UNDERSTANDING LEARNING PROCESSES IN THE PROMOTION OF SUSTAINABLE LAND MANAGEMENT IN MOZAMBIQUE

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ABSTRACT

As a result of the livelihoods of millions of rural households being jeopardized due to soil degradation and the need to feed a growing population, decision-makers and research organizations in sub-Saharan Africa (SSA) are focusing on the sustainable intensification of agricultural systems, addressing, in particular, sustainable land management (SLM). Despite investments, land managers' acceptance and adoption of technologies and practices are still low (FAO, 2016). Furthermore, in cases where the adoption of sustainable land management practices was documented, it was later observed that the utilization of the practices occurred mostly during the SLM project life cycle and ended afterward (Giller et al., 2009; Anderson and D'Souza, 2014; Emerson & Snyder, 2018).

This research uses the innovation systems framework to understand SLM in Mozambique, a country of 28 million inhabitants with more than 70% directly dependent on rural agriculture. The research uses qualitative methods to understand the role, perceptions, knowledge, and experiences of (a) promoters of sustainable land management, (b) agricultural extension workers, and (c) farmers in Sussundenga, Mozambique.

The first essay uses social learning theory to understand learning processes and approaches in SLM, addressing (1) learning and the factors that promote or hinder learning, (2) the interactions between land management actors in innovation and learning processes, and (3) how these factors influence the process of innovation in SLM. We find that the nature of the organization will determine the learning strategies they adopt and that learning is constrained by internal and external factors such as organizational learning mechanisms and the security of access to funding, respectively. We find minimum interactions between organizations that could learn from each other and between organizations and the farmers they are working with. Additionally, we do not find evidence of co-innovation and participatory innovation design with farmers. The actual setting of SLM in Mozambique is dominated by the perception of experts of what works and what is necessary.

The second essay explores the paradigm shift in the provision of extension services, from supply-driven to demand-driven extension, which places learning at the center of the model. The essay's finding reveals that the provision of sustainable land management still follows the traditional transfer of technology and supply-driven extension model.

Extension workers understand that land management is a complex and dynamic process that requires continuous updates of knowledge. The study's significant contribution is the understanding of learning among extension workers in sustainable land management. The formal learning process, through academic and on-the-job training, is perceived as the most important. The study finds evidence that social learning plays an important role in the success of sustainable land management. However, social learning among extension workers is constrained by limited opportunities and incentives to integrate this learning into broader sustainable land management advisory and extension systems.

The third essay explores farmers' knowledge and belief systems on land management and how these influence farmers' strategies and decisions on land management. The study indicates a variety of indicators when assessing soil, and while these indicators provide an initial assessment of the soil, it is not sufficient to indicate the soil's actual condition. The laboratory analysis of the soil indicates that the farmer's classification of soil is not aligned with the actual soil condition. To address the perceived soil condition, farmers employ a variety of land management practices, both local and introduced by promoters. And they tend to neglect practices contrary to their beliefs. The study finds a disconnect between farmers' interests and the approaches of external organizations to land management. Farmers tend to focus on short-term economic gains and livelihood improvements, while external organizations focus on improving medium- to long-term soil health and livelihoods.

To my father, Manuel Manjichi (in Memoriam) and my father-in-law, José Carlos Monteiro (in Memoriam), and all the feminist fathers in Mozambique who believe in and support women's education.

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CHAPTER I

INTRODUCTION

Food security remains a major challenge in sustainable development in sub-Saharan African (SSA) countries. Adverse environmental conditions and the degradation of agricultural lands affect SSA countries' agricultural production and jeopardize the livelihoods of millions of rural households (Vanlauwe et al., 2015; van Ittersum et al., 2016).

To minimize and mitigate the adverse impacts of land degradation, research and development organizations have responded with innovations in sustainable land management, including conservation agriculture, integrated soil fertility management, and agroforestry systems to improve agricultural land (FAO, 2016; Liniger et al., 2011; Schwilch et al., 2012a).

Sustainable Land Management (SLM) is an integrated and participatory knowledge-based approach to support the management of land, biodiversity, and water resources to sustain livelihoods and ecosystem services (World Bank, 2008; de Vente et al., 2017). The SLM approaches and practices have the potential to address land degradation and mitigate its adverse effects on human livelihoods and ecosystems services.

