T (Source of seeds)**

01=purchased  
02=own grown seedlings  
03=community tree nursery  
04=other (specify)

### **U (Maintenance of trees)**

01=manual weeding  
02=pruning  
03=use of weedicides  
04=establishing fire lines

### **V (Type of Inputs)**

01=fertiliser (NPK 15-15-15)  
02=fertiliser (NP 20-20)  
03=urea (sulphate of ammonia)  
04=pesticides/fungicides

05=herbicides/weedicides  
06=planting material  
07=improved seeds  
08=other (specify)

## **Section 3: Household Income and Assets (Wealth)**

### **W (Implements)**

01=cutlass  
02=hoe

### **X (Source of funds)**

01=loan from the bank  
02=loan from credit union



03=ax

04=mattock  
05=head pan  
06=tractor  
07=basket  
08=sacks  
09=other (specify)

**Y (Ownership of assets)**

01=cart  
02=car  
03=motor bicycle  
04=bicycle  
05=tractor

**Z (Marketing channels)**

01=farm  
02=market  
03=home  
04=market, home  
05=cocoa buying centres  
06=others (specify)

**AB (Type of self-employment)**

01=pito brewing  
02=handicrafts  
03=selling of cooked food  
04=shoe shine/repairing  
05=charcoal production  
  
06=gari processing  
07=table top/market stall  
08=general retail shop  
09=tailoring/seamstress  
10=other (specify)

**AD (Payment of wages)**

01=cash  
02=payment in kind  
03=use of plough  
04=free transportation to/from farm  
05=other (specify).

03=loan from 'susu' collectors

04=loan from traders  
05=loan from money lenders  
06=income from crop sales  
07=income from non-farm  
08=income from livestock sales  
09=other (specify)

06= refrigerator  
07=television  
08=house  
09=others (specify)

**AA (Type of marketing costs)**

01=transport cost  
02=on-loading cost  
03=off-loading cost  
04=market tolls  
05=transport, on-loading  
06=transport, market tolls  
07=selling cost  
08=others (specify)

**AC (Type of wage employment)**

01=employee working for rural private employer  
02=employee working for government  
03=hired farm labourer  
04=exchange work in relative's farm  
05=exchange work in friend's farm  
  
06=exchange work in local transport owner's farm  
07=other (specify)