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Farmers' Knowledge, Perceptions, and Socioeconomic Factors Influencing Decision Making For Integrated Soil Fertility Management Practices in Masaka and Rakai Districts, Central Uganda

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Farmers' knowledge, perceptions, and socioeconomic factors influencing decision making for integrated soil fertility management practices in Masaka and Rakai districts, central Uganda

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DEDICATION

I dedicate this thesis to my mother Hellen, my nieces Kristina, Abigail and Krystabel, and my nephews Kris, Kristian, Calvin and Martin. You are the inspiration for what I am today. May God bless you all.

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NOMENCLATURE

CBS	Central Broadcasting Services
CEDO	Community Empowerment Development Organization
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
MADDO	Masaka Diocesan Development Organization
MDLG	Masaka District Local Government
NAADS	National Agricultural Advisory Services
NEMA	National Environmental Management Authority
NGO	Non-Governmental Organization
RDLG	Rakai District Local Government
UBOS	Uganda Bureaus of Statistics
UNCTAD	United Nations Conference on Trade and Development
USAID	United States Agency for International Development
VSLA	Village Savings and Lending Association

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ABSTRACT

Declining soil fertility, exacerbated by continuous cultivation of land, poverty and limited access to productive assets, is a crucial factor limiting crop production among smallholders in Uganda. Integrated soil fertility management (ISFM) practices that involve a combination of organic and mineral fertilizers, and other improved farming practices such as planting legumes and diversified crop rotations within cropping systems have been promoted but their adoption rate has remained low. Using empirical data collected through in-depth interviews with 27 smallholders in Masaka and Rakai Districts, this study examined factors influencing farmers' decision-making processes in experimenting with and adopting ISFM practices and technologies. Significant roles are played by the relative advantage of a practice (derived from local availability of materials, multifunctionality of the practice and cost of investment), ability to observe the success of the practice before adoption (either from fellow smallholders or through experimentation), and compatibility of the practice with existing farm operations. However, the influence of these factors varies among farms because of significant heterogeneity in household wealth, land tenure, social networks, access to input-produce markets and extension services. Extension agents and farmer-to-farmer interactions are the most trusted information sources for ISFM. Recommendations to facilitate adoption ISFM practices include: use of iterative learning approaches that foster interaction among farmers, extension specialists, and researchers; conducting benefit-cost analyses of various practices to facilitate development of adaptable and flexible ISFM measures; and catering for heterogeneity in smallholders' resource endowments - particularly land size, livestock ownership and income; and policies and programs that improve tenure security and access to credit to facilitate investment in ISFM practices and technologies.

CHAPTER 1: GENERAL INTRODUCTION AND PROBLEM STATEMENT

Food and nutrition insecurity and poverty are major challenges in developing countries, particularly in sub-Saharan Africa (Ellis, 1993; FAO, IFAD, & WFP, 2013; Khan et al., 2014; UNCTAD, 2011). In Uganda, declining soil fertility (Sanchez et al., 1997; Wortmann & Kaizzi, 1998; Zake, Nkwiine, & Magunda, 1999) exacerbated by continuous cultivation of land, poverty, and lack of access to productive resources (Barungi, Edriss, Mugisha, Waithaka, & Tukahirwa, 2013; Henao & Baanante, 2006; Henao, Baanante, Pinstrup-Andersen, & Pandya-Lorch, 2001; Lunze et al., 2012; NEMA, 2001; Sanchez, et al., 1997; Sserunkuuma, Pender, & Nkonya, 2001; Wortmann & Kaizzi, 1998; Zake, et al., 1999) continue to be the most important factors aggravating crop yields among smallholder farmers[1] who constitute about 85 percent of the country's rural population (World Bank 2013) and subsist on less than two hectares per household (Banadda, 2010). Other limiting factors include unreliable rainfall patterns, pests and diseases, and weak information and advisory services (Barungi, et al., 2013; Kyomugisha, 2008; MAAIF, 2010). These factors leave farmers with a narrow range of motivations and opportunities to adapt and/or invest in sustainable Integrated Soil Fertility Management (ISFM[2]) techniques.

Over the years, efforts addressing soil fertility in Uganda have focused on improving the nutrient balance and the bio-physical characteristics of the soil (Lunze, et al., 2012; Wortmann & Kaizzi, 1998) by encouraging use of fertilizers (both organic and inorganic), improved varieties and incorporation of other improved farming practices, including planting legumes and diversified crop rotations within cropping systems (Bekunda, Bationo, & Ssali, 1997; Kaizzi, Ssali, & Vlek, 2006; Nkonya et al., 2008) but with less consideration of farmers' local knowledge and context/constraints that mediate the decision making process regarding adaptation, adoption and/ or maintenance of ISFM technologies and practices in rural areas of developing countries (Deugd, Röling, & Smaling, 1998; Pannell et al., 2006; Scoones & Toulmin, 1998; UNCTAD, 2011;

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[1] Ellis (1993) defines a smallholder farmer as a household which derives its livelihood mainly from agriculture, predominantly utilizes family labor in farm production, is characterized by partial engagement in input and output markets, and is both a producer and a consumer of agricultural goods.

[2] Vanlauwe (2010), defines ISFM as, ""*a set of soil fertility management practices that necessarily include the use of fertilizer, organic inputs and improved germplasm, combined with the knowledge on how to adapt these practices to local conditions, aiming to maximize agronomic use efficiency of the applied nutrients and improved crop productivity*" whose overall goal is improving livelihoods of people relying on agriculture by developing and creating profitable, socially just, nutrient dense and resilient agricultural production systems.

Vanlauwe et al., 2010; Vanlauwe, Ramisch, & Sanginga, 2006). Such an approach has been criticized for overlooking the local context and farmers' priorities (Corbeels, Shiferaw, & Haile, 2000; Davis et al., 2012; Fairhead & Scoones, 2005; Reijntjes, Haverkort, & Waters Bayer, 1992; Yengoh, Armah, & Svensson, 2010).

Farmers' perceptions and knowledge about soil fertility management, and socioeconomic factors, including landholding, security of land use rights, and assets ownership; labor availability; access to credit; access to information and markets, and social networks/relations that affect farmers' decision making with regard to adoption of soil fertility management have not been sufficiently explored (Ramisch, 2010; Tittonell, Vanlauwe, De Ridder, & Giller, 2007) resulting in low adoption of soil fertility technologies and management.

The aim of this research is to contribute towards filling this gap by examining factors that influence the decision-making process in terms of farmers' current knowledge and perceptions towards ISFM. Specifically, this research explores how smallholder farmers' perceptions, knowledge and key socioeconomic factors (landholding, security of land use, farm labor supply, access to information and markets, and the social networks/relations) influence their decision-making processes to adopt ISFM practices within rural communities of Central Uganda.

By understanding factors that may enhance or constrain smallholder farmers' ability to adapt and adopt improved soil fertility technologies and management practices, this research creates an opportunity for scholars, practitioners, and farmers to identify and utilize appropriate soil fertility management strategies relevant to the local context.

Justification of this study

Masaka and Rakai Districts lie in the central region of Uganda with agriculture as the major source of rural livelihoods (MDLG, 2011; RDLG, 2011). Principal crops grown in this region are coffee, bananas, maize, beans, and sweet potatoes. The districts are faced with low and declining soil fertility intensified by increased population pressure, soil erosion, and poor farming practices including continuous cropping and bush burning (MDLG, 2011; NEMA, 2001; Olson & Berry, 2003; Sebukyu & Mosango, 2012). Such land changes, both natural and anthropogenic, have increasingly raised concern among scientists and farmers due to the resulting decline in soil fertility (Bekunda, 1999; Olson, 1998; Vanlauwe, et al., 2010; Zake, et al., 1999) and the related impact on food and nutrition security, poverty and rural livelihoods of smallholder farmers (Fungo, Grunwald, Tenywa, & Nkedi-Kizza, 2013; Pretty et al., 2006; Rodenburg et al., 2014; Vanlauwe, et al., 2010; Vanlauwe, et al., 2006; Vanlauwe et al., 2014).

Recent findings from the participatory rural appraisal conducted by the project[3] team in Masaka and Rakai districts (Tenywa et al. 2014 unpublished data) indicate that some farmers are currently applying farm yard manure, ash and inorganic fertilizers specifically, Urea and Diammonium Phosphate (DAP) to boost soil fertility while others do not. Such variations in farmers' interventions towards improving soil fertility raise a central question of why some farmers within a given farming system (maize-bean cropping system) choose to adopt and invest in improved soil fertility management practices such as use of organic manure and inorganic fertilizers while others do not.

Farmers' perceptions, knowledge about soil fertility and context have been identified as key aspects that facilitate farmer decision making processes to adopt or adapt ISFM approaches (Corbeels, et al., 2000; Séhouéto, 2006). The current study provides an opportunity to understand farmers' awareness and differentiated local knowledge regarding soil fertility change and management that are revealed in local taxonomies and language (Ramisch, 2004), and the socioeconomic environment within which decision making processes are embedded.

The aim of this study is to examine factors that influence smallholder farmers' decision-making processes to adopt ISFM practices within maize-bean cropping systems. Specifically, this

[3] In 2013, a new collaborative research project; "Farmer Decision Making Strategies for Improved Soil Fertility Management in Maize-Bean Production Systems (ISU SO2.1)" under the USAID Feed the Future Legume Innovation Lab funded projects was initiated in Masaka and Rakai districts of Uganda. The project's *central premise* is that, addressing soil-related constraints requires understanding farmers' current practices and enhancing their capabilities in diagnosing and finding solutions to yield constraints. The goal is to promote sustainable widespread improvements in bean productivity and soil fertility through: (1) characterization of smallholder farmers' agricultural innovations, current knowledge and practices, problem diagnosis and livelihood and risk management strategies; (2) development of models about concerning famer decision making; (3) development and validation of appropriate soil diagnostic and decision support aids among others. The current study is part of a series of independent studies that have been undertaken in trying to understand the overall farmer decision-making strategies within the project implementation areas.

research explores (1) how farmers' perceptions and local knowledge about soil fertility management influence their decisions to adopt or adapt ISFM practices, and (2) how key socioeconomic factors (landholding, security of land use, farm labor supply, access to information and the social networks/relations) are influencing adoption decisions for ISFM among smallholders in Uganda.

CHAPTER 2: LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This chapter reviews existing research on adoption of soil fertility management practices and theories that have been used to understand this behavior. While several studies have been conducted to explain why farmers (dis)adopt new practices, there seems to be growing concern suggesting that focus should be tailored towards local contexts that reflective of potential adopters. We review this literature focusing on farmers' local context regarding their local knowledge; practice characteristics; farm and farmer characteristics and the institutional factors that influence farmer adoption behavior.

Farmers' local knowledge

Regarding soils, local knowledge can be defined as "the knowledge about soil properties and management possessed by people living in a particular environment for some period of time" (Winklerprins, 1999). Such knowledge includes complex practices and decisions made by local people based on experience built over time; it is dynamic, continually changing and rarely systematized (Boven & Morohashi, 2002). It adapts and integrates novel notions over time, may be location specific or vary among individuals from different social groups differentiated by factors such as wealth, gender, ethnicity and occupation. Such knowledge is transmitted and shared within specific social and agroecological contexts (Séhouéto, 2006; Warburton & Martin, 1999) providing a framework for decision-making in a plethora of social, economic and environmental activities and livelihoods among rural households. Therefore, the term local knowledge emphasizes the fact that farmers constantly produce and adopt new forms of knowledge subject to certain patterns of their own cultural, agroecological and socioeconomic conditions as an adaptation mechanism.

Local farmer knowledge as an entry point to agricultural innovation

Following the work by Chambers and Leach (1989), it has become more fully recognized that local knowledge is valid and needs to be considered in agricultural development in many developing countries including Uganda. Chambers and Leach (1989) argue that the problem of dis-adoption of agricultural technologies lies neither with the farmers nor their farms, but rather with the technology itself, and the embedded priorities and processes of its generation. In contrast to a top-down approach, advocates for farmer-participatory approaches envisage farmers and researchers as co-developers of new technologies.

Farmers have increasingly been recognized as sources of local knowledge and technologies, who thus must be involved in technology adoption research (Chambers & Leach, 1989). Besides, various technologies currently used were designed by farmers (Ramisch, 2004). Therefore, it is important in all development initiatives including ISFM to take into consideration farmers' perceptions, knowledge and practices and to assess how they influence their farming decisions (Brokensha, Warren, & Werner, 1980). Assessing and considering the knowledge held by farmers allows development of more appropriate technologies as well as favoring communication between farmers and other interventionists (Desbiez, Matthews, Tripathi, & Ellis-Jones, 2004). It enables farmers to confidently seek new options while facilitating the process of filling the "knowledge gap" that exists between local and scientific traditions.

Integrated soil fertility management

The concept of ISFM involves simultaneous integration of individual soil management practices with an overall aim of exploiting complementarity effects that exist among these multiple technologies (Marenya & Barrett, 2007). A core assumption in this approach is that each soil fertility management practice (technology) has a significant contribution to make in enhancing soil fertility and productivity; none of them is sustainably sufficient in meeting all soil fertility requirements (Place, Barrett, Freeman, Ramisch, & Vanlauwe, 2003; Vanlauwe, 2004); thus, they should be used in complementary ways.

Sanginga and Woomer (2009) state that the most important aspects of ISFM germane to smallholder farming systems in Africa include: (i) judicious use of mineral fertilizers [such as lime and rock phosphate], (ii) efficient management of available organic resources [animal manure, crop residues, compost and green manure], (iii) broader incorporation of nitrogen-fixing legumes into cropping systems and (iv) protection of soils, their biota, and organic matter.

Combining scientific knowledge and local knowledge for ISFM

Numerous studies (Chambers & Leach, 1989; Isaac, Dawoe, & Sieciechowicz, 2009; Pulido & Bocco, 2014; Ramisch, Misiko, Ekise, & Mukalama, 2006; Rist & Dahdouh-Guebas, 2006; Winklerprins, 1999) have emphasized the richness of farmers' local knowledge about soil fertility, which they constantly use to adapt local farming systems to changing environmental conditions. This changes over time to fit within their farming decision strategies (Dawoe, Quashie-Sam, Isaac, & Oppong, 2012). For instance, Ramisch, Misiko, Esike and Mukalam (2006) in Kenya, while using 'folk' ecology (a participant learning technique that builds on folk knowledge) and the knowledge held by 'outsiders' (scientists) found out that farmers develop names for nutrient inputs that they apply or see within their areas which help them better understand soil fertility management. In this study, Ramisch et al. (2006) found that farmers had renamed nitrogen and phosphorous using pronounceable female names *jeni* and *Fosi*. From a meta-analysis of previously published studies on land degradation, (Pulido & Bocco, 2014) conclude that, in many cases farmers have reasonable knowledge of the causative factors and strategies to reverse land degradation that is useful and should be developing best alternative practices. Relatedly, Dawoe et al. (2012) found farmers to have a well-developed intimate knowledge system about their soils, nutrient loss and cycling processes based on experience and the information that they obtained from learning approaches involving their fellow farmers and extension agents. This type of knowledge that farmers possess has been found to correlate with scientific knowledge (Saito, Linquist, Keobualapha, Shiraiwa, & Horie, 2006).

Farmers have developed traditional approaches to enhancing soil fertility and conservation such as: the use of organic manure (mainly from livestock and compost); fallowing; mulching; and intercropping (Kolawole, 2002), making their knowledge in soil fertility management a subject of interest. Although practices such as fallowing can no longer be extensively used in many areas due to the competing land use demands as caused by increased industrial growth and population pressures, a combination of manure application, mulching and intercropping with scientist-based approaches to soil fertility management remains plausible.

A shift towards ISFM provides an opportunity to integrate farmers' local knowledge and practices with scientific approaches to achieve sustainable soil fertility management since it assimilates existing practices. ISFM is based on scientific understanding of the underlying biological processes of soil fertility while promoting alternatives that make the best use of locally available inputs to suit local agro-ecological conditions, and farmers' resources and interests

(Mairura et al., 2007). In this study we seek to further explore this phenomenon among smallholder farmers in Masaka and Rakai Districts.

Theoretical framework

Various studies have been conducted to understand factors that motivate farmers to adopt improved soil fertility management practices (Mercer, 2004; Negatu & Parikh, 1999; Pannell, et al., 2006; Prokopy, Floress, Klotthor-Weinkauf, & Baumgart-Getz, 2008; Pulido & Bocco, 2014). In addition, theoretical frameworks have been used to understand and explain the adoption behavior of farmers including the diffusion of innovations (Rogers, 2003), planned behavior and reasoned action (Fishbein & Ajzen, 2010), social learning (Bandura, 1977) and econometric models (Feder, Just, & Zilberman, 1985). However, in spite of all these studies and theoretical frameworks used, there remains a lack of consensus on which elements could be the primary drivers of adoption. Besides, efforts to relate farmers' attitudes and behavior to personal, contextual and farm attributes have largely failed (Lockeretz, 1990).