Despite the potential of SLM and the significant investment in the dissemination of SLM practices, the upscaling of SLM practices remains low. Even where adoption has been documented, it is often observed that it occurred mainly during the lifecycle of a particular SLM program and ended afterward (Giller et al., 2009; Anderson & D'Souza, 2014; Emerton & Snyder, 2018). The low adoption of SLM raises questions among development scholars,

including the questions on innovation development process, the fitness of innovations to local conditions, and the integration of the needs of the SLM stakeholders.

Furthermore, it is recognized that successful intervention in agricultural and resource management requires (i) acknowledging that there are various actors with interdependent roles in agricultural systems (Schwilch et al., 2012a; Schwilch et al., 2012b), (ii) the integration of different knowledge systems, particularly local knowledge (Schiller et al., 2015; de Vente et al. 2017); and (iii) the acceptance that innovations occur at all levels and not only within research environments (Leeuwis, 2004).

This dissertation, focusing on Mozambique, aims to understand how promoters, extension workers, and farmers (or land managers) in this specific context learn about innovation, build knowledge, and utilize the knowledge to improve the diffusion and utilization of SLM practices. The study will contribute to the existing literature and provide insights into how stakeholders in rural settings in Africa create, disseminate, and utilize land management innovations and knowledge.

The promoters of SLM innovations in Mozambique are the organizations implementing the SLM research and development program and are actively involved in the diffusion of innovations. Extension agents work for public and private extension organizations that innovations communicate and transfer. Farmers (and land users) directly manage and benefit from land resources (ex., through agriculture, livestock production, and forestry activities).

Often, studies on adoption of SLM tend to focus on farmers adoption determinants, and few addresses other actors in the system. Understanding how these actors (farmers, promoters, researchers, and extension workers) interact in land management systems and

how promoters and extension agents work and support the diffusion of innovation in SLM is a gap in current research. Recent studies on innovation diffusion have broadened the understanding of diffusion determinants to include perspectives, views, and roles of organizations involved in developing and disseminating agricultural technologies (Schut et al., 2014; Schwilch, 2012b; Hermans et al., 2019).

Secondly, agricultural extension systems are crucial in the diffusion of innovations and are positively correlated with the adoption of agricultural technologies (Leeuwis, 2004; Davis & Heemskerk, 2012). Agriculture extension facilitates access to knowledge and innovations and communication and interactions in innovation systems (Anderson & Feder, 2007; Davis & Heemskerk, 2012), connecting the agricultural value chain actors.

Third and last, farmers (used interchangeably with land managers) are not just the primary users of land but also key stakeholders in the SLM process. They own knowledge and are interested in innovations and improving their soil conditions. They are often perceived as rational agents with profit maximization as a core determinant of their behavior. However, this assumption is challenged by the low adoption rates of SLM practices. Since the late 1990s, farmers have been recognized as having their belief systems driving their behaviors and influencing the decision to adopt SLM innovations (Barbero-Sierra et al., 2018). In addition, studies have proven that the farmers' belief system is valid and relevant (de Vente et al., 2017; Schut et al., 2014; Schwilch, 2012b). However, there is limited evidence first on how farmers use their knowledge to assess SLM innovations and, secondly, how an organization promoting SLM innovations integrates traditional knowledge when designing and implementing SLM programs.

1.1. Dissertation Research Framework

The dissertation research utilizes the Agricultural Innovation Systems Framework (Spielman & Davis, 2009). The Agricultural Innovation Systems (AIS) framework considers that innovations can occur outside the traditional research environment (Lundvall et al., 2002), and multiple actors in the system are involved and interact with each other to create, diffuse, and utilize the technology (Carlsson et al., 2002). The innovation systems framework addresses innovation as a dynamic, iterative, and interactive process that characterizes the diffusion of innovation. It recognizes that the system's actors adapt and adjust the innovation based on their knowledge, perceptions, context, and needs (Leeuwis, 2004).