We, therefore, argue that farmer decision-making to adopt new soil fertility management practices is a complex process contingent on multiple factors: biophysical, economic, social and psychological. These can only be understood by using a holistic approach that integrates farmer characteristics, farm attributes, contextual factors and farmer perceptions about the specific practices that they consider adopting.

Diffusion of Innovations Theory

Diffusion refers to a process by which an innovation is communicated through given channels among members of a social system over time. An innovation can be an idea, practice or concept perceived as new by individuals or groups (Rogers, 2003). Though the words 'innovation' and 'technology' have been interchangeably (Rogers, 2003), defines technology as "a design for instrumental action that reduces the uncertainty in the cause-effect relationships involved in achieving the desired outcome." A technology consists of two components, that is, a 'hardware' component which is made of tools that represent the technology as a material or physical object and the 'software' component which is made up of the information base for the tool (Rogers, 2003). Viewed from this perspective, ISFM practices (e.g. animal manure, mulch, inorganic fertilizers etc.) represent the hardware component while knowledge required for sustainable use and adoption (e.g., method of application, application rate) is the software component of the of the practices.

Based on perceived attributes of a technology, Rogers (2003) and Nutley, Davis and Walter (2002) propose five characteristics upon which the rate and likelihood of adoption a technology is judged. Some of these characteristics are intrinsic to the technology itself while others concern the adopters' characteristics and their usage of the technology. They are: relative advantage, compatibility, complexity, trialability, and observability.

Relative advantage is defined as the way in which a given technology is perceived as better than any technology it might replace (Rogers, 2003). It is dependent upon a farmer's unique set of interests influenced by economic (costs, yields), social (current circumstances), and cultural (norms, beliefs) context within which the innovation will be applied (Pannell, et al., 2006). Relative advantage of the technology plays a significant role in adoption among farmers, often in terms of short term economic benefits (Pannell, et al., 2006). Compatibility refers to how the technology fits or is perceived to be consistent with adaptors' existing values and practices. Synchronization of a new technology with an existing one increases the chances of adoption since it makes the new technology relatively familiar. Complexity refers to the difficulty of understanding the application and actual use a given technology. If potential adopters consider an innovation to be complex, its adoption tends to be low.

Trialability refers to the opportunity for a potential user to try out a technology (innovation) in an experimental setting. The targeted user can test the merits and demerits of a technology without necessarily committing to purchasing or adopting it. This plays a critical role in enhancing persuasion and implementation of the technology by minimizing uncertainty and risk associated with adoption of such a technology (Pannell, et al., 2006; Rogers, 2003), and is dependent on upon the observability of results (Cary, Webb, & Barr, 2001; Pannell, et al., 2006). Observability refers to how visible the use of the technology is to others. Seeing, hearing and knowing that other individuals are using the technology significantly encourages adoption. Soil fertility management strategies whose results are observable to potential adopters are more likely to be adopted (Reimer, Weinkauf, & Prokopy, 2012). Also, perceived attributes, particularly observability of a practice plays a key role in influencing the normative and control beliefs of the adaptor (Reimer, et al., 2012). Access to information is regarded to be a key factor influencing adoption. The decision to adopt an innovation is regarded as a mental process which follows a sequence of stages: knowledge, persuasion, decision, implementation and confirmation (Rogers, 1995, 2003).

Although it is a good theory for identifying and defining key aspects that influence adoption, diffusion of innovations theory has significant limitations in understanding technology adoption. First, the theory is limited in predicting outcomes resulting from technology adoption and exploring alternative approaches that accelerate the adoption rate (Mahajan, Muller, & Srivastava, 1990). Second, similar to economic theories of decision-making processes, the theory has emphasized understanding adoption in relation to income goals. Farmers who do not adopt the new innovation that would increase their income are considered to be irrational, yet decisions to adopt innovations also involve non-economic needs (Knowler & Bradshaw, 2007).

Theory of planned behavior

Ajzen's (1985) theory of planned behavior, recently extended to the model of Reasoned Action Approach by (Fishbein & Ajzen, 2010) is another approach that has been used to understand the decision-making process on adoption of soil conservation management practices (Beedell & Rehman, 1999; Fielding, Terry, Masser, Bordia, & Hogg, 2005; Reimer, et al., 2012). This theory explains human behavior as a result of three factors: attitude (the degree to which execution of the behavior is evaluated positively or negatively); subjective norm (the perceived social pressure to engage or not to engage in the behavior), and perceived behavioral control (which predicts the behavioral intention).

This theory posits that the attitude towards the behavior, the subjective norms and the perception of behavioral control lead to a positive or negative intention to perform the behavior (Ajzen, Albarracín, & Hornik, 2007), and have varying levels of influence depending on the behavior being adopted (Reimer, et al., 2012). The three factors (subjective norm, perceived behavioral control and attitude), are informed by individuals' beliefs stemming from various sources, and are partly a function of personal attributes and past experiences (Reimer, et al., 2012). However, this theory takes a reductionist approach which does not embrace the role of social learning, yet it is very instrumental in understanding the decision-making process. This has led to adoption of behavioral models that help to explain how human behavior and self-efficacy enhance adoption. Among these is the theory of social learning (Bandura, 1977).

Social Learning theory

Literature provides various definitions of social learning based on different contexts in which it is applied. In the context of natural resource management, Muro and Jeffrey (2008) define social learning as *"the communication and interaction of different actors in a participatory setting which is believed to result in a set of social outcomes, such as the generation of new knowledge, the acquisition of technical and social skills as well as the development of trust and relationships which in turn may form the basis for a common understanding of the system or problem at hand, agreement and collective actions."* (pg. 339). The theory posits that people learn by observing the behavior of others (Bandura, 1977).

Learning occurs within a social environment based on various strategies such as observation (of neighbors), imitation (of associates/peers) or modeling (by friends). Such learning may or may not result in change in behavior, depending on the level of attention of the learner (cognitive capacity), ability to remember the observed behavior (retention capacity), ability to replicate the observed behavior (motor capacity) and desire to put into practice the observed behavior (motivation level), all of which are influenced by the model's behavior, attitudes and outcomes of such behaviors (Bandura, 1977).

Kolb (1984) suggests that during the learning process, an individual undergoes four key stages: experiencing, reflecting, conceptualizing, and experimenting. Concrete experience in and through action is the center stage for the learning process. Individuals observe the effects of their actions from which they learn deeply as they reflect upon such experiences. They, in turn, develop abstract concepts (analysis) and generalizations (conclusions) from these experiences and apply what they have learned through active experimentation in subsequent situations resulting in new concrete experiences with a reflective feedback process on the consequences of their actions (Keen, Brown, & Dyball, 2005; Loeber, van Mierlo, Grin, & Leeuwis, 2007). This occurs primarily in situations where there are differences between expectations and experience or between ideas and desires resulting in transformations of individuals' perceptions and beliefs about worldviews, actions and themselves (Loeber et al., 2007). Learning is enhanced when it is considered to be a social event, which requires joint action with many actors involved (Loeber et al., 2007).

Based on this review of the aforementioned theories, it is evident enough that technology adoption in agriculture remains a complex process which cannot be explained by a single theory but rather a combination of them incorporating the perceived attributes of the technology to be adopted, and the contextual, informational and behavioral constructs of the adopters. Combining categories of perceived technology attributes derived from Rogers' diffusion of innovation theory with theory of planned behavior to identify the differences in norms, perceived controls of adopters as modified by Reimer et al (2012), and theory of social learning enables a better understanding of farmers' decision-making processes for adoption to various soil fertility management practices.

Factors influencing farmers adoption of soil management practices/technologies

The decision-making process to adopt new agricultural practices depends on both intrinsic factors such as knowledge, perceptions and attitudes and extrinsic factors such as the characteristics of the farmer (age, education, social networks, farming experience), biophysical characteristics (soil quality, farm size, slope), farm management characteristics (land tenure, labor source, wealth) and the external (contextual) factors (information sources and type, market access, etc.) (Baumgart-Getz, Prokopy, & Floress, 2012; Knowler & Bradshaw, 2007; Meijer, Catacutan, Ajayi, Sileshi, & Nieuwenhuis, 2015; Prokopy, et al., 2008; Reimer, et al., 2012).

Farmers' knowledge

Knowledge about the technology is often influenced by farmers' access to information (Baumgart-Getz, et al., 2012; Greiner, Patterson, & Miller, 2009; Lambrecht, Vanlauwe, Merckx, & Maertens, 2014; Prokopy, et al., 2008) and social networks within which the farmers interact (Greiner, et al., 2009; Knowler & Bradshaw, 2007; Pannell, et al., 2006). Access to information increases farmers' awareness (Lambrecht, Vanlauwe, Merckx, et al., 2014) and evaluative capacity of existing soil management practices (Prokopy et al., 2008). This in turn influences farmers' views about the practices (perceptions) based on their felt needs and prior experience

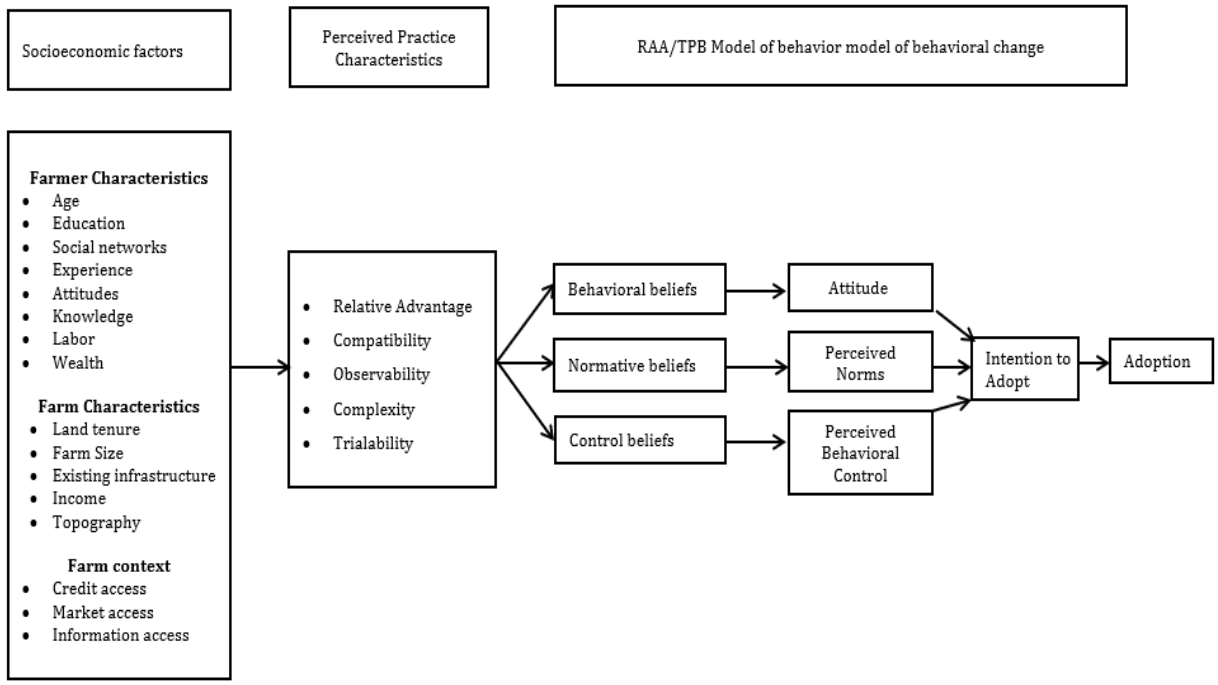


Figure 1: Modified graphic depiction of the study conceptual framework (Adapted from Reimer et al. 2012)

although this may not always be a true reflection of reality (Meijer, et al., 2015). In addition, social networks play a vital role in exposing people to new ideas and information through interactions (Prokopy, et al., 2008), thereby increasing the likelihood of adoption (Knowler and Bradshaw 2007).

Farmer perceptions

Meijer et al. (2015) consider farmers' perceptions as their views of a given technology in terms of their felt needs and prior experiences. In relation to land degradation, Pulido and Bocco (2014) define farmers' perceptions as the causes and status of land degradation as detected and expressed by farmers on their lands. The decision of farmers to adopt soil conservation practices begins with their perception of erosion as a problem. These perceptions are shaped by farmers' personal characteristics (e.g., age, education, conservation attitude, norms beliefs) and the physical characteristics of the land (e.g., slope) (Ervin & Ervin, 1982).

Farmers' perceptions and adoption of soil conservation practices have been widely studied (Ervin & Ervin, 1982; Meijer, et al., 2015; Pannell, et al., 2006; Pulido & Bocco, 2014; Reimer, et al., 2012). In all these studies there is a consensus that farmers' perceptions towards technology attributes influence their adoption behavior of those technologies. Reimer et al. (2012) found farmers' perceived characteristics of the conservation practices was a powerful prediction of adoption within two watersheds in the United States Midwest region.

Besides technology attributes, studies suggest that farmers' perceptions towards adoption of soil fertility management practices are strongly linked to their experiences and knowledge about the practices in question (Meijer, et al., 2015; Reimer, et al., 2012; Warren, Osbahr, Batterbury, & Chappell, 2003). For instance, (Meijer, et al., 2015) argue that the knowledge farmers have about a new practice closely relates to their perceptions towards such a practice which together frame the farmers' attitude as whether to adopt the practice or not. Ervin and Ervin (1982) argue that farmers' personal characteristics such as age and education also play a critical role in framing their perceptions towards adoption.

Although this aspect of perceptions towards technology adoption has been widely studied, there is a dearth of literature about influence of farmer perceptions towards adoption of integrated soil fertility practices, thus warranting further investigation.

Risks

Cary et al. (2001) define a risk as the "uncertainty about likely benefits or costs associated with a sustainable practice, uncertainty about the effectiveness of the practice, uncertainty as to when the benefits might be realized and uncertainty regarding the social acceptability of the practice." Risk influences farmers' attitudes and perceptions towards adoption behavior (Ghadim, Pannell, & Burton, 2005) in that risk averse farmers easily adopt new conservation practices that are perceived to reduce risk (Pannell et al. 2006) and also are in line with their economic motivations and goals (Greiner et al. 2009). In addition, farmer personal characteristics such as wealth (livestock, land, cash), past farming experience as well as age, greatly influence their risk attitudes and perceptions (Ghadim, et al., 2005).

Farmer and farm characteristics

Building on the concept of systems resilience Carpenter, Walker and Andereis (2001) , Prokopy et al. (2008) broadly consider farm and farmer characteristics that enhance a farmer's ability to adopt as capacity. It is "the ability to maintain the function of a system as it undergoes some type of change" (Prokopy et al., 2008:302). Prokopy et al. (2008) and Baumgart-Getz et al. (2012) argue that the key capacity variables considered to be important in influencing farmers' adoption decisions include age, education (formal education and farmer [extension] training), income, farming experience, tenure, social networks, labor, capital and information.

While both Prokopy et al. (2008) and Baumgart-Getz et al. (2012) use this concept (capacity) to combine both farmer and farm characteristics, most adoption literature separates them (Reimer et al. 2012; Meijer et al. 2015). In this study, we chose to adopt the latter categorization since one of the categories (farmer characteristics) relates to the management ability of the farmer, while the other category (farm characteristics) relates to farm resources (Chomba, 2004).

Adoption literature of agricultural technologies posits that the decision to adopt technologies including ISFM practices, is affected by both farmer and farm attributes (Bategeka, Kiiza, & Kasirye, 2013; Kassie, Jaleta, Shiferaw, Mmbando, & Mekuria, 2013; Knowler & Bradshaw, 2007; Lambrecht, Vanlauwe, & Maertens, 2014; Marenya & Barrett, 2007; Meijer, et al., 2015; Mugwe et al., 2009; Prokopy, et al., 2008). For instance, based on household size, households with more adults are more likely to adopt ISFM since many of the ISFM practices are labor intensive (Kassie, et al., 2013; Lambrecht, Vanlauwe, & Maertens, 2014; Marenya & Barrett, 2007). As household size increases, the likelihood of adoption of ISFM practices is expected to be high.

Household heads are the final decision makers regarding choice of soil fertility practices and technologies. While most adoption studies have found a negative effect of age to adoption of soil conservation (Kassie et al. 2013; Marenya et al. 2009, Mugwe et al. 2007, Ervin and Ervin et al. 1982), some studies have shown a positive correlation (Ng'ombe, 2014; Okoye, 1998; Warriner & Moul, 1992) and others have found age to be insignificant. This implies that the influence of age on adoption of technologies is inconclusive (Knowler and Bradshaw 2007) and warrants a more nuanced study.

In almost every adoption study, education of the farmer is considered to positively influence the farmer’s likelihood of adopting a new technology or practice because farmers with better education have more exposure to new ideas and information, and thus have better knowledge to effectively analyze and use available information (Kassie et al. 2011; Knowler and Bradshaw 2007; Prokopy et al. 2008). While most studies consider education in terms of number of years of formal education, the categorization of education by Baumgart-Getz et al. (2012) seems more appropriate. In contrast to formal education, it reflects knowledge farmers attain through other means such as extension programs, workshops, and field days.

Important to adoption of soil fertility practices and technologies is farmers’ experience. As a farmer grows older, (s)he has generally been exposed to more ideas, information (Prokopy et al. 2008) and production practices (Kassie, Teklewold, Jaleta, Marenya, & Erenstein, 2015) thereby being more efficient and accurate in judgment of expected benefits (Lambrecht et al 2014). This, in turn, facilitates the potential to adopt new technologies. A meta-analysis by Knowler and Bradshaw (2007) found that farmers’ experiences positively influence adoption soil conservation practices. However, other meta-analyses on the same parameter have found quite inconclusive results. For instance, Prokopy et al. (2008), reviewed adoption literature of best management practices within the US, and found farmers’ experience to have mixed results. Baumgart-Getz et al. (2012) found farming experiences were not significantly related to adoption, thus calling for further studies (Prokopy et al. 2008).

Household wealth

We consider household wealth to include livestock ownership, farm size (acres), farm income and equipment. With respect to wealth, it is regularly theorized that adoption of any new technology requires sufficient financial well-being, particularly if new equipment is needed (Knowler, 2015; Knowler & Bradshaw, 2007). Several analyses of the role of income and farm profitability on adoption have revealed a positive influence (Baumgart-Getz et al. 2012; Knowler and Bradshaw 2007; Prokopy et al. 2008). In relation to ISFM in many developing countries, the presence of livestock plays a key role in adoption of animal manure since the animals not only contribute synergistic crop-animal production interaction, but, cattle and oxen can also be a source of draft power (Kassie, et al., 2013). Size of the farm (acreage) as a measure of physical capital has been found to be a best (financial) predictor of adoption (Baumgart-Getz et al. 2012) since it can be used as collateral to access credit for investments in soils (Deininger & Ali, 2008).

Farm labor

Labor is a major production cost in agriculture. The lack of sufficient labor on the farm is theorized to impede the use of various soil fertility management practices (Kamau et al. 2013; Marenya et al. 2007; Mugwe et al. 2009). In many developing countries, families continue to provide the bulk of farm labor for most farm operations because many households cannot afford to hire wage laborers (Marenya et al. 2007). This implies that the lack of family labor coupled with family liquidity constraints to hiring labor greatly affect the adoption of ISFM practices (Meranya et al. 2007; Mugwe et al. 2009).

However, when addressing farm labor concerns, it is important to identify other community adaptive mechanisms through which labor is mobilized on farms. Mugwe et al. (2009) observed that farmers sometimes trade their labor for food or make reciprocal arrangements in which they pool their labor efforts together through their farmer-to-farmer local network systems and work on each other’s fields during peak labor requirement periods. This could help in ascertaining whether such labor arrangements favor adoption of specific soil fertility management practices at the expense of others within the package of ISFM.

Land Tenure

Secure land tenure has been widely demonstrated to play a critical role in influencing farmers' willingness to invest in soil conservation practices (Kassie, et al., 2013; Teshome, Graaff, Ritsema, & Kassie, 2014). Empirical studies on land tenure security in relation to investment and productivity argue that the positive relation between secure land tenure and investment is based on three key factors: assurance, collaterization and realizability effects (Grimm & Klasen, 2008; Jacoby & Minten, 2007).

In relation to land management, it is argued that 'assurance effect' of secure land tenure provides a guarantee to farmers to invest in both short and long-term soil management practices (Grimm & Klasen, 2014) because it eliminates threats of appropriation (Banerjee & Ghatak, 2004). The 'collaterization effect' predicts how land can be used as collateral thus facilitating access to financial services (loans) for investment in agriculture (Beekman & Bulte, 2012; Feder & Feeny, 1991).

'Realizability effect' refers to the possibility of transferring of land ownership between people through land markets (land sales or rent). Such an incentive of factor mobility makes it easier for farmers not only to invest in soil improvement practices, but also to increase their possibilities to rent land (Abdulai, Owusu, & Goetz, 2011). A study by (Kassie, et al., 2013) in rural communities of Tanzania found that adoption of long-term soil fertility management practices such as soil and water conservation technologies, conservation tillage, and animal manure was more common on owned than on rented or borrowed land. They also found out that farmers were more likely to use chemical fertilizers on rented land than their own. Based on this previous research, it is posited in this study that, secure land tenure (mainly through the assurance effect) will influence the adoption of improved soil fertility management practices among farmers within a maize-bean cropping system.

Social networks and Social Norms

Farmers in rural households have various social connections used to share and receive new ideas and information to improve farming. Literature on adoption of soil fertility management technologies suggests that farmers' engagement in social networks plays a significant role in influencing their behavior towards adoption (Baumgartz-Getz et al. 2012, Greiner et al. 2009; Knowler et al. 2007, Kassie et al. 2015). Studies on the role of social networks in influencing adoption of technologies mainly focus on the structural component of social capital in terms of farmer organization (formal and informal) and the relationships that exist therein.

Such relationships could be horizontal in terms of the social ties between individuals with similar (homophilous) characteristics (e.g., members of a farmer group) or vertical, where attention is placed on the association of individuals with dissimilar (heterophilous) characteristics (e.g., relations between government or extension agents and farmers groups) (Rogers, 2003). Trust—"the expectation that arises within community of a regular, honest and cooperative behavior based on commonly shared norms on the part of the other members of that society" is considered key in influencing behavior towards collective action (Fukuyama, 1995). Social networks are means through which individuals access information, new ideas, and reduce information asymmetries (Di Falco & Bulte, 2011; Prokopy, et al., 2008) which, in turn, increase the likelihood of adoption (Baumgartz-Getz et al. 2012, Knowler et al. 2007, Prokopy et al. 2008).

In this study, we follow the categorization of social networks by (Prokopy, et al., 2008). We distinguish two categories of social networks: (1) 'local network' defined as a farmer's relationship with fellow farmers in the area either through a farmers' group (association) or peers with whom new information and ideas are shared; (2) 'Agency network' defined as a farmer's relationship with rural institutions or other trustworthy individuals in the locality. This includes extension agents from government programs and non-government organizations who directly work with farmers and traders (wholesale and retail) for both inputs and farm produce. (3)'Kinship' to represent the close relatives that the farmer relies on when in need of critical support such as labor during peak farming periods (Teklewold, Kassie, & Shiferaw, 2013).

Such a classification is very important as different social networks may affect the adoption of soil fertility management practices in different ways. That said, studies on the role of social networks (social capital) in influencing adoption of soil conservation practices are few, thus warranting further research (Knowler & Bradshaw, 2007; Reimer, et al., 2012).

Information Access

The role of information access in adoption studies has been extensively studied. Most adoption studies suggest that farmers' access to quality information positively impacts their adoption behavior. A meta-analysis on adoption literature of conservation agriculture found that farmers' access to information positively influenced their decisions to adopt soil conservation practices (Knowler & Bradshaw, 2007). In Uganda, access to information has multiple pathways including extension agents (programs), non-government organizations (NGOs), fellow farmers, etc. (Kansiime & Wambugu, 2014; Lu, MacDonagh, Semalulu, & Nkalubo, 2002; Mugonola, Deckers, Poesen, Isabirye, & Mathijs, 2013).

Access to information through extension agents and programs not only increases farmers' awareness about improved technologies but also facilitates access to quality information that is more appropriate and adaptable to their local conditions (Lambrecht, Vanlauwe, Merckx, et al., 2014). They, in turn, use this information according to their individual perceptions, attitudes and characteristics within the biophysical and economic realms to influence their decisions on soil fertility management adoption. Mbaga-Semgalawe and Folmer (2000) argue that once farmers have access to information, they should be able to perceive the problem (e.g., declining soil fertility) on their farms, and have the capacity to distinguish various possible alternatives and incentives before they can make the decision to adopt.

However, while most studies show that information access is often necessary for adoption of soil conservation and management practices, it is important to determine whether there are variations in which households will have access to this information based on their wealth status within a locality. For example, Lu et al. (2002) found out that poor farmers were more likely to get information about new technologies through their family members and fellow farmers compared to the rich farmers who had better access to extension and NGO agents and programs.

Contextual factors

Access to credit

Access to rural credit and savings plays an important diffusion and adoption role of ISFM practices (Sanginga & Woomer, 2009). Credit access facilitates purchase of inputs especially improved seed varieties and inorganic fertilizers if linked to well-developed input supply and market access infrastructures (Geta, Bogale, Kassa, & Elias, 2013; Jeannin, 2012; Teklewold, et al., 2013).

Access to markets for inputs and farm produce

In most countries in SSA, farmers' adoption decisions for soil fertility technologies are influenced in part by level of access to, and use of, external inputs such as mineral fertilizers, improved seed and herbicides (Giller, Witter, Corbeels, & Tittonell, 2009). Farmers' proximity to input sources positively increases their use (Kamau, Smale, & Mutua, 2014; Kansiime & Wambugu, 2014; Kassie, et al., 2013).

Generally, the closer the resource-poor farmers are to input markets, the lower are their transaction costs in terms of travel time and transportation costs, thereby lowering production costs (Shiferaw, Okello, & Reddy, 2009) and increasing opportunities to access to new and improved soil fertility management technologies (Teklewold et al., 2013).

From the analytical framework above, we suggest that farmers' adoption behavior of ISFM is shaped by both the perceptual and behavioral factors. The perceptual factors are mainly a combination of farmers' personal attributes (e.g. education, social networks and information sources), the characteristics of the farm (e.g., soil quality, slope) and contextual aspects (e.g. access to credit, and market for both inputs and farm produce).

The behavioral factors are shaped by farmers' attitude, subjective norms and perceived behavioral control as suggested by the theory of planned behavior. We anticipate that relative advantage, observability and compatibility as suggested by Reimer et al. (2012), could be the most important perceived practice characteristics influencing adoption behavior. In addition, we anticipate that socio-economic factors such as education, information access, social networks, soil fertility awareness and farmers' wealth would have the greatest influence on adoption (Knowler et al., 2008; Meijer et al., 2015; Prokopy et al., 2008).

Table 1: Summary of variables predicted to influence adoption of ISFM practices

Variable	**Influence on Adoption of ISFM**
Soil fertility awareness	More adoption
Farmers Experience	Inconclusive results
Education	More adoption
Household wealth	More adoption
Farm labor	More adoption
Secure tenure	More adoption
Social networks	More adoption
Information Access	More adoption
Credit access	More adoption
Access to input-produce markets	More adoption

Methodology

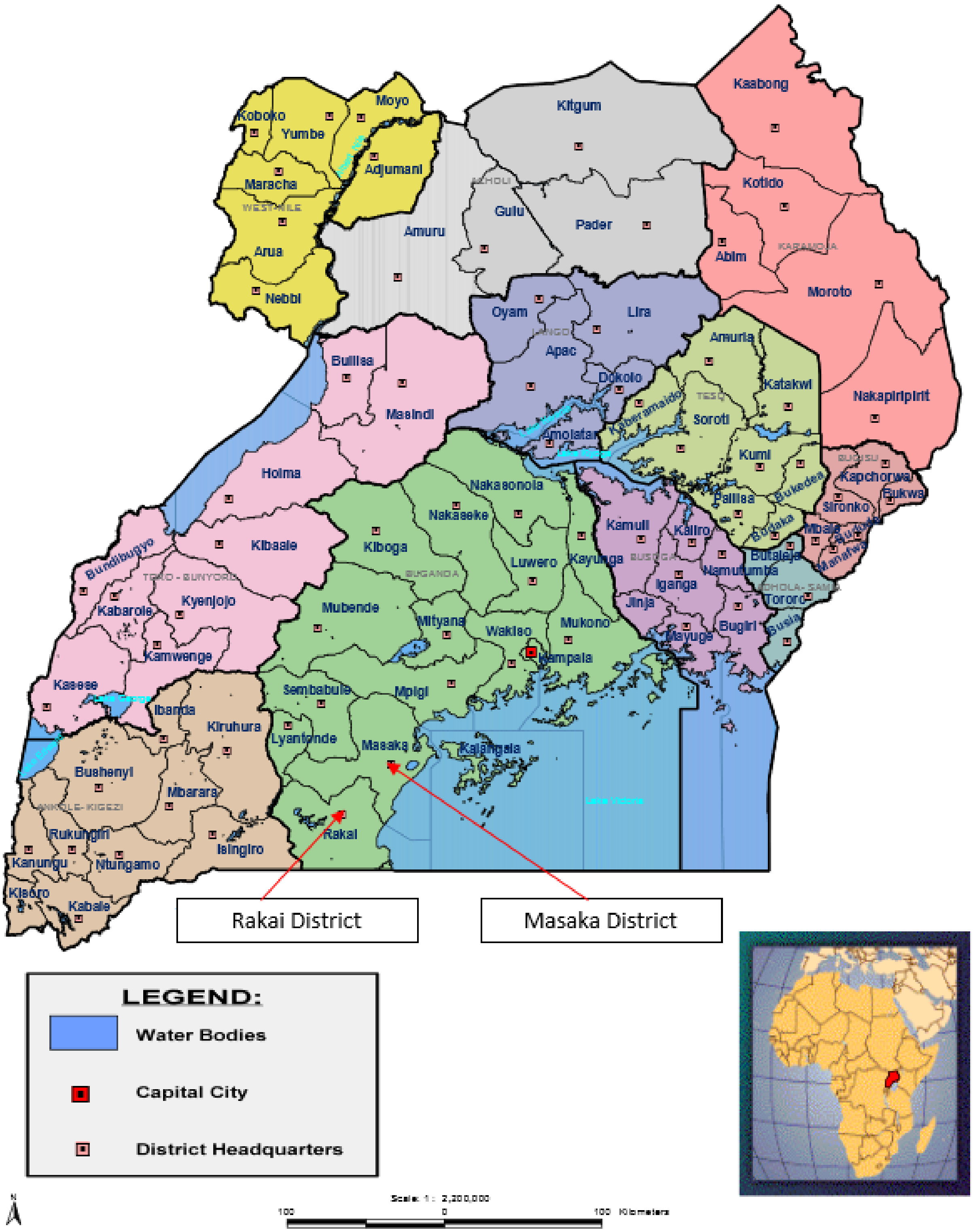
The purpose of this study was to gain an in-depth understanding of farmers' perceptions and socioeconomic factors that influence their decision-making processes when adopting ISFM practices and technologies. To achieve this, a qualitative methodology with an emphasis on a multiple case-study approach was used given the exploratory and inductive nature of our study (Yin, 2008). A multiple case study approach is appropriate for exploring subjective and cultural processes that underlie the social practices (Lockie, Mead, Vanclay, & Butler, 1995), giving research participants an opportunity to express their views and engage in face-to-face interactions while allowing the researcher to probe and stimulate conversation to uncover important context-specific information that may not have otherwise been considered by quantitative research instruments (Baxter & Jack, 2008; Dunn, 2005, 2013). This study sought to explore in as much detail as possible how farmers managed soil fertility, what perceptions farmers hold about soil fertility, how these perceptions and knowledge held about soil fertility management influence their decisions to adopt ISFM practices, and (2) how key socioeconomic factors: landholding; security of land use; farm labor supply; access to information; and social networks/relations are influencing adoption decisions for ISFM among smallholders.

Geographical location of the study area

This study was conducted as part of the 'Farmer Decision Making Strategies for Improved Soil Fertility Management (ISFM) in Maize-Bean Production Systems' project. The study was conducted in three-project sites 130-180 km south west of Kampala: Mukungwe and Kabonera sub-counties in Masaka District and Lwankoni sub-county in Rakai district (Figure 2). Both districts lie within the Lake Victoria Crescent Agro-ecological zone of Uganda 1174m asl between 0-25^0 S, and 34^0 E and 0^o S for Masaka and 31^0 -32^o E for Rakai, respectively. Mean annual precipitation is 1200 mm (Mar.–May and Sept.-Nov.), and a mean annual temperature is 20°C at an average elevation of 1174m above sea level.

Soils in this area are predominantly Ferralsols characterized by red-colored sandy clay loam texture. Black and gray clay soils derived from hill wash soils are also found in the valley bottoms. The main economic activity is smallholder farming of banana, beans, maize, sweet potatoes, cassava and passion fruits among other crops. Land uses include annual crops, perennial cropping and integration of livestock (mainly cattle and pigs).