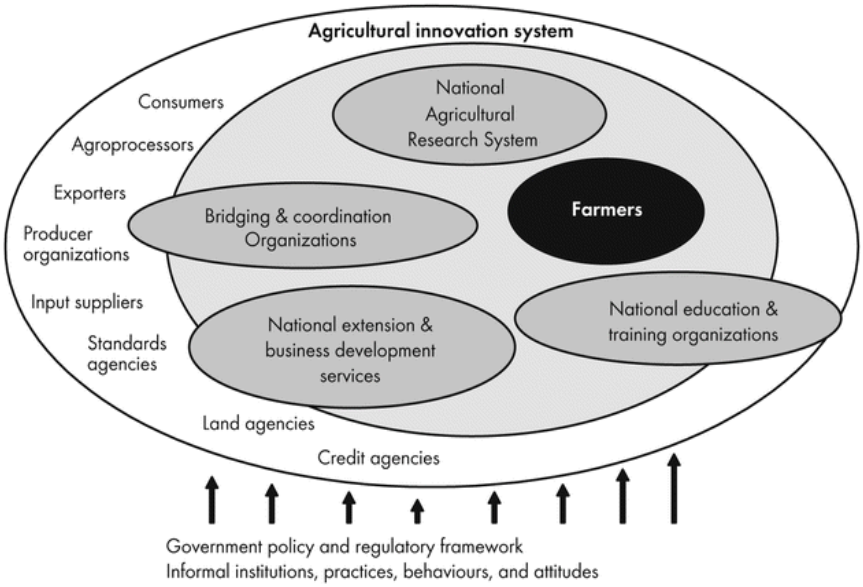

Figure 1. Agricultural Innovation Systems (Source: World Bank, 2006)

The creation, diffusion, and utilization of innovations are dynamic and interactive processes. Three elements define the system (Fig 1): (i) the actors (or agents) and their attributes, (ii) the relationship and interactions *between the actors, and* (iii) the institutions

and institutional arrangements shaping the interactions in the system (Lundvall, 2007; Spielman et al., 2009; Hall, 2007; World Bank, 2006). An important element of AIS is that through interactions, the actors in the systems engage in learning and can improve the systems processes.

Data was collected using a qualitative approach. Several research tools were used, including document analysis, participant observation, in-depth and semi-structured interviews, focus group discussions, and biophysical analysis of soil samples. The dissertation contains three papers, each focusing on a particular actor set.

The first paper, *"Learning in a multi-stakeholder environment: The case of sustainable land management in Mozambique,"* examines the learning processes among promoters of sustainable land management. The paper adds to the existing literature on learning in agricultural system innovations by examining how learning shapes innovation processes in organizations promoting SLM in Mozambique. It examines how they decide which innovations to promote, the roles that different actors play, and the factors that promote or hinder learning in organizations promoting sustainable land management. It addresses (1) learning and the factors that promote or hinder learning in land management, (2) interactions between land management actors in innovation and learning processes, and (3) how these factors influence the process of innovation in SLM. The study found that the nature of the organization will determine the learning strategies they adopt, and that learning is constrained by internal and external factors such as the internal organizational mechanisms for learning and the funding schemes. The research shows that while, in theory, organizations claim to actively interact and collaborate with each other, in practice, collaboration is minimal and often restricted to information sharing. Collaboration is

adversely affected by the funding schemes that force these organizations to compete (instead of collaborating) for funds, particularly when some are perceived as external with a limited understanding of the local context. Additionally, we do not find evidence of co-innovation and participatory innovation design with the participation of farmers. The actual setting of SLM in Mozambique is dominated by experts' perceptions of what works and what is necessary. Regardless of recent changes and calls for a demand-driven approach in agricultural technology development and diffusion, the paper shows that in Mozambique, the promotion of sustainable land management practices still needs to mimic a dogmatic and prescriptive approach, with researchers and development organizations defining the SLM priorities.

The second paper, *"Provision of sustainable land management extension and advisory services in Sussundenga: views and perceptions of the extension workers*," examines the learning process among extension workers in sustainable land management in Sussundenga, Mozambique. Data were collected in 2021 from 35 extension workers, 10 extension supervisors, and project managers. The study results show two major sustainable land management advisory providers and extension services: NGOs and public extension. All extension workers in the district have been involved in at least one program that promotes sustainable land management practices. The study results indicate that public and nongovernmental extension services have different approaches when promoting sustainable land management. Extension workers perceive that the limited collaboration and coordination between extension providers and research organizations and the limited participation of farmers in technology selection weaken the current sustainable land management advisory and extension services. The study's significant

contribution is to reveal the learning process among extensions in sustainable land management. The formal learning process, through instructional and on-the-job training, is perceived as the most important. The study further finds evidence that social and informal learning plays an essential role in the success of sustainable land management. However, limited opportunities and incentives to integrate this learning into broader sustainable land management advisory and extension systems limit informal learning among extension workers.

The third paper, *"Farmers' perceptions and knowledge of Sustainable Land Management Practices in Sussundenga, Mozambique,"* addresses the knowledge and perceptions of farmers about land conditions. The research uses structured interviews and analysis of soil samples to analyze how farmers respond to external interventions and the rationale behind their decisions about land management. The research finds that farmers use their systems to classify the soils, assess the soil conditions, and make management decisions. A significant finding of the study is that the farmer's soil condition assessment is often incompatible with the soil condition measured through soil analysis. Although farmers' parameters to assess soils provide valuable information, these are not accurate, and farmers often fail to include important parameters such as soil organic matter. Furthermore, the research shows that farmers acknowledge that the condition of soils is declining, and they are managing the soils to respond to the changes. Farmers often conflict with the need to increase production and take conservation measures. Farmers' immediate goal is to increase yields and secure household income. Farmers will prioritize land management practices that are more likely to increase production in the short term. Furthermore, organizations that promote sustainable land management are "pushing" for

practices aimed at soil conservation, but with only medium to long-term production effects.

1.2. Relevance of the Study

The dissertation finds a disconnect between promoters, extension providers, and farmers in sustainable land management. First, the dissertation finds that, while there is the claim of a paradigm shift to participatory, demand-driven approaches and inclusion of farmers' views in the design and dissemination of innovation in Susundenga, there is evidence that this is not the case. The approaches to SLM innovations are still top-down and donor-centered. Second, the study identified learning opportunities and found evidence that promoters and extension workers are learning at an individual level. However, they face constraints in integrating the learning into the broader institutional level. Third and last, the study confirms that farmers have knowledge and built a belief system on land management. Farmers often analyze the alignment of new information with their belief systems when receiving new information and making land management decisions. The study did not find evidence that farmers' experiences and knowledge are considered beyond establishing demonstration plots.

Despite the constraints in innovation systems, research finds opportunities to improve the system. The three stakeholder groups share the same purpose of improving farmers' livelihoods. Promoters, extension workers, and farmers agree that soil fertility is important in achieving food security but differ on areas to prioritize when managing the land for food security. To reach the potential of SLM interventions, decision makers and organizations that promote them should: (i) understand farmers' belief systems and local context and site-specific agroecological conditions, and distribute technologies that fit the

local context using approaches that respond to farmers' belief system on land management; and (ii) incorporate mechanisms of reflection and learning from experiences to change institutional processes, allowing them to move from a short-term project cycle perspective to a long-term and holistic intervention in sustainable land management. This requires a shift in the current funding mechanism, including funding for extension systems, in particular funds for public extension services, incentives to collaboration across organizations and the shifting roles, and inclusion of a coordination role. It also requires building the capacity of local organizations and farmers to engage them in decision-making. It also requires building the capacity of locally based organizations and farmers to engage them in decision-making.

1.3. The Study Area

The study was carried out in Sussundenga District in Manica Province, Mozambique. The district is described as one of the country's most important agricultural development corridors and has a long history of land management and soil health programs. The district's history with land management and soil health programs provided the conditions to use a case study in which it is possible first to understand farmers' perceptions, behaviors, and construction of knowledge and secondly to explore the main findings from essays one and two focusing on promoting organizations and extension workers, respectively.

Sussundenga district (Fig.2) is located in Central Mozambique. The district has two major seasons: the dry season from May to September and the rainy season from October to April (also the hot season with high humidity). The agricultural systems are primarily rainfed. Annual rainfall varies between 800 and 1000 mm. The predominant land use types

are agriculture, forest planting, and natural vegetation. Agriculture remains the primary livelihood strategy in the district, and data from the 2015 Agricultural Census (INE, 2015) show that in the Sussundenga district, there are approximately 194 000 smallholder farms, mostly considered subsistence farmers.