Figure 2: Location of Masaka and Rakai Districts



Source: http://reliefweb.int/map/uganda/map-uganda-including-new-districts-region-jul-2006

Data collection

Marshal et al. (2013) encourages researchers to establish an appropriate sampling size for a qualitative study. Following a meta-analysis of qualitative studies, Marshall et al. (2013) recommend that a sample size of 15-30 respondents is ideal for a case study methodology for a researcher to reach theoretical saturation.[4]

Following approval from the Institutional Review Board (Appendix C), primary data were collected during the summer of 2014 using in-depth interviews and direct field observations from a total of 27 selected farmers in three tiers: (1) innovative farmers currently engaged with the project in the preliminary on-farm field study, (2) identified innovative farmers in the community who are not currently engaged with the project, and (3) farmers who were part of initial project focus group discussions conducted by the project team during its participatory rural appraisal study in January 2014. The selection process involved writing down each farmer's name within each tier on a separate piece of paper and placing the papers for each tier in a container. For each of the three sub-counties, three respondents were randomly picked from each tier to constitute our study sample.

Interviews were conducted with key household decision makers for the day-to-day farm activities, and sometimes with other family members involved in the farming activities. These were typically the household heads who were either male or female, and in a few cases both husband and wife were engaged in the interview.

Data collected from interviews with the 27 farmer respondents were complemented by interviews with four key informants including sub-county extension officers from the Ministry of Agriculture Animal Industry and Fisheries under the National Agriculture Advisory Services (NAADS) programme and district production officers. This served as one of the ways to ensure validity of the study findings. The unit of analysis for this study was the farming household.

In-depth interviews were used because of the flexibility they offer to researchers in adjusting the interview(s) based on the respondent feedback (Berg, 2009) while maintaining the

[4] A point during data collection when no new or relevant information emerges from respondents during the data collection process (Marshall et al. 2013).

ability for the researcher to compare across units of analysis (Reimer et.al. 2012). Second, in-depth interviews provide an opportunity for the researcher to understand participants' personal experiences (Weiss, 1994) while enabling them to broaden their conversation (Dunn, 2005) within a much more context specific environment.

All interviews were conducted by the author, and at times and places convenient to the interviewees. All interviews were guided by a series of open-ended questions directed from the interview schedule (Appendix A) and responses recorded using a portable digital recorder. Questions in the interview schedule broadly addressed four main themes: farmers' perceptions of ISFM practices, learning information sources, current ISFM being applied, and contextual factors influencing farmers' adoption decisions. In addition to the audio recordings, the author also took field notes to document other observations including body language and other important gestures so as to further enrich the transcripts.

Data analysis

Data from audio recordings were transcribed verbatim using a nuance Dragon Dictate software program. Interviews were analyzed using a qualitative data coding technique (Neuman 2005) based on the theoretical propositions framing the study (Yin 2008). The theoretical framework used to analyze our study findings was Theory of Reasoned Action in addition to the theory of diffusion of innovations as adopted and modified by Reimer et al. (2012).

To identify the major themes of the study, open axial and selective coding techniques (Neuman, 2005) were applied using a line-to-line re-reading and underlining of sentences and words found to be important in the discussion. Using the axial coding technique, a word map document indicating key codes and links between codes and the main themes that arise from the content was developed. In addition, the frequency of specific words defining key themes was tallied as means of validating the research findings. All coding was done using NVivo 9, a qualitative research analysis software program.

Coded data about major adoption drivers in NVivo was extracted and transformed to numerical values in an excel spreadsheet to create a simple SPSS dataset for running general statistical descriptions. Using a binary labelling technique, we assigned a value of 1, to represent positive influence of a variable to adoption and 0, to represent no influence.

Validity and credibility of data

Generalization

One of the major concerns with qualitative case studies is that the small sample size might make it difficult to generalize research findings from particular cases to a larger population (Hodkinson & Hodkinson, 2001). The purpose of this study was not generalize study findings to other areas but rather, to construct a narrative description of the adoption phenomenon in Mukungwe, Kabonera and Lwankoni sub-counties. Rather than using deductive generalization, we constantly compared our study findings with previous work about ISFM adoption for purposes of establishing theoretical generalizations as recommended by Yin (2009).

Validity:

Internal validity of the study was established through triangulation by using multiple information sources (farmers and key informants), and different data collection methods (In-depth interviews and field observations) as recommended by (Creswell, 2007; Gray, 2013). In addition, validity was further enhanced through cross-comparison of data from the three study focus sub counties, and the three farmer tiers. External validity was established through conducting of interviews until a saturation point was attained as well as relating our findings to already existing adoption literature about ISFM practices.

Ethical considerations

Dowling (2005) defines ethics to be " the conduct of researchers and their responsibilities and obligations to those involved in the research including the sponsors, the general public and most importantly, the subjects of the research" (pg. 26). In order to achieve this, permission for respondents' consent was obtained prior to conducting the interviews. Also, respondents were informed that their participation in the interview was completely voluntary and that they were at liberty to discontinue the interview at any time or pass on questions they felt uncomfortable answering. The purpose of the research study was read and explained to the respondents, and the confidentiality of their responses guaranteed during data analysis and reporting.

CHAPTER 3: STUDY RESULTS

In the following section, we begin with a brief discussion of respondents' characteristics, their local knowledge of soils and related practices being used over time to mitigate soil fertility constraints. Thereafter, farmers' perceptions about ISFM practices and technology attributes, learning pathways through which farmers acquire knowledge, and the major background factors framing and influencing farmers' adoption decisions within the local context are analyzed and discussed

Farmer characteristics

Of the 27 farmers interviewed, 11 were female and 16 male. Respondents' age ranged between 28 and 78 years with a median 45 years (Figure 3). Fourteen of these farmers had attained formal education beyond primary level with six farmers receiving secondary education and eight having tertiary or vocational training. Average landholding size was 7 acres (median 5 acres) although overall, land ownership ranged 1.5-30 acres. Nearly all farmers reported farming to be their primary source of income, although 15 respondents reportedly have additional non-farm income—mainly retail and wholesale trade of agricultural produce and farm inputs, monthly salaries and allowances, and cash remittances from relatives living off-farm.

Most important cash crops were coffee, beans, maize, bananas and passion fruit, while the main food security crops were beans, cassava, sweet potatoes and maize were the. Beans and maize are important both as food and cash crops. Coffee wilt disease and Banana bacterial wilt have threatened the two traditionally predominant cash crops.

Cattle, pigs, goats and chicken are the main livestock raised by farmers in the study area. However, many of the farmers reported reduced livestock numbers due to land fragmentation. Many preferred zero grazing or tethering cattle. Goats and pigs were mostly confined in housing structures, while chicken were predominantly on free range save for a few farmers who raised them commercially.

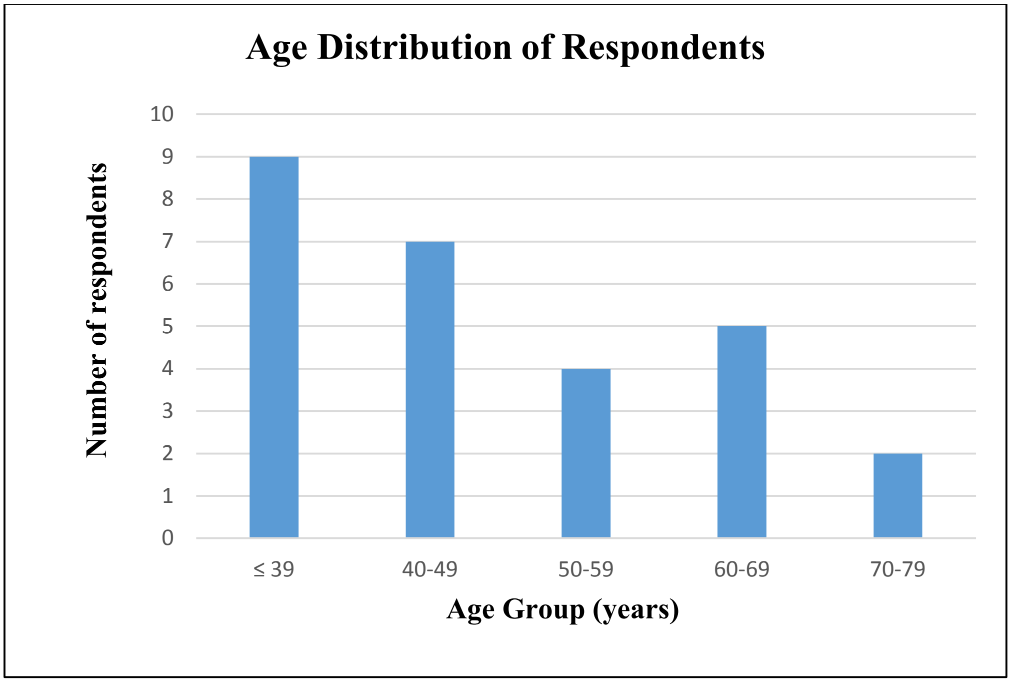


Figure 3: Age Distribution of Respondents.

Farmers' localized knowledge and perceptions about soil fertility management

Farmer local indicators of soil fertility

Important questions related to farmers' local knowledge about soil fertility management include: how do farmers locally assess the quality of their soils? How adequately can farmers determine drivers of declining (or improving) soil fertility? How do they readily differentiate soil fertility constraints from other factors such as crop diseases and weather conditions that affect crop yields?

Analysis of respondent interviews indicates that farmers have valuable local information and insights about the quality of their soils and the capacity to determine the drivers of soil fertility decline. Based on their farming experiences (and the history of their farms), farmers have developed local soil classification systems used to rate soils as either 'good' (fertile) or 'tired' (exhausted/ degraded).

Farmers were classified two to three types of soils commonly used for crop production, based on soil color, texture and structure. The three soil types identified were: *lidugavu* (black, soil which is friable and easy to work with), *Limyufumyufu* (reddish-brown, medium textured soil that is often gritty) and Luyinjayinja (often red colored, stoney and compacted soil). Further, farmers reported to be using vegetation growth of native plant species, especially weeds and crop yields as factors in assessing soil quality. Weeds such as ‘ennanda’ (*Commelina bengalensis L*), ‘ssere’ (*Bidens pilosa*), ‘dodo’ (*Amaranthus spp*), Kanyebwa (*Oxalis spp*), ‘kafumbe’ (*Galinsoga parviflora*) as well as ‘ekisagazi’ (*Pennisetum purpureum*) were typical indcators of “good” soils. While weeds such as ‘lumbugu’ (*Cynodon dactylon*) and Mukonzi konzi (*Panicum maximum*) were indicators of degraded soils. Other indicators mentioned to be useful in determining the fertility of the soil were: time period land has been under fallow, ability of the soil to hold moisture and, the presence of earthworms as important clues regarding soil fertility.

Following previous work by Dawoe et al. (2013) and Deisbiez et al. (2004), farmers' indicators of soil quality are categorized into three broad themes: a) Crop performance indicators: crop features reflecting the quality status of the soil, b) Soil characteristics: soil attributes which in accordance to farmers' assessment differentiate a soil type as fertile or degraded and, c) Biological indicators: Native vegetation whose existence or growth on a particular is indicative of the soil quality status (Table 2).

Table 2: Farmers' specific indicators for assessing soil quality

Indicator	Fertile soil	Infertile soils
Crop Performance • Crop vigor • Crop yield • Leaf color	 • Fast growth rate, tall crop stand • Consistently high yields • Large green leaves	 • Slow growth rate and stunted plant development • Consistently low yields • Small, yellowish and narrow leaves
Soil Characteristics • Soil Color • Moisture retention capacity • Soil workability • Soil texture	 • Dark color (black). • High • Easy to work • Relatively smooth and friable	 • Red or reddish-brown • Low • Compacted and hard to open up • Stony and gritty
Biological • Presence of indicator weeds	• *Commelina bengalensis L* • *Bidens pilosa* • *Oxalis latifolia* • *Galinsoga perviflora* • *Amaranthus spp*	• *Digitaria abbyssinica* • *Cynodon dactylon* • *Panicum maximum*

Farmer perceptions of soil fertility

To determine farmers' perceptions about the fertility of their fields, respondents were asked how fertility of their soils had changed in the past decade, probable causes of such a change. Most respondents cited a decline in fertility of their fields. They used terms such as *'tired'* or *'old'* to describe an exhausted or highly degraded soil with crop yield decline as the key indicator of soil productivity. Farmers perceived continuous cropping and climate change to be the major drivers of declining soil fertility. Other causes of declining soil fertility mentioned including inappropriate application of inorganic fertilizers, and farming on vulnerable landscapes (steep hills/slopes) without using appropriate soil and water conservation techniques. These aspects are best captured in the following statement by Farmer 8:

> “The soils are tired. We have over tilled this continuously without resting it. “Second, I think it is climate change. We now experience drastic and severe weather patterns characterized by droughts longer than ever before. We see more prevalence of pests and so are the diseases.”

Soil fertility management practices

Sustainable ISFM involves integration of local knowledge with scientific methods through promoting utilization of locally sourced resources that suit the local context and interests of the users (Mairura et al., 2007; Vanlauwe 2006). The case of ISFM in Masaka and Rakai districts is not any different. Farmers are trying out and adopting an array of soil fertility management practices within their means to improve soil fertility. However, adoption is highly heterogeneous depending farmers’ on level of experience in farming and resource base.

Farmers use various soil fertility practices that were broadly clustered into four major theme: Animal manure (mainly from cattle, pigs and poultry), inorganic fertilizers (Diammonium Phosphate [DAP], Nitrogen Phosphorous and Potassium [NPK], Urea and Calicum ammonium nitrate [CAN]), foliar sprays (SuperGrow, Di-grow, VegMax), and traditional practices[5] (Ash, mulching, crop rotation, fallowing, intercropping, construction of waterways, and agroforestry). Most farmers were using traditional practices, followed by organic manure and fertilizers; mineral fertilizers were the least widely adopted (Figure 4)

[5] Within the study context, traditional practices refer to all soil fertility management practices that cited to be part of the farmers’ farming systems for more than two decades since being promoted by researchers and extension agents

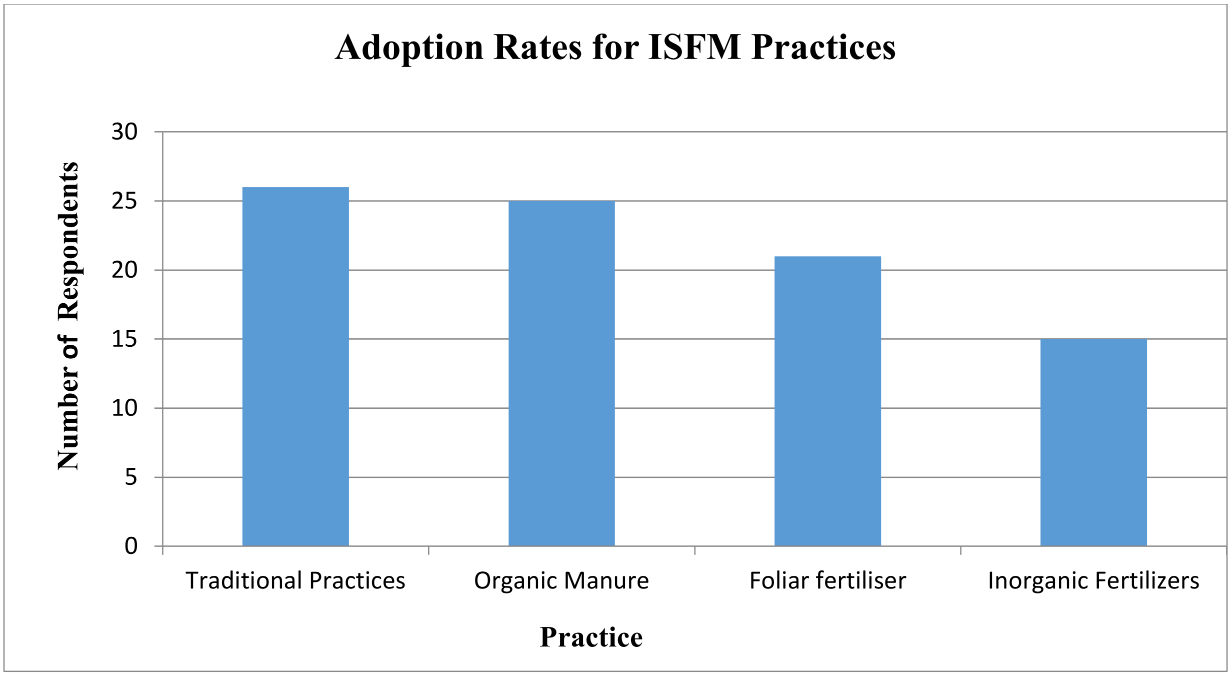


Figure 4: Adoption of ISFM by category

Manure

During data analysis, animal manure is comprised of four sources—cattle, pig and poultry manure and bioslurry. Bioslurry is a bi-product from biogas production, often used as an organic manure source by farmers. In relation to other soil fertility management practices, 25 respondents reported using manure. Of these, 14 were using only one manure source; nine were using a combination of two manure types while only two applied three types of manure.