Several research and development organizations have widely promoted sustainable land management practices in Sussundenga and elsewhere in Manica province. Examples of interventions in the district with an SLM focus include SIMLESA (https://simlesa.cimmyt.org/), PROMAC (https://ncbaclusa.coop/project/mozambique-conservation-agriculture-promotion-promac-ii/), Feed the Future RAMA-BC (resilient agriculture market activities –(https://ncbaclusa.coop/project/mozambique-feed-the-future-resilient-agriculture-market-activities-beira-corridor-rama-bc/)

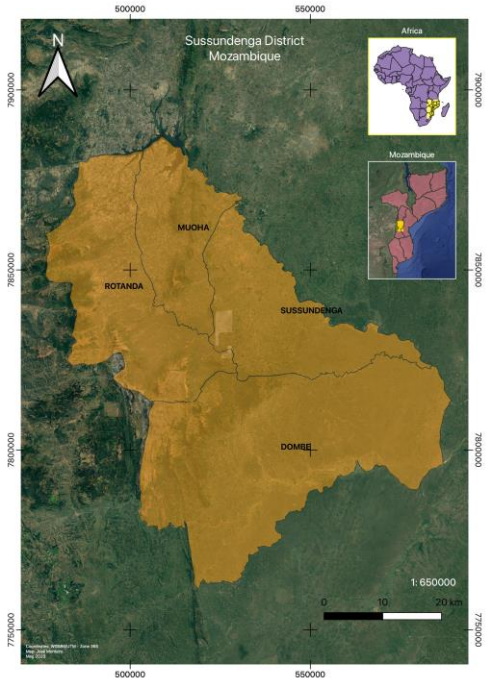

Figure 2. Sussundenga District (image created by José Monteiro)

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CHAPTER II

LEARNING IN A MULTI-STAKEHOLDER ENVIRONMENT: THE CASE OF SUSTAINABLE LAND MANAGEMENT IN MOZAMBIQUE

Abstract

Sustainable land management (SLM) practices have been widely promoted in sub-Saharan Africa as a tool for the sustainable intensification of agricultural systems. Innovation and learning are important in the promotion of SLM to find management practices that are effective and doable for farmers. The study used in-depth interviews and participant observation and discusses learning processes and approaches in SLM, addressing (1) factors that promote or hinder learning in land management, (2) how these factors influence the process of innovation, and (3) the interactions between land management actors in the innovation and learning processes in SLM. The study finds that the type and nature of the organization (international vs. national NGO, community-based, or public institutions) determine the learning strategies they adopt, and that learning is constrained by internal and external factors such as the internal mechanisms for learning and the security of access to funding. We find minimum interactions between organizations that could learn from each other and between organizations and the farmers they work with. Additionally, there is limited evidence of co-innovation and participatory innovation design with farmers. The actual setting of SLM in Mozambique is dominated by experts' perceptions of what works and what is necessary.

Keywords: agricultural technology adoption, agricultural innovation systems, conservation agriculture, integrated soil fertility management, sub-Saharan Africa

2.1. Introduction

Land degradation has damaged sub-Saharan African agricultural systems and jeopardized millions of rural livelihoods (Vanlauwe et al., 2015; van Ittersum et al., 2016). Research and development organizations have responded with innovations in sustainable land management (SLM), including conservation agriculture, integrated soil fertility management, and agroforestry (FAO, 2016; Liniger et al., 2011; Schwilch et al., 2012). The success and sustainability of SLM programs have been questioned due to the low adoption of SLM innovations (Giller, 2009; Andersson & DeSouza, 2014; Knowler & Bradshaw, 2007). Even where adoption has been documented, it is often observed to be short-lived, occurred during the SLM program's lifecycle, and ended afterward (Giller et al., 2009; Anderson & D'Souza, 2014; Emerson & Snyder, 2018).

Slow adoption of SLM practices has led a body of research to understand the determinants of adoption (Anderson & D'Souza, 2014; Knowler & Bradshaw, 2007) while questioning the linear approach to the diffusion of innovations (Spielman et al., 2009; Leeuwis 2004). In the last two decades, researchers have used the concept of agricultural innovation systems and have broadened the understanding of the diffusion of innovations, including the perspectives, views, and roles of organizations that form an innovation system (Schut et al., 2014; Schwilch, 2012; Hermans et al., 2019); the interactions across organizations; and learning processes factors operating within the system in natural resource management, agriculture, and food systems (Leeuwis, 2004; Klerkx et al., 2012; Kilelu et al., 2013; Schwilch et al. et al., 2012; van Mierlo et al., 2013).

The growing literature on learning in agricultural innovation systems draws most evidence from European (van Mierlo et al., 2013; Fieldsend et al., 2021) and Latin American

(d'Angelo & Brunstein, 2014) contexts. Evidence from the African context is emerging, with some studies documenting innovation platforms (Kilelu et al., 2013) and mapping the interactions between organizations in national innovation systems (Yongabo & Göktepe-Hulté, 2021; Spielman & von Grebmer, 2006). This article adds to the existing literature on learning in agricultural systems innovations by examining how learning shapes innovation processes in organizations promoting SLM in Mozambique. It examines the role of the promoters and how they make decisions about which innovations to promote, the roles that different actors play, and the factors that promote or hinder an organization's learning in land management.

2.1.1. Conceptual Framework

This study uses agricultural innovation systems (AIS) as an analytical framework (Spielman et al., 2009; Schut et al., 2015). AIS recognizes that the creation and diffusion of innovation are dynamic, iterative, and interactive processes in which the system's actors adapt and adjust the innovation to fit their context. The adaptations are based on the actors' knowledge, perceptions, context, and needs (Leeuwis, 2004); they can occur outside the traditional research environment (Carlsson et al., 2002; Lundvall et al., 2002).

Hall & Janssen (2006) defined an innovation system as *"a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect the way different agents interact, share, access, exchange, and use knowledge."* (p 18). The innovation can be developed, tested, used elsewhere, and transferred to a specific context. The core of an innovation system is the array of actors (individuals and organizations) interacting with each other, and how these interactions are governed by existing

institutions (Carlsson et al., 2002; Hall & Janssen, 2006; Klerkx et al., 2012). During interactions, actors learn and act to change the components of the system (e.g., institutional changes) to build effective and sustainable innovation systems.

The actors and roles in an innovation system

Actors are the core of innovation systems, and a pluralistic organizational environment characterizes agricultural innovation systems. Often, in sub-Saharan African countries, the actors actively involved in agricultural development are research organizations, extension services, nongovernmental organizations, and farmers' groups (Spielman et al., 2006). Input companies and traders are also part of the value chain but are often not involved in decision-making. The nature and number of actors in the AIS vary according to the level (local, regional, or national), the technological innovation (e.g., land management, irrigation, or improved seeds), and the existing institutional framework supporting agricultural innovations.

Carlsson et al. (2002) distinguish the actors into two categories: individuals (e.g., farmers, extensionists, or researchers) and organizations (e.g., research centers, government entities, or NGOs). The actors in the system participate in a process in which they *"co-generate knowledge, processes, and innovation*" (Hall et al., 2006), and their participation is determined by their roles, experiences, perceptions, and knowledge (Lundvall et al., 2002). Furthermore, Leeuwis (2004) and Klerkx et al. (2010) argue that the actors are neither static nor independent but active, dynamic, and interdependent agents with their perceptions about innovation, adapting it to respond to their needs. Any change in the system needs to acknowledge the interactive and dynamic decision-making process among all the actors (Emerson & Snyder, 2018; Klerkx et al., 2010).

In a pluralistic environment, with different providers of extension services, the involvement and engagement of actors are likely the factors contributing most to the success of innovation systems (Schwilch et al., 2012). Actors play different roles (innovators, brokers, traders), which are not static but somewhat influenced by local conditions and existing institutions, which can vary significantly from country to country (Ortiz et al. (2013).

Relationships and Interactions in the System

The relationships and degrees of interaction among the actors in the system determine its effectiveness and performance (Lundvall et al. (2002). The interactions strengthen social capital (Carlsson et al., 2002) and ultimately foster social learning (Lundvall, 2007; Carlsson et al., 2002; Leeuwis, 2004), leading to more innovative and sustainable innovation systems. Several factors determine these relationships and their interactions, including the types of organizations, their roles, the location of the organizations (e.g., external versus local organizations, community-based organizations, or NGOs), and the time operating in the system. Depending on the institutional context, actors can have various relationships, including collaborative, competing, conflicting, or complementary relationships (Hounkonnou et al., 2012). The degree of interaction varies. In more innovative systems, interactions are more frequent and robust, often creating synergies, networks, and communities of practice.

Recent agricultural research and development trends have focused on creating synergies between organizations and establishing a more collaborative environment. The promotion of agricultural innovation platforms (Schut et al., 2015; Schut et al., 2016; Kilelu

et al., 2013) is an example of a networking platform that aims to strengthen relationships and foster learning in agricultural development.