Perennial crops particularly coffee and bananas, were the preferred crops applying animal manure save for poultry manure that is increasingly being applied on maize and sometimes on beans. Farmers' preference of animal manure reflects its availability on-farm and improved soil structure and organic matter content over time.

Inorganic fertilizers

Only 15 respondents were using mineral fertilizers, primarily DAP, Urea, NPK and CAN. DAP and Urea were mostly used on maize, passion fruit and horticultural crops (Green pepper, eggplants and tomatoes) while NPK and CAN were applied on mostly coffee and bananas.

Apart from NPK, all the other mineral fertilizers were dissolved in water before application. Farmers reported applying two soda bottle top-full in 20 litres of water and used at most 60 liters to spray an acre of maize. At times, farmers dissolved both a pesticide or fungicide and fertilizer before spraying. This mode of application was preferred because it was perceived to be both cost saving in terms of using less fertilizer and time as compared to the recommended practice of direct application of fertilizers to the soil prior to planting. Such an approach was considered to be a tedious and time-consuming process. This was best stated by Farmer 19:

> "….contrary to the recommended application of Urea in the soil, I dissolve it in the spray pump and spray my vegetables, maize and beans. The reason behind this is because Urea is very expensive and when applied directly to the soil large quantities are required yet as farmers we have limited resources in terms of cash to buy the fertilizer."

However, none of the farmers interviewed had conducted soil tests to evaluate the fertility status for their soils prior to using these fertilizers. In addition, some of the farmers argued that unpredictable soil moisture regimes as a result of erratic rainfall patterns have forced them to discontinue use of DAP and CAN. They claimed that both DAP and CAN burn crops when rainfall is low thus making it unprofitable to invest in such practices. This is well captured in the following statement by Farmer 25 regarding soil fertility practice that had not worked well on the farm and why:

> "CAN did not work well for me. I applied it to my maize field for two consecutive seasons but the results were horrible. Rather than making my maize crop look good and give me a better harvest, the fertilizer scorched my maize due to lack of enough soil moisture during application. With the present erratic rainfall trends, I have vowed not to risk using CAN again because it is not logical to keep making losses as a farmer."

Key informants attributed the farmers' failure to conduct soil tests to their lack of cash resources for analysis of the soil samples. Key informants noted that less than 1% of all farming households in Masaka district, had such analyses done, limited to a few commercial farmers.

These study findings highlight some major concerns. First, high purchase costs of fertilizers and lack of sufficient knowledge about recommended application rates influence inappropriate use of mineral fertilizers. Second, application of fertilizers below the recommended agronomic levels implies nutrient mining in farmers' fields despite their efforts. Third, a change in weather patterns presents a great production risk in terms of yield loss. Together, these could lead farmers to developing negative attitudes towards the fertilizers, thus affecting long-term adoption rates.

Traditional Practices

Farmers in both Masaka and Rakai study communities had similar traditional soil management systems. These included crop rotation, intercropping, mulching, ash, fallowing, and construction of waterways, agroforestry and composting. We categorize these practices as traditional in the sense that they have been part of the farmers' farming systems over a decade. Nearly all farmers (26) applied these practices, adopting between 3-5 traditional soil management practices. Intercropping (25 farmers) and crop rotation (24 farmers) were the most adopted traditional practices, while construction of waterways (7 farmers) was the least adopted (Figure 5).

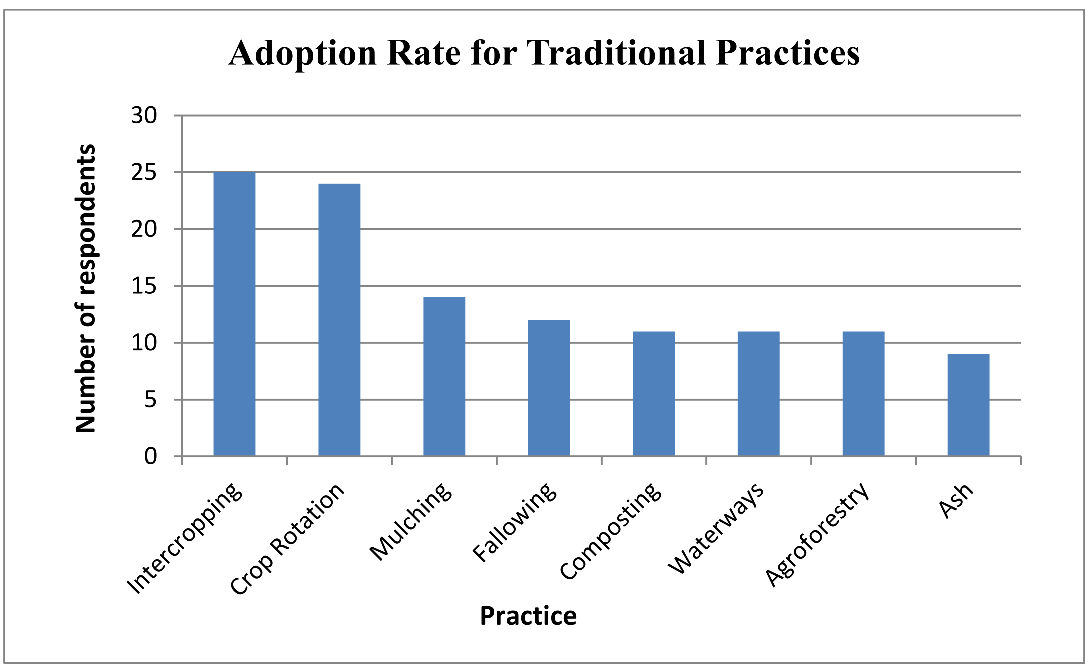


Figure 5: Adoption Rate for Traditional Practices

Crop rotation

Farmers are well aware of crop rotation as a practice that can be used to improve crop productivity. Farmers reported rotating legumes (beans and groundnuts) with cereals (typically maize) and tubers (sweet potatoes and cassava) as the fallow crop. Fields observations revealed that rotation is mostly used on fields farther away from the homesteads and received less manure. Local contextual conditions such as small land parcels, labor constraints and rainfall patterns played a big role in influencing farmers' choices of crops to include in the rotation. For example, farmers with small land parcels preferred not to include cassava in their rotation system because it has a longer maturation period. Other farmers preferred rotations because they help in reducing on pest infestations among crops

Intercropping

The most commonly used traditional practice among farmers was intercropping because of its multiple functions—soil conservation, reduced labor costs and time during weeding as well as maximizing use of the available land for production. Most of the farmers intercropped beans with other crops but mostly coffee and bananas. Farmer 19 best exemplified this by stating that:

> "In my coffee plantation, I interplant coffee with beans and, at times, I interplant maize with cassava and bananas. The more you minimize on having bare soil, the better because it helps you to protect your soil from soil runoff."

Interviews with key informants revealed that, just as with crop rotation, intercropping is always among the first line of interventions that resource poor farmers use to address soil fertility concerns on their farms. Increasing land fragmentation makes both intercropping and crop rotation to be feasible substitutes to fallowing among land constrained households.

Fallowing

All farmers indicated that for a long time, fallowing had been one of the most common traditional soil fertility management practices used. However, application of this has declined in the past decade due to increased population pressure on the already limited land for crop production. Farmer 5, who farms 3 acres of own land, best presented this in the following statement:

> "Fallowing is practice I always used and I would still prefer to use it. However, it's no longer feasible to do that because of the increasingly high competing land use demands. I have cattle to graze, and children to feed which makes it literally impossible to have a piece of my land rest for one or two seasons."

Study results revealed that of the 27 farmers interviewed, only 12 practiced fallowing primarily those with relatively large land parcels. In addition, farmers reported that the fallow period has been reduced in both acreage and duration. Many farmers fallowed their land for no more than 6 months (one growing season).

Farmers with small sized land parcels preferred to include root crops such as cassava and sweet potatoes in their crop rotation cycles as an 'improved' technique to fallowing. These crops are planted last during a rotation cycle, and the time taken before the crop is harvested is considered a fallow period. Similar findings have been found elsewhere. For instance, a study about drivers to land use changes in Eastern Uganda by Ebanyat et al. (2010) revealed that many farmers grew cassava as a fallow crop and equated their fields with cassava as the last crop in rotation cycle as a resting phase. While it might be a good practice to include crops with different rooting depths into a crop rotation cycle, the perception that such a phase constitutes 'fallow' remains questionable. Crops planted during such 'resting phases' require nutrients, most of which are removed during the harvest, thereby leading to further soil degradation (Ebanyat et al., 2010).

Compost:

Although an organic source of manure, compost manure is considered a traditional practice because many farmers reported using it for more than two decades in their cropping systems since being promoted by extension agents. Almost all the farmers have used compost on their fields and acknowledged its effectiveness in improving soil fertility, but many had abandoned its use.

Only 11 farmers were still using the practice. Efforts to continue using it were threatened by its high labor intensiveness, long preparation time and the competing demand on scarce of materials. Farmer 19 attested to this:

> "I used to apply compost manure but because of the tedious process involved in making it and hauling it to the field, I decided to stop preparing it. In addition, we now live on

> fragmented pieces of land as a result of increased population growth, which has in turn limited us in accessing sufficient amounts of grass that we used to compost. Labor issues have also in a way curtailed me on preparing and using it [compost]. Composting needs routine turning of the decomposing materials to ensure even decomposition……I am getting much older and have less energy for this."

This statement implies that only farmers with sufficient farm labor and access to enough materials to make the compost may use this practice. Additionally, households with small land size were those that applied compost manure. This could be associated the bulkiness and labor demands compost as a resource. Farmers with multiple land parcels, some of which are away from the homestead, cited transport and labor costs as the biggest disincentives to its use; this might explain why most of those who owned relatively larger farm resorted to other soil fertility enhancing inputs.

Mulching

Crop residue mulch is a one of the most common practices for improving soil fertility mentioned. Fourteen farmers cited using harvest residues from maize and beans, banana leaves and almost all other plant material that is cleared from crop fields during weeding and land preparation. Farmers preferred using mulch because of the various benefits it provides for the soil. They noted that mulching (i) conserves both the soil and water by minimizing soil surface erosion and keeping the soil 'cool' (controlling evaporation of soil moisture); (ii) suppresses weed growth since it keeps the ground fully covered most of the time thus, saving them on weeding and labor associated and, (iii) upon decomposition, the mulch contributes to the soil organic matter thereby increase soil nutrient availability. Farmer 18 best exemplified this: "I also do a lot mulching with residue from my harvesting especially maize stover. This helps to suppress weed growth, keep the soil moist and also [it] decomposes to provide more plant nutrients over time…"

Most farmers only mulched crops considered to have high economic returns such as coffee, bananas, passionfruit and vegetables. This was further supported by analysis of key informant interviews. They all stated that mulch was a common practice among farmers that have coffee and banana plantations as well as those involved in production of horticultural crops. However, its low adoption was a result of competing demand for mulching material as animal feed, fuel and at times thatching. Farmers with livestock preferred to provide the mulch materials as animal feed and later use animal manure from the livestock than to directly apply it to the gardens.

Factors influencing adoption of ISFM practices

In order to determine which factors influence farmers' adoption decisions, respondents were asked to identify current practices that they were using to improve fertility of their soils, how they selected these practices and why they were using those practices among all available options. Analysis of the interviews found that farmers were using multiple practices based on economic, biophysical, and social contextual factors. These factors influenced farmers' decisions in combination based on farmers' short and long-term goals of improved soil fertility management. Farmers' perceived attributes of the proposed practices (relative advantage of the practice, observability and compatibility of the practice with the farmer's farming system), household wealth status, farm labor and time, social networks, security of tenure and, access to input markets had the greatest influence to farmers' adoption decisions.

Further analysis of the adoption of practices revealed that almost all farmers were adopting more than one type of practice at a time. Thirteen farmers adopted a combination of at least three types of practices (primarily organic manure, foliar sprays and traditional practices). Only seven farmers reported using all four types, while six were using only two practices (Figure 6)

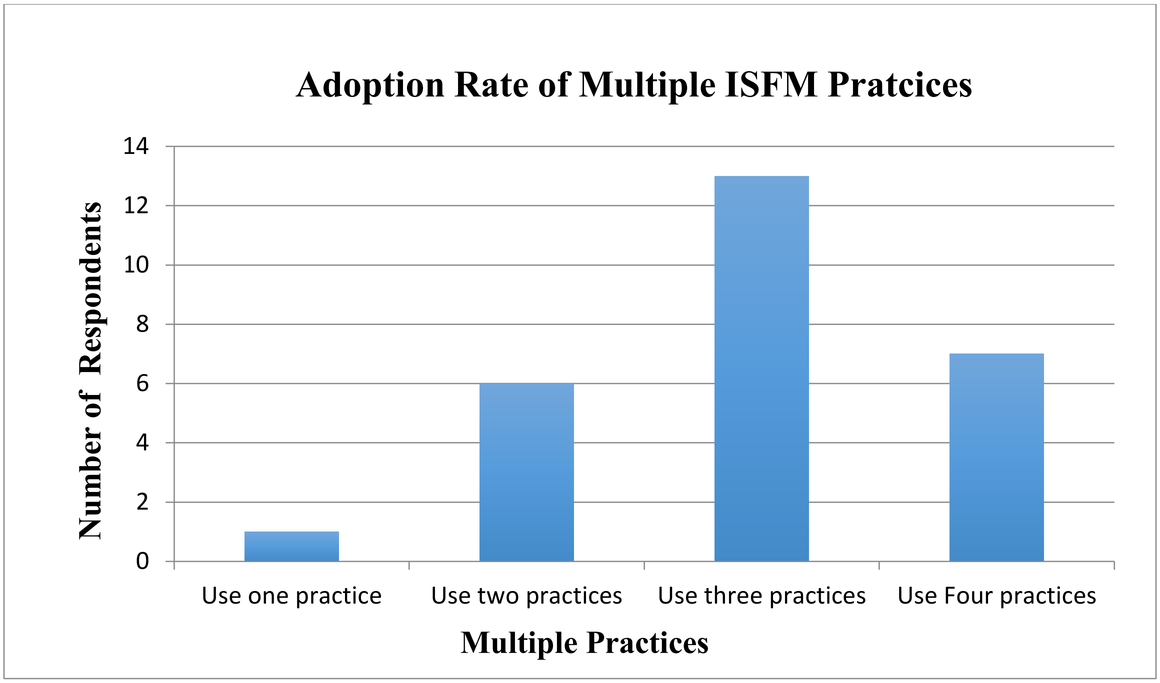


Figure 6: Adoption Rates of Multiple ISFM Practices

Perceived attributes of a technology

Relative advantage of a practice

Nearly all respondents cited the benefits of a practice in relation to other available practices as a critical factor in influencing their adoption decisions. Local availability of the practice resources, increased crop yields, reduced input costs and long-term benefits were the primary motivations for adoption of both traditional practices and animal manure.

For instance, all farmers who used animal manure reported that its availability on-farm and its ability to provide nutrients to crops for several cropping seasons while improving soil aspects structure and water holding capacity were important considerations. Although this was the general perception towards all manure sources, further analysis with animal manure sources indicated that some farmers preferred poultry manure to cattle manure. This was mostly as a result of poultry manure providing quick and noticeable positive effect to crops (in terms of growth vigor) compared to cattle manure yet, it still met all the other benefits derived from cattle manure. This was best exemplified in the following statement by Farmer 19:

> "Among the animal manure sources, I prefer chicken manure and it's been my best because it gives immediate impact on crop growth and vigor……..If you planted on a typically bad soil like this one you are looking at (red stony soil), the size of the maize cob that can be harvested from such maize is unbelievable!"

Most farmers preferred using foliar sprays over inorganic fertilizers because foliar sprays were considered to be relatively cheap and packaged in small quantities that resource poor farmers could afford to purchase. Inorganics fertilizers on contrast, are often packaged in 50 kg bags.

Observability

Farmers' ability to observe modes of application benefits has influenced them to adopt some of the soil fertility practices that they currently use. This was particularly important for practices considered new in their farming systems and for which they were uncertain of their performance. Nearly all interviewed farmers revealed that being in position to see that a practice actually works—from own trials, farmer-to-farmer field visits, at group demonstrations established by extension agents, or farmer excursions to model farmers within their districts and beyond influenced them to adopt poultry manure, foliar sprays and fertilizers as mentioned earlier. Farmers 8 best represented this by stating that:

> "Most times all I do is to observe from fields of my colleagues that I trust…once I see them doing something interesting and that given good results, I adopt it and immediately implement [the practice] on my farm since I have seen it work elsewhere."