Learning in Innovation Systems

The fundamental element in innovation systems is the capacity to learn and use the learning to act and introduce the changes into the system (Klerkx et al., 2012; van Mierlo et al., 2010; Lundvall, 2016). There are different concepts of learning (social learning and interactive learning), different types of learning (formal vs. informal), and different sources of knowledge (scientific vs. traditional), and the effectiveness of innovation systems lies in their capacity to integrate these differences into the system (Hall & Janssen, 2006).

In this paper, social learning (Reed et al., 2010) is used interchangeably with interactive learning (Lundvall, 2002; Lundvall, 2016; Klerkx et al., 2010). This paper combines the work of Leeuwis (2006), Muro & Jeffrey (2008), Reed et al., 2010 and van Mierlo (2010) and defines *social learning* as a process in which repeated exposure and observation of behaviors and practices lead individuals and organizations to change behaviors, attitudes, procedures, and processes. Although there is a vast literature on organizational learning, its application to agricultural development is still emerging. Van Mierlo et al. (2010) propose a framework for understanding organizational learning in agricultural innovation systems. They define the key elements as the needs or drivers of learning and the condition and level of learning.

First, individuals and organizations have reasons to learn, and learning is driven by internal factors *(aspirations, identities, capacities) and external factors (opportunities, incentives, and threats or barriers)* that drive the learning process. Second, there are two levels of learning: individual and organizational. Individual-level learning refers to learning

among individual actors in the system (e.g., farmers, researchers, and practitioners of extension). Individual learning occurs through daily and past experiences and interactions with others or through educational and training programs. Individual learning and knowledge creation are socially situated (Leeuwis, 2004), and one's experiences shape it. Each experience is different and used in different ways.

The second level of learning is organizational (Lundvall, 2016), and it results from feedback from other organizations, the external environment, clients, beneficiaries, and the organization's experience. An essential distinction in organizational learning is the type of learning: single-loop and dual-loop (Muro & Jeffrey, 2008; van Mierlo et al., 2010). Single-loop learning describes a process in which individuals and organizations receive feedback from the external environment, using the information to change a particular aspect of their activities without significant changes in the individual or organization's goals, practices, or policies (Argyris, 1977). In dual-loop learning, organizations use the information to reflect, correct, and adapt programs and organizational policies and practices (Argyris, 1977). Dual loop learning results in long-term and systemic changes in the organization's practices, processes, and, ultimately, its policies.

Sustainable Land Management and Innovation Systems

The World Bank (2008, p. 5) defines SLM as *"a knowledge-based procedure that helps integrate land, water, biodiversity, and environmental management (including input and output externalities) to meet rising food and fiber demands while sustaining ecosystem services and livelihoods."* SLM is an iterative and interactive system, with different actors interacting to (co-) create and share knowledge (Klerkx et al., 2010). It is intended to be centered on people and shaped by multiple knowledge systems (Liniger et al., 2017; FAO,

2016), embodying the integration and balance of scientific and local knowledge (Liniger et al., 2011; FAO, 2016). Branca et al. (2013) present evidence that the local conditions (e.x. agroecological conditions, rainfall, vegetation) affected the success of SLM practices, thus confirming the need to co-design or co-create innovation in SLM.

Liniger et al. (2004) argued that SLM programs often fail to function as systems, fail to acknowledge the different knowledge systems and fail to address local context and local needs. This happens when organizations responsible for implementing SLM are biased, lack a comprehensive understanding of local conditions, do not learn and use the experiences to design new interventions, and attempt to introduce one-size-fits-all approaches.

2.2. Methods

This research used a qualitative approach (Patton, 2015) to explore the perceptions and learning behaviors of different actors from different actors in SLM. Qualitative data provide an insider's perspective, understanding, and the meaning of the processes leading to SLM learning.

A purposive sampling was used to identify and select the interviewees (Patton, 2015). The focus is on the organizations implementing SLM promotion projects, including research organizations, NGOs, farmer-based organizations, and the public sector. First, individuals with knowledge and experience in land management in Sussundenga were identified. Seven organizations with active projects were identified using the combination of these individuals' knowledge and the Conservation Agriculture Platform database. Second, individuals in the identified organizations were interviewed, and they helped identify other respondents in those organizations. The criteria selection criteria included

experience in sustainable land management programs (more than five years), being in a senior position, having been involved or participating in at least one program in the Sussundenga District. This approach yielded 22 respondents across the seven organizations