Besides observability being an attribute through which farmers are motivated to adopt new practices, other farmers to use practices observed from fellow farmers on grounds that such practices had been taken through a series of modifications and adaptations to suit their local context–a process that farmers perceived to save both time and costs of experimentation. This was well captured in the statement from farmer 16 below:

> "I like visiting experimenting farmers for the reason that they have not only obtained good knowledge about the new practice or any other practice they are currently applying in their fields, but they have also adapted these practices to our local situation. That saves me time and effort since I will be directly applying that [practice] which has already proven to be

working in our area."

Experimentation

Study findings revealed that 19 out of 27 preferred to try out practices prior to to adoption. This was mainly because most farmers are risk averse and wished to only select practices they were convinced will work. Most of those 19 respondents experimented with manure, fertilizers and foliar sprays. However, the level of experimentation varied across farmers. While some of them tried out more than one type of practice on a single crop in a given cropping season, others preferred to try out just one practice at a time on a single crop. Rarely were multiple practices tried out on multiple crops and across multiple seasons.

For instance, Farmer 6 experimented on beans using both DAP and SuperGrow to determine whether there are variations in crop performance based on the input type, while Farmer 4 only used manure in a split design to determine its effect on crop yield in a maize field. Other criteria that farmers cited using during practice assessments included cost of the input and amount of labor time invested into the application of the practice. Most farmers experimented practices on three major crops: coffee, beans and maize.

Although not a rigorous experimentation process to generate sufficient data, trying out new practices reduced farmers' risk aversion and, increases their awareness and willingness to consider adopting such practices.

Compatibility

Perceived compatibility of waterways and multipurpose agroforestry trees in farming systems emerged an important adoption incentive particularly among those with marginal land parcels susceptible to erosion as well as those who practiced mixed farming. Farmers with highly erodible land reported constructing waterways and planting agroforestry trees along the periphery of their marginal lands as soil and water conservation techniques aimed at reducing soil surface runoff. Farmer 25 discussed this by stating that: "I constructed waterways because part of my land is on a steep slope and when it rains, there is always soil surface runoff which I realized was washing away the soil [top soil] yet I need it for farming." He planted such trees because to cut some tree branches and use them as animal fodder. For farmers with livestock, farmer 26 best exemplified their adoption rationale for agroforestry trees in the following statement:

> "I have …planted animal fodder trees and elephant grass which equally serve as soil fertility management techniques. We were trained that calliandra fixes nutrients in the soil while elephant grass helps to protect the soil from soil erosion by controlling surface runoff."

Calliandra calothyrsus was the most cited tree planted although key informants cited *Sesbania sesbans* as another animal fodder tree that has been promoted in the communities.

Ease of use

19 of 27 farmers preferred adopting practices that they viewed as time and labor saving, did not require a lot technical expertise to implement and were better packaged. Respondents indicated that they were more interested in adopting practices that reduce the amount of time that they spent doing farm activities, especially weeding and planting. Farmer 3 best exemplified this by stating that:

> "The fertilizers we use by spraying [foliar sprays] are much easier to apply…By this [spraying] we are trying to make agriculture less time consuming and labor intensive since agricultural labor is becoming very expensive, yet the workmen are not easy to find. With spraying, you take a shorter time and spray a bigger area. Foliar sprays come in handy…they are sold in small bottles making it cheaper for every farmer to afford buying, unlike DAP and NPK which are mostly packaged in 50kg bags."

Complexity

Complexity in terms of labor intensiveness, time, and package size were significant barriers to adoption of most practices particularly animal manure, compost manure, contraction of waterways and inorganic fertilizers. For instance, farmer 16 revealed that he does not use compost manure because "it's labor intensive…it involves a lot of work and the compost manure itself is bulky making it less desirable to me."

Household wealth

Household wealth includes livestock owned, size of land (acres) a household owned, farm income and any other equipment or supplies owned that could facilitate households' in adoption of soil fertility management practices.

Livestock ownership

Farmers' willingness and ability to use manure greatly depended on household ownership of livestock since livestock waste was considered the most important manure source for farmers in the study area. Most farmers were raising livestock (mainly cattle, pigs and poultry) from which they collected manure for their fields.

Land size

Variations in land ownership greatly influenced adoption of soil fertility management practices. Farmers with more land (above 3 acres) adopted most of the reported soil fertility management practices compared to farmers with three acres or less. Use of organic manure, mulching, agroforestry, waterways and fallowing were dominant among farmers with large land parcels, while small landholders dominated use of inorganic fertilizers and foliar sprays in addition to intercropping and crop rotation. Increased land fragmentation was the major reason cited as causing such variations. Similar findings were reported by Kassie et al. (2013) among smallholders in rural Tanzania where farmers who owned less land were more likely to adopt intercropping, chemical fertilizers and conservation tillage as the their integrated soil fertility management practices.

Income

During the interviewing process, respondents were asked how they mobilize resources to adopt current soil fertility management practices on their farms. Farmers mobilize resources through sale of farm produce and animal products as well as off-farm through retail trade, cash remittances, and salaries for professionals. Many farmers reported on-farm income from sale of farm produce and livestock products as their main capital source for investment in ISFM compared to 10 farmers who reported off-farm income as their main income source. Farmers stated that much of this income is used to purchase inorganic fertilizers, foliar sprays and pesticides in addition to smoothening payments for hired labor. Only a few were using their on-farm income to purchase animal manure, specifically poultry manure.

Coffee, beans, maize, bananas, vegetables, milk and eggs were the major farm products sold to generate income, while trade in farm produce, farm inputs and other home consumption items, monthly salaries for professionals and allowances to some for the politicians served as the main off-farm income sources. Other household assets that farmers cited to be facilitating their adoption of various soil fertility management practices were wheelbarrows to reduce on labor drudgery, knapsack sprayers used to spray during control of pests and diseases as well as the application of foliar and inorganic fertilizers.

Labor availability

All respondents were fully engaged in on-farm activities and were occasionally supported by their children during school holidays. In addition to family labor, 23 respondents reported hiring labor in order to accomplish most of their farm production activities. Study results revealed that farmers' active engagement in on-farm activities together with support from their children facilitated use of labor-intensive practices, particularly animal manure, compost and mulching. Farmers cited collection and transportation of manure to the fields, and routine turning of compost materials roles done mostly by family members. Hired labor was particularly used during land preparation, sowing, weeding, harvesting (depending on the yield) and construction of waterways.

Important to note is that two farmers established other ways with which they mobilize labor on their farms. Farmer 27 was part of a farmers' group which pools labor and rotates in shifts as a team to support each other during the cropping season. The statement below best exemplified this arrangement.

> "I do not hire labor but, we have a group of about four women and all we do is to do rotational labor sharing. We meet together prior to planting time and schedule how we can support each other—something that is built on mutual trust."

Farmer 26 stated that she exchanges part of her crop harvest, particularly cassava, for labor for weeding, sowing and harvesting times. This reduces the costs involved in hiring of labor, which is quite costly during peak times.

Education

Education consists of formal education/training, and extension training through workshops, demonstrations and advice during on-farm visits by an extension agent. Overall, our study results revealed that education greatly influenced adoption of ISFM. Most of the farmers who were able to use at least three of the four categories of ISFM practices were farmers who had at least attained secondary education. For example Farmer 1—a Senior Four graduate was practicing fallowing because it was something he had learned at school. He stated that "I learnt that land needs some rest, especially if you have quite large field such that new weeds emerge, cut them and let them decompose such that the soil regains its vigor to support crop growth." On the other hand, all respondents reported that attending trainings organized and facilitated by extension agents, including fields demonstrations and farm excursion visits had greatly influenced their decisions to adopt, particularly foliar sprays and inorganic fertilizers.

Land tenure

Similar to previous ISFM technology adoption studies (Kassie et al., 2013, Teshome 2014), study results indicated that there is distinct variation in adoption of ISFM based on differences in land tenure arrangements. Farmers preferred to apply both long-term (e.g., animal manure, agroforestry, waterways, compost, and fallowing) and short-term (inorganic fertilizers and foliar sprays) ISFM practices on owned land but only apply short-term ISFM practices on rented or borrowed land. Farmers stated that different tenure arrangements were the key factor determining such actions.

Discussions with renters/borrowers of land (5 respondents) indicated that land is mostly rented/borrowed on a seasonal or yearly basis through sharecropping or by cash payment for renters and by share cropping or sharing of labor by borrowers. In addition, renters/borrowers reported experienced increased incidences of landlords not honoring the rental or borrowing terms by continuously evicting them from the rented lands prior to harvesting their crops or cancelling their leases without prior notices which made them feel too insecure to invest in long-term ISFM practices for which benefits accrue over time. This was best described by farmer 27 who stated that:

> “on rented land, you are not allowed to grow crops that will take more than four months such as bananas, coffee and cassava. You are not even allowed to plant trees and at any one time they [landlords] might decide to evict you and regain their land …because you are not sure as to whether you might harvest crop in some instances, most farmers just like me will hardly apply any inputs. If they do apply any inputs, it would be fertilizers such as DAP, Urea or foliar sprays such as SuperGrow which quickly release nutrients within a short time period.”

This clearly indicates how insecure land tenure arrangements have increased farmer uncertainties thus forcing them to make strategic decisions with regard to land investment.

Discussions with these respondents revealed that land in these communities is rented out or borrowed on a seasonal or yearly basis but with certain conditions—farmers on such land must not plant trees and they are not permitted to plant perennial crops such a coffee, in addition to paying rent for the leased land. These conditions were being stated because coffee and banana crops as perennials consume a lot of nutrients from the soil, and they are crops traditionally grown not only for long-term cash flows but also as a sign of property ownership, while trees have for a long time been used as benchmarks for land boundaries. Therefore, planting such crops creates a potential threat of loss of land for the landlords. Conversely, the renters or borrowers of land reported to have experienced increased incidences of evictions from rented or borrowed land even when they have met all the obligations thus creating increased incidences of farmer uncertainty to application of certain soil inputs.

As a result, analysis of interviews revealed that farmers applied both long-term (e.g. animal manure, agroforestry, waterways, compost, and fallowing) and short-term (inorganic fertilizers and foliar sprays) ISFM practices mainly on farmer-owned land while use of short-term practices including intercropping and rotation are dominated on rented or borrowed land. However, renters or borrowers of the land reported that over time there have been incidences of eviction from the rented land.

Social networks and access to information

In order to understand the multiple channels through which farmers access information and participate in learning about new ISFM ideas, Three categories of social networks were identified: local networks, agency networks and kinship networks as defined by (Prokopy et al., 2008; Teklewold et al., 2013). Study results indicate that the ability of farmers to interact with fellow farmers, relatives and extension agents plays a significant role in their adoption decisions. In order to determine farmers' level of participation within networks and between, we asked farmers if they were members of any farmers' association. We also asked them to cite information sources for the various soil fertility management practices they had acquired over time.

Local networks

Most farmers were members of at least one farmers group through which they interacted and shared information with fellow farmers. Farmers' ability to adopt traditional soil fertility management practices (with the exception of agroforestry) and animal manure was primarily the result of farmer-to-farmer interactions during group meetings, on farm visitations and from relatives. All farmers who adopted poultry manure acquired knowledge about its use and impact to crop growth and yields from fellow farmers and relatives.

Agency networks

All farmers including those who did not belong to any farmers groups were in close interaction with extension agents in their areas. These extension agents were either from the government advisory services programme (NAADS) or from local not-for-profit agencies that directly worked with farmers in the agricultural production sector. Prominent amongst these were Caritas-MADDO, Kitovu mobile, CEDO, VI-Agroforestry and World Vision that had recently phased out.

Farmers stated that the use of fertilizers, foliar sprays, multipurpose trees and construction of waterways, although traditional, were promoted by the extension agencies. The NAADS programme promoted the use and adoption of foliar sprays and fertilizers. Key informants explained that that promotion of these practices was primarily through trainings at group level, experimentation in demonstration sites, conducting on-farm field monitoring visits and radio talk shows as well as directly supplying the inputs to members at a subsidized cost.

Both VI-agroforestry and NAADS were identified as having contributed to the promotion and adoption of both multipurpose trees and construction of waterways. P Agronomic practices including use of pesticides and planting of improved bean seed varieties was attributed to CEDO and NAADS.

Besides extension agents, some farmers interacted with stockists and often asked them how to apply fertilizers and foliar sprays upon purchase. They also established bonds of mutual trust in that could access inputs on credit. For example, Farmer 3 stated that:

"…we can also get fertilizers from stockists on loan and pay back later, but, this is based on the respected and reputation you have garnered from the public over time—you must be a person of good morals and integrity to benefit from this [partnership with stockists]."

Kinship

Kinship refers farmers' relatives with whom they interact to share knowledge and rely on for support during implementation of some soil fertility management practice. Most farmers revealed how they depended on their spouses and children's physical, technical and financial support. All farmers noted that use of compost, ash and fallowing to enhance soil productivity were practices that they had learned in childhood from their parents. They also depended on family labor to apply manure as well as manage their fields. A few (3) received cash remittances from their spouses and children that they, in turn, invested in purchasing farm inputs such as fertilizers, pesticides and foliar sprays. A few had relatives who have technical expertise regarding agriculture by virtue of their professional training, and often consulted them to learn how to improve their farming systems.

Information sources

"Knowledge is cumulative and can only be increased when shared and discussed." (Farmer 10). Building on this statement, Pannell et al. (2006) argue that for farmers to begin implementing new technologies, new knowledge and skills are obtained through multiple pathways. In our study, besides knowing the various networks through which farmers interacted to acquire new knowledge about ISFM, farmers were asked to identify their main information sources. Farmers received information about soil fertility management practices from their fellow farmers (27), extension agents (26), farm visits (23), and own and farmer led experimentation (24). Others included relatives, radio, agricultural fairs, formal training and cellphones. Farmers cited easy access, reliability and being knowledgeable as the key reasons why fellow farmers and extension agents were their prime information sources.

Although farmers have various information sources, valued sources of information are highly trusted based on the personal experiences and relationship built with the information source, quality of the information received and the opportunity to receive instant feedback. Extension agents (mostly NAADS extension officers), and fellow farmers were the most trusted sources, followed by radio. Representative statements for their choices of preference included:

> "….these farmers have their own indigenous knowledge which they have built over time based on experimentation with various concoctions they have developed themselves. Now such a person is giving you firsthand information based on what he/she has applied and seen working unlike you [scientists] who are learned and will at times give us recommendations based on what you have learned or seen being recommended in literature but without any hands on experience" (Farmer 1)

> "As for the NAADS technical staff, they are dependable and easily reached on phone in that you can call to have instant feedback. Besides, they always make farm visits where we get to have direct feedback from the fields themselves" (Farmer 8)

It is no surprise that extension agents were the most trusted source. In Uganda information dissemination with regard to new agricultural technologies from research organizations is mainly through the extension system (Mugonola et al., 2013).

Access to credit

Only 16 of 27 respondents accessed credit for investment in soil fertility management practices from various sources, in cash or in kind. Major credit sources included village savings and lending associations (VSLAs), 'merry-go-round' farmers groups, microfinance institutions/commercial banks and other agencies (primarily NAADS and Community Empowerment Development Organization, CEDO). Most of the farmers preferred to access credit through Village Savings and Lending Associations (VSLAs) because of very low interest rates offered and the flexibility to borrow cash without presenting collateral as compared to commercial microfinance institutions and banks. Additionally, farmers expressed concern over the unpredictable weather changes that have in the recent past led to significant crop failure, thus forcing many to avoid borrowing money for fear of being victim to poor loan recovery by the lenders. Vision Fund and Centenary Bank were the only mentioned credit service providers from which farmers received money.

While most credit is offered as cash, other players such as, Bangladesh Rural Advancement Committee (BRAC), Masaka branch, CEDO, NAADS and a few stockists have developed mechanisms through which they can extend credit to farmers. These players preferred to provide credit in kind by supplying farmers with needed agricultural inputs. Farmers mentioned seed, fertilizers and foliar sprays to be the main inputs supplied.

Market access to farm inputs and produce

Farmers' market access to inputs, and produce influenced adoption decisions for 20 and 21 farmers respectively. Reduction in distance travelled to access inputs and increased demand for farm produce at farm gate were the greatest incentives influencing farmers' decisions. For instance, increased adoption of foliar sprays, mineral fertilizers and poultry manure have increased in the recent past because of an increased number of retail input dealers within local communities. Farmers stated that this greatly reduced their transport costs and increased convenience since many of these inputs are readily accessed when needed within their communities. For example, Farmer 1 was able to use adopt poultry manure because of consistent supply, timely delivery and packaging of the manure. However, farmers decried an increase of counterfeit products on the market which, if not checked, could affect farmers' attitudes and willingness to continue using these inputs.

For farmers who adopted inputs to enhance soil productivity as a result of having access to produce markets, increasing farm gate demand for their produce and better road networks played a great role. Better roads have expanded boundaries of trade for many who receive traders from different parts of the country including the capital city and neighboring countries (northern Tanzania, Rwanda, Kenya and South Sudan) for their beans and maize. Farmer 17 best exemplified this in the following statement:

> "There is market of all our agricultural produce on-farm…this has been one of the motivations I struggle and apply some soil inputs such that we not only produce for home consumption but also for the market –for a better income source."

CHAPTER 4: DISCUSSION OF RESULTS

Current farmers' knowledge about soil fertility

The study provides evidence that farmers have explicit and relatively comprehensive sets of soil indicators used in the classification and assessment of soil fertility. These are attributes they visualize or perceive based on their farming experiences. Similar to findings by Dawoe et al. (2012), soil color, texture, structure, crop yield and vegetative growth (indicator weeds) were criteria used to classify soils by farmers. Of these, crop yield and soil color were the most important characteristics used although the other criteria were equally important. Corbeels et al. (2000) argue that use of soil color and soil texture in classifying soils (and perhaps assessing soil quality) is important because the two attributes are a true reflection of the parent material that determines a soil's properties. In this study, farmers considered black soils to be the most fertile with good water holding capacity, friable and thus easy to work with during cultivation. The red soils were considered the least fertile, with poor soil moisture retention and relatively compacted, making them difficult to till. Although no soil tests were conducted to determine the actual soil fertility status of these soils, numerous studies have been conducted elsewhere and confirmed that farmers' classification of soils greatly correspond with the scientific soil quality indicators. For example, Corbeels et al. (2000) found that farmers' classification of fertile and infertile soils in the Ethiopian highland of Tigray was well correlating with scientists' classification.

Consistent with previous research (Corbels et al., 2000; Dawoe et al., 2012), using an approach that recognizes local taxonomies and nomenclature could perhaps ease adoption of improved soil fertility management practices. Constructing soil classification systems based on local knowledge provides opportunities for development of hybridized approaches that are highly contextual and can help to advance the relevance, adaptation and adoption of in-depth scientific knowledge of soil process.

Farmers' perceptions of soil fertility management

Pulido and Bocco (2014) argue that farmers' awareness of soil degradation as a problem is the first step in influencing their decisions about improved soil fertility management practices. As such, farmers become motivated to seek alternative ways to avert current problems based various perceived constraints, including the characteristics of technologies available to them. Consistent with this notion, farmers that have a strong sense of the causes and consequences of soil degradation within their areas have influenced them to adopt new.

Farmers revealed that continuous cropping and climate change were perceived key drivers to soil degradation, while declining crop yields and increased incidence of diseases and pests were the immediate consequences they experience. In turn, farmers have adopted various ISFM practices, which reflect four categories: animal manure, inorganic fertilizers, traditional practices and foliar sprays. Many studies on adoption of ISFM practices have found similar results. For example, a study by Mugwe et al. (2007) among smallholder farmers in Kenya revealed that farmers were willing to adopt new soil fertility management practices only if they perceived soil fertility to be a problem. This implies increased farmer awareness about soil degradation as a major production constraint that would have significant livelihood impact for smallholders through trainings and other sensitization approaches might facilitate adoption.

Farmer decision-making processes for adoption of ISFM practices

Today, declining soil fertility is a major challenge facing most smallholder farmers in Masaka and Rakai districts who recognize that soil fertility is a key production constraint on their farms and have adopted various ISFM practices in an effort to enhance productivity. Adoption of these practices was linked to farmers' socioeconomic contextual factors and practice characteristics as perceived by the farmers. Practice characteristics, access to markets for farm inputs and produce, as well as farmers' active interaction within and among various social networks emerged as key drivers to adoption.

Perceived practice characteristics and adoption

Of all the six perceived characteristics of ISFM practices studied, relative advantage of the practice, compatibility, observability and experimentation were the most important attributes that influenced adoption, while complexity was the most important barrier to adoption.

1. Relative advantage of the practice

Perceived benefits of the practices varied both within and between practice categories. Farmers were motivated to adopt practices that provided multiple benefits, were locally available, and had high returns on investment.

- ***Local availability***—Farmers continuously reported that that their first preference is for practices for which resources exist and use family labor. Animal manure, mulching and fallowing, favored inorganic fertilizers and foliar sprays.
- ***Multifunctionality***—Respondents described how they preferred to adopt certain practices over others as a result of performing multiple functions. Since farmers face multiple demands, practices that are likely to provide more than one benefit are easily adopted (Mcdonagh, Lu, & Semalulu, 2014). Most farmers prefer to use manure on owned land because it offers dual benefits—meeting nutrient requirements and improving soil physical properties such structure and texture. Similarly, farmers with livestock adopted agroforestry trees that fix nitrogen in the soil, they also help to minimize soil erosion and provide animal fodder when harvested. In their study of qualities most likely to influence adoption, Mcdonagh et al. (2014) found that farmers were planting Napier grass strips to control soil erosion and as a source of animal feed.
- ***Cost-benefit analysis***—Farmers' willingness to invest in ISFM depended on whether the interventions resulted in increased yields and income. Farmers expressed the need to invest in practices which would enhance their crop yield in both the short and long-term. They were interested in practices that would save labor and time, reducing production costs. Accordingly, farmers were increasingly adopting foliar sprays and fertilizers to enhance crop yields in the short run while applying manure to serve as a nutrient enhancement in the long-term. However, this was a disincentive to continued application of compost manure. Requirements for preparation, transportation and application were the cited as key factors leading to its discontinued use.

2. Trusted information source and Observability/Experimentation

The ability to observe practice benefits from trusted information sources or through their own experimentation influenced farmers' adoption decisions. Farmers in these communities often visited fellow farmers and interacted with extension agents to acquire new knowledge related to practices they intended adopt. Many preferred trying out new practices on their farms prior to adoption. Many farmers are risk averse and are only ready to adopt practices that they are sure of being successful and within their means. Lambrecht et al. (2014) argue that farmers' interactions with technical personnel such as extension agents enhance transfer of technical information required to conduct accurate experimentation. Experimentation itself allows farmers to develop more realistic expectations about the technology which could enhance sustained adoption. These findings underline the significance of participatory learning in adoption. The iterative process of information exchange between farmers and extension experts provides an opportunity to refine and adapt new knowledge to suit local contexts.

3. Compatibility

Depending on the landscape and type of farm, some ISFM practices were being adopted by farmers due to the terrain of their farms or as a resulting of having a mixed farming system. Examples include conservation practices such as establishment of waterways and planting of calliandra trees based on such grounds. In addition to practice attributes of a technology, we found that there were other key social economic factors that interact with practice attributes to influence adoption of ISFM.

4. Complexity and ease of use

Improved soil fertility management practices that require more labor and time (e.g., composting) are less likely to be adopted by famers. Farmers are faced with many activities that require timely application if they are to obtain positive results; delays put achievement of benefits at risk. In addition, foliar sprays that take a short time to apply and can be combined with other farm management practices such as pest and disease management are quickly adopted.

Farm Characteristics

Land Tenure—Grimm & Klasen (2014), argue that the ability of land users to invest in both short and long-term soil fertility management practices depends on security of tenure. Increased failure of landlords to honor renting/borrowing terms for renters/borrowers coupled with short-term renting leases prevented farmers from using management practices such as animal manure, compost, agroforestry and waterways for which returns to investment accrue over a long period. Such farmers were more motivated to adopt practices that enhance productivity within a short period of time such as foliar sprays and mineral fertilizers, or not apply any inputs when faced with limited cash to purchase these inputs. These findings corroborate the results by Kassie et al. (2013) that smallholder farmers with insecure land tenure in rural Tanzania are less likely to adopt soil and water conservation practices, animal manure and conservation tillage.

Farmer characteristics

1. **Household wealth**—farmers' wealth included: farm size (acres), livestock, farm labor and total farm income.

- ***Farm Size***—Farmers with large land area are more likely to adopt soil fertility management practices than those with small areas (Marenya et al., 2007; Prokopy et al., 2008). Study findings support this phenomenon, although there were differences regarding the type of practice adopted. Farmers with larger land areas reported using more extensive soil fertility management practices such as fallowing, agroforestry and waterways in addition to the chemical fertilizers and foliar sprays, while farmers with less land often opted to use intensive practices such as chemical fertilizers and foliar sprays. This seems to reflect land fragmentation in causing farmers to intensify agricultural production through use of labor saving and yield augmenting practices. Key informants confirmed this by stating that most of the soil conservation practices (e.g., construction of waterways) involve significant amounts land portions that farmers with small land parcels are unwilling or unable to sacrifice.
- ***Farm Labor*** availability—Similar to Ebanyat et al. (2010), this study found labor availability to be a key production factor influencing adoption of ISFM practices. This is because most of the practices currently used by farmers to enhance fertility are labor intensive. However, there is a relatively distinct division of labor with regard to adoption of these practices. Application of animal manure and other soil conservation practices (composting, mulching) was primarily done by household members particularly women and children, while land preparation, weeding and harvesting involved use of hired labor. In addition, resource constrained farmers have developed other mechanisms through which they mediate labor constraints. Rather than paying cash for hiring labor, some farmers exchange part of their produce to hire labor to work on their farms while others have developed labor sharing arrangements with group members. This was particularly stated by women. Similar findings were reported by Mugwe et al. (2007) who

found that resource-poor farmers accessed sufficient labor through reciprocal arrangements with fellow neighboring farmers.

- ***Livestock ownership***—Manure was the second most used soil fertility management practice. This is could be attributed to the local availability of manure sources and the synergistic benefits that accrue from having livestock as part of a mixed farming system. Crops generate income through sale of produce and crop residues serve as feed for livestock that, in turn, provide manure to improve soil fertility and cash through sale of livestock products (e.g., milk and eggs) or the animals themselves to purchase other farm inputs such as inorganic fertilizers (Marenya et al., 2007). However, our study revealed some unique arrangements since most farmers applying poultry manure preferred to purchase it from outside sources as far as Kampala (about 230 km from the nearest study community) than to raise poultry on-farm. Besides poultry management being a labor and capital-intensive enterprise, farmers have established cordial relationships with bulk buyers of their produce who supply them with manure to enhance crop yields.
- ***Farm income***—A majority of the farmers obtained most of their cash from sale of farm produce which they used to purchase other inputs, including fertilizers and foliar sprays. Fertilizers are capital-intensive inputs which can only be used if farmers have the financial means to purchase them. In addition, cash is important for hiring of labor to carry out various farm activities such as weeding and land preparation (Mugwe et al., 2007; Turinawe et al., 2015). This implies that farmers are willing adopt capital-intensive inputs if the investment results in high yields and guaranteed income. In addition to being a manure source, livestock serves a form of wealth that farmers can use to leverage other inputs on their farms through sale (Shiferaw and Holden 1998) Farmers at times sold their livestock, primarily goats and chickens, to raise funds for purchasing fertilizers, herbicides and pesticides.

2. **Education**—Both formal and extension trainings influenced adoption of soil fertility management practices except inorganic fertilizers. Variation in formal education influenced adoption of inorganic fertilizers, because it is a knowledge intensive process (Teklewold et al., 2013), which requires being able to 'decode' and 'analyze' information (Bryan, 2014) to efficiently integrate such practices into their farming systems. The significant role of extension training in adoption reflected the quality of trainings offered, provision of subsidized inputs

(seed, fertilizers and foliar sprays) to the farmers and trust that farmers had in the field extensionist as an information source.

3. **Social networks**—Study results underscore the role of social networks in influencing adoption. Farmers' adoption decisions depended on those of other actors within their networks, with trust and information sharing being important attributes to facilitate the adoption process. For instance, the decision of farmers to adopt poultry manure, chemical fertilizers and foliar sprays was greatly influenced by farmers' interactions with fellow farmers in groups/associations as well as with extension agents through farmer visits, on-farm experimentation (both farmer-led and extension-led), and trainings. Similar to Mugwe et al. (2007) and Kassie et al. (2013), we find that social networks help reduce farmers' labor and financial constraints, thus enhancing their likelihood of adopting ISFM practices. Farmers reported using capital-intensive inputs such as fertilizers as a result of cost-sharing arrangements under the NAADS program, as well as being able to borrow cash from their VSLAs and 'merry-go-round' groups. Women farmers reported labor sharing arrangements with women in their local farmers groups.

Contextual Factors

1. ***Input-Produce markets***—Sanginga and Womer (2009), argue that strengthening and increasing farmers' access to input-output and credit markets provides one of the best ways to enhance sustained adoption of ISFM practices such as inorganic fertilizers. Study results reveal that farmers are increasingly adopting capital-intensive inputs, particularly inorganic fertilizers and foliar sprays because of improved market infrastructures in terms increased number of input dealers and produce buyers as well as better road networks. Together, these factors have reduced transaction costs (Teklewold et al., 2013). However, input markets are faced with challenges of having substandard fertilizers inputs on the market. This could in the long run reduce farmers' willingness to adopt fertilizers.

2. ***Credit Access***—Although there are few credit service providers in rural areas, most farmers are not willing to use the few existing financial institutions. The major reason is that farmers are becoming increasingly risk averse as a result of bad experiences with weather shocks (prolonged droughts, erratic rainfall patterns and increased incidences of pests and diseases).

> Such experiences have reduced their confidence in accessing credit because of fear of being unable to repay back the loans which typically have high interest rates. However, one way farmers are trying to counter this challenge of credit access is by forming informal VSLAs or 'merry-go-round' groups through which they can mobilize cash to invest in fertility management practices. Farmer 10 stated that she prefers to access credit through their informal 'merry-go-round' savings group. This further underlines the role of farmers' engagement in social networks. Besides information access, farmers' engagement in such groups gives them the opportunity to access financial resources to invest in agriculture, although some of them preferred to invest in off-farm businesses from which they could gain some profits that they would later invest in agriculture. For example farmer 5 stated that: "…at times I borrow some cash from our farmers' group and a small microfinance institution here called FINCA. I then use this money to buy tradable goods for my shop including the fertilizers that I apply on my farm. It is the profits from these goods that I then use to purchase any other farm inputs that I need."

Although not part of our a priori expectations, we found that plot characteristics and type of enterprise on a plot influence farmer investment decisions in ISFM. Presence of sloped land greatly influenced adoption of agroforestry and waterways plot size. We also found that farmers were less likely to use chemical fertilizers on land they perceived to be very fertile, and used animal manure predominantly on crops they considered to provide great economic returns to investment such as coffee and vegetables. This implies that future sustained promotion of ISFM requires development and integration plot specific characteristics in its design.

In addition, analysis of study interviews revealed that some farmers especially those adopting long-term soil fertility management practices had a strong stewardship ethic which influenced them to adopt such practices. Farmers expressed the desire to have better farms in the next decade and the need to pass on better cropping fields to their children in the future. For instance, farmer 10 stated that her decision to use animal manure was to build a fertile soil that could support crop growth in the near future. She mentioned that: " …many of the soil management practices I am using today are not necessarily market oriented in terms of enhancing soil productivity, but rather are focused on building my soils. I want in the next 5-10 years to have built a very rich soil that can support growth of any crop." By this the farmers was highlighting the significance of long-term planning and soil conservation enhancing soil fertility. To express good legacy as an aspect of stewardship ethic, farmer 5 stated that: “Animal manure is strictly applied on my own land where I am sure of getting its long-term benefits and, I want to pass on a better land to my children just like my parents did to me.” These statements reflected that farmers’ ISFM adoption range over different farmers’ goals and motivations to farming. While financial return in terms of increased crop productivity could the primary goal for most farmers, sustained long-term production beyond present times is also key. This could imply that soil fertility is a critical component to ensuring better household food security and sustainable livelihood among rural communities.

Below is a table that summarizes key socioeconomic factors identified to influence adoption of ISFM from the study.

Table 3: Summary of Socioeconomic Variables Influencing Adoption of ISFM

Variable	**Influence on Adoption of ISFM**
Soil fertility Awareness	Farmers are aware of causes and impacts of poor soil quality.
Experimentation experience	On-farm experimentation with inorganic fertilizers and foliar sprays has positively enhanced their adoption
Education	Formal education enhances adoption of multiple soil fertility practices.
Extension training	Extension training has the greatest role in increasing farmers' knowledge and adoption of all ISFM
Livestock	Livestock ownership positively enhances adoption of animal manure
Land Size	Farmers with large land parcels adopt both labor intensive and capital intensive ISFM practices, while those with small sized land mainly adopt capital intensive practices
Household Income	Farm produce is the main income source and positively enhances adoption of both capital intensive and labor intensive practices through direct input purchases and hiring of labor on-farm
Farm labor	Family labor availability positively influences adoption of labor intensive practices (agroforestry, mulching and construction of waterways)
Secure tenure	Secure tenure enhances adoption of both short and long-term ISFM, while tenure insecurity stimulates use of inorganic fertilizers and foliar sprays on
Social networks	Farmer-to-farmer interaction encourages adoption of poultry manure and traditional practices (ash, intercropping, composting) Farmer interactions with extension agents and stockists (vendors) enhances adoption of capital intensive inputs through direct purchases and subsidies
Information Access	Information access increases adoption by increasing farmers' knowledge about practices. Extension agents and fellow farmers are the most trusted sources and pathways for information dissemination.
Credit access	Credit access through informal farmers' groups enhances adopted of inorganic fertilizers and foliar sprays.
Access to input-produce markets	Access to input-produce markets increases adoption of capital-intensive practices as a result of improved local availability, and guaranteed income source, respectively.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

Summary and conclusion

The objective of this study was exploring how farmers' perceptions, local knowledge and key socioeconomic practices influence their decisions to adopt ISFM. Study results reveal that farmers have well-developed local knowledge about soil fertility based on their farming experiences and phenomena, which is easily visualized to classify and assess fertility changes. Soil color and crop yield were the most important visual characteristics that farmers used to determine soil quality. Spurring sustained advances in adoption of ISFM will require understanding and integration such knowledge with scientific advances because it provides opportunities for developing context-specific interventions adaptable to local biophysical and socioeconomic situations of adopters.

Consistent with conclusions by Reimer et al. (2012), this study confirms that perceived practice attributes are central to adoption of ISFM practices. However, in addition to relative advantage, compatibility, and observability, the study found experimentation to be very important in influencing farmers' adoption decisions. Complexity of the practice was the primary barrier to adoption. Perceived benefits of each practice varied both between practices and farmers based on differences in farm, farmer and contextual factors. While many adoption studies examining relative advantage of practices have mainly focused on the economic aspects of the practice (Pannell et al., 2006; Barry & Cary 1992), study results reveal that farmers consider local availability and multifunctionality benefits of the practices to be very important when evaluating relative advantage. Beyond the perceived practice attributes, farmers have other values believed to be influencing adoption. The need to ensure household food security, the desire to pass on a better productive farm to future generations (farm legacy) and the need to build the fertility of the soil not for the current season but other seasons to come ahead (stewardship) are two key values which motivated farmers to adopt various ISFM practices.

Results underscore the role of household wealth, social networks, security of land tenure, farm labor availability, education, unreliable rainfall patterns, access to input-produce markets and credit access on farmer adoption decisions. Household wealth in terms of livestock, farm labor, and farm size emerged as major determinants of adoption of ISFM practices implying that their availability to the farmer is very critical.

While increasing the number of livestock might not be feasible due to land fragmentation, integration of high-yielding animal breeds and improved forage species with high biomass can be a solution to increasing livestock products from which they generate more income to purchase fertilizers and manure. Farm size could be increased through ensuring tenure security where land titling and registration are improved to encourage land access through the realizability effect (Grimm & Klasen, 2014). Similarly, increased adoption of long-term soil fertility management practices on rented land might be improved by instituting public policies that guarantee security of tenure, and facilitating land administration institutions to implement such policies and ensuring that informal contracts which most farmers make with landlords are honored.

Social networks, particularly local and agency networks, had the greatest impact in enhancing adoption by facilitating learning (through observations, experimentation and farms visits), and improving farmers' access to information, fertilizers, labor and credit. This suggests that institutions promoting ISFM practices should consider using learning approaches that facilitate iterative learning among participants and local adaptation of novel practices for sustained adoption. Also, there is need for government and other development partners to develop proper policies and institutional mechanisms aimed at linking farmers to input-produce markets and credit. This may be achieved through improvement of infrastructure such as roads to reduce farmers' transaction costs and provision of favorable credit schemes targeted towards liquidity-constrained farmers at affordable interest rates.

The effect of unreliable rainfall patterns on adoption of inorganic fertilizers, particularly CAN and DAP for targeted adoption strategies and underscores the significance of providing appropriate weather forecasts regarding the timing, amount and distribution of rainfall during the cropping season. Furthermore, variations in farmers' perceptions about soil fertility and plot specific characteristics such as slope influenced adoption of inorganic fertilizers and, agroforestry and waterways respectively. This implies that promotion of sustained ISFM practices requires development and integration of plot specific characteristics in its design. Farmer experimentation is an important element of learning. It helps farmers acquire site-specific knowledge about practices, and adapt these practices to their context-specific socioeconomic and biophysical conditions. Promotion and increased adoption of ISFM practices should build on farmers' unique interests, including observation and experimentation to try out and interpret results of novel practices.

Results confirmed the importance of extension services in the adoption ISFM practices, particularly inorganic fertilizers and foliar sprays. As means of scaling up adoption of ISFM practices, government policies and strategies that improve access to extension services should be strengthened. In addition, the quality and adequacy of the extension services in target areas through better training for technical and communication skills should be encouraged. This could be achieved through refresher trainings on key soil fertility management aspects such as use of soil testing kits in conducting on-farm soil analysis.

Besides improving quality and adequacy of extension services, government still needs to play a significant role in increasing the human resource capacity of the districts in terms of recruiting more extension staff. With the current disbandment of the NAADS extension agents, this seems to be a big challenge yet NAADS extension services emerged as a most trusted source. Where not-for-profit agencies are playing an extension role, there is need for better coordination with the NAADS program to avoid duplication of services although at times this might be a challenge since such agencies operate on donor funds defined time frames that could hinder long-term sustainability.

While foliar sprays, fertilizers, pesticides and fungicides are increasingly being used by farmers, there are no agreed standards in terms of safety, application rates and timing of application. Therefore, trainings aimed at increasing farmers' awareness regarding use of chemicals should emphasize aspects of safety, recommended application rates and timing of application if farmers are to realize better results in terms of crop yield.

Relatedly farmers reported to be using foliar sprays as a soil fertility management practice, but, no research has been conducted within country to determine their efficacy. Therefore, there is need for research to determine the nutrient composition of these sprays and appropriate application rates for enhanced impact on crop yields. Further, farmers reported the increased incidences of counterfeit inputs on the market. This calls for government through the MAAIF and Uganda

National Bureau of Standards to strengthen the quality standards unit with enough personnel to conduct routine supervision of input dealers.

While most research has focused on adoption of practices in isolation, study results suggest that farmers typically adopt (and adapt) several practices concomitantly, perhaps as complements, or supplements to address overlapping constraints. This is an important area that requires further research to specifically understand which ISFM practice combinations are most adopted by farmers based on their varied socioeconomic constraints as well as understanding the primary goals behind farmers' choice combinations (i.e., complementary, supplementary or substitution goals). This would be an important approach to good policy formulation and programs development about best strategies to promote in enhancing soil productivity.

Study results also revealed the effect of land tenure on farmers' decision making strategies, with a majority of farmers preferring to use both short and long term soil fertility management practices on owned land than on rented/borrowed land. But our sample size of farmers renting/borrowing land (only 5 respondents) was too small to draw definitive conclusions. Further studies looking at adoption decisions among smallholder farmers in this region should look at land tenure as an important factor. Particularly important will be to focus on whether significant variations in use rights between renters and borrowers of land and structures that are in existence to resolve conflicts between land users and owners to ensure sustained land investment.

While the study identifies farmers' decision making processes for ISFM to be complex, we find some strategies that farmers have adapted and adopted to enhance productivity within their diverse socioeconomic realm. Resource constrained farmers in terms of labor and credit access have adapted reciprocal labor sharing approaches as well as saving and borrowing money through VSLAs and 'merry-go-round' groups, respectively. These are important approaches that development practitioners and programmes could strengthen and replicate within communities as means of strengthening farmers' social capital and resilience to labor and cash constraints.

Recommendations for greater adoption possibilities

Develop iterative learning approaches that encourage integration of traditional knowledge with scientific knowledge—While scientific research provides great insight about soil biophysical process that could be influencing soil fertility, farmers' traditional knowledge provides the site-specific context local conditions required to adapt new scientific knowledge to farmers' farming socioeconomic environment. Efforts to enhance adoption of ISFM will require use of participatory learning approaches that encourage collective learning and sharing of information between targeted adopters and researchers.

Adopt transdisciplinary approaches in understanding farmers' decision-making strategies—The study revealed that there is heterogeneity in farmers' goals, motivations and constraints to farming which in turn influence their adoption strategies. Such complexity requires a multi-disciplinary research approach that encourages multiple researchers to work beyond paradigms of their specific training in developing more innovative, multifaceted solutions to fundamental challenges i.e. declining soil fertility.

Promote ISFM practices that offer multiple solutions to farmers' problems—Farmers reported that they preferred practices that provided multiple services to their farming system. This a very important aspect that could enable promotion of improved seed, and multipurpose legume tree species in form of improved fallow within their farming systems.

Conduct cost-benefit analyses for the various practice options available to the farmers. Farmers cited the initial cost of investment as a key aspect they consider when selecting practices to adopt. Increasing the integration of capital-intensive inputs such as fertilizers, foliar spays, pesticides and fungicides by farmers will require researchers to internalize the various costs and returns to investment that might accrue if farmers opted to use such input combinations. Such an approach would help in developing recommendations that cater for heterogeneity in smallholders' resource endowments, particularly land size, livestock ownership and income.

Future research

Future adoption studies need to further consider the roles of short and long term farmers' motivations to farming as well the extent to which farmers' participation in diversified social networks facilitate adoption of specific ISFM practices and technologies. This could be a good way to design targeted ISFM practices and enhance adoption among heterogeneous farmers groups. This study used an explorative research approach in trying to understand farmers' decision-making strategies regarding ISFM. Future studies in Masaka and Rakai districts might consider using results of this study to conduct quantitative studies in order to thoroughly understand farmers' adoption behavior and validate the study findings.

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APPENDIX A: FARMER INTERVIEW GUIDE

A. Farmers’ Perceptions and Motivations

1. What are the most important crops on your farm?
2. Which are the most important cash crops? Food security crops?
3. What is the acreage of beans production for season 1 2014 and Season 2 2013?
4. During the last 5-10 years, has the fertility of soils on your farm changed?
   a) How do you differentiate between fertile soils and infertile soils?
   b) How has the fertility of your farm changed during the last 5-10 years?
   c) What are indicators of this change?
5. What has caused this change in soil fertility?

B. Farmer Experience/ Knowledge

1. In what ways do you consider yourself (and your family) as experimenting and innovating with ways to improve your farming system and livelihoods?
2. How do you *learn* to improve your farm? (own experimentation, outside sources of information, training, discussion with others) for:
   a) Production of priority crops
   b) Productivity (maximizing output in relation to land and other inputs)
   c) Soil fertility (both short-term productivity gains and long term productivity maintenance / enhancement).
3. How have you managed soil fertility on your farm?
   a) 5-10 years ago

b) Currently

c) How did you select these specific soil fertility management practices and technologies?

d) Why do you use these methods now?

e) What has worked well? Why?

f) What has not worked well? Why?

4. How do you assess the results of your experiments? How do you decide what to do next?
5. Which soil fertility management practices and technologies that you are aware of that you wish to experiment/try on your farm?

C. Socioeconomic Factors

1. What resources are needed for each soil fertility management practice and technology that you use?

2. How do you obtain/mobilize the resources for these fertility management practices and technologies?

3. In order to make improvements on your farm, do you sometimes need to borrow money from someone or some institution? For which specific improvement?

D.1. Landholding and Land Use Rights (skip if farmer does not rent land)

1. What is the size of the land that you and your family members farm?

2. Is any of this rented? If you rent land for farming, what is nature of the relationship between the land owner and yourself (relative, friend, neighbor, King's land, other)?

3. If you have hired land for farm production, briefly describe the terms involved in hiring land for farming in this area.

4. How do land rental terms affect your choice of soil fertility management practices and technologies?

D.2. Farm Labor Relations

1. How many family members work on the farm?
2. Are there times during the agricultural season that you have hired some labor to work on the farm? When? Why?

D.3. Access to Markets

1. In what ways has market access for buying farm inputs influenced soil fertility management practices?
2. In what ways has market access for selling produce influenced soil fertility management practices?
3. How has this changed in the last 5-10 years?

E. Information Sources and Systems

1. Do you belong to any farmers' group or association in the community?
2. Where have you learned about farming and soil fertility management practices?
3. What specific soil fertility management practices have you learned so far?
4. What are your most trusted sources of information about this? Why those?
5. With whom do you discuss problems and solutions related to soil fertility?
6. Have you shared your knowledge and practices about soil fertility management with someone else?

F. Socio-demographic Characteristics (of interviewees and household)

1. Age
2. Sex

3. Education

4. Adults (18+) in Household

5. Children (17-) in Household

APPENDIX B: KEY INFORMATION INTERVIEW GUIDE

1. How long and in what capacity have you worked with farmers in this area?

2. In your own opinion, to what extent do farmers in this area know which soil nutrients are missing or limit productivity in their farms? How do they determine that? (Explain)

3. What are the most common soil fertility management practices used by farmers in this area? What are some other uncommon or unique practices that also seem to be effective?

4. What improved soil fertility management practices have you so far disseminated to farmers in this area? How have you done that?

5. To what extent are these practices adopted by farmers? Are some practices adapted by farmers in innovative ways? If so, how?

6. What specific challenges have YOU encountered in the promoting these new soil fertility management practices?

7. What criteria do you think farmers use when selecting soil fertility input(s) or practice(s) to adopt? (Explain).

8. What constraints do farmers say they face in utilizing various soil fertility management practices and technologies?

9. How, where and when do farmers (men and women) interact with each other – whether formally or informally - to discuss topics covered during agricultural training, issues related to adoption or non-adoption, and their own innovations?

10. What suggestions would you make to improve the adoption (and adaptation) of soil fertility management by farmers in this area?

APPENDIX C: IRB EXEMPT FORM

IOWA STATE UNIVERSITY
OF SCIENCE AND TECHNOLOGY

Institutional Review Board
Office for Responsible Research
Vice President for Research
1138 Pearson Hall
Ames, Iowa 50011-2207
515 294-4566
FAX 515 294-4267

Date: 7/11/2014

To: Naboth Bwambale
409B East Hall

CC: Dr. Robert E Mazur
318 East Hall

From: Office for Responsible Research

Title: Farmers' Perceptions, Knowledge and Socioeconomic Factors Influencing Decision Making for Integrated Soil Fertility Management in Masaka and Rakai Districts, Uganda

IRB ID: 14-311

Study Review Date: 7/11/2014

The project referenced above has been declared exempt from the requirements of the human subject protections regulations as described in 45 CFR 46.101(b) because it meets the following federal requirements for exemption:

- (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey or interview procedures with adults or observation of public behavior where
  - Information obtained is recorded in such a manner that human subjects cannot be identified directly or through identifiers linked to the subjects; or
  - Any disclosure of the human subjects' responses outside the research could not reasonably place the subject at risk of criminal or civil liability or be damaging to their financial standing, employability, or reputation.

The determination of exemption means that:

- **You do not need to submit an application for annual continuing review.**

- **You must carry out the research as described in the IRB application.** Review by IRB staff is required prior to implementing modifications that may change the exempt status of the research. In general, review is required for any modifications to the research procedures (e.g., method of data collection, nature or scope of information to be collected, changes in confidentiality measures, etc.), modifications that result in the inclusion of participants from vulnerable populations, and/or any change that may increase the risk or discomfort to participants. Changes to key personnel must also be approved. The purpose of review is to determine if the project still meets the federal criteria for exemption.

  Non-exempt research is subject to many regulatory requirements that must be addressed prior to implementation of the study. Conducting non-exempt research without IRB review and approval may constitute non-compliance with federal regulations and/or academic misconduct according to ISU policy.

  Detailed information about requirements for submission of modifications can be found on the Exempt Study Modification Form. A Personnel Change Form may be submitted when the only modification involves changes in study staff. If it is determined that exemption is no longer warranted, then an Application for Approval of Research Involving Humans Form will need to be submitted and approved before proceeding with data collection.

Please note that you must submit all research involving human participants for review. **Only the IRB or designees may make the determination of exemption**, even if you conduct a study in the future that is exactly like this study.

Please be aware that **approval from other entities may also be needed.** For example, access to data from private records (e.g. student, medical, or employment records, etc.) that are protected by FERPA, HIPAA, or other confidentiality policies requires permission from the holders of those records. Similarly, for research conducted in institutions other than ISU (e.g., schools, other colleges or universities, medical facilities, companies, etc.), investigators must obtain permission from the institution(s) as required by their policies. **An IRB determination of exemption in no way implies or guarantees that permission from these other entities will be granted.**

Please don't hesitate to contact us if you have questions or concerns at 515-294-4566 or IRB@iastate.edu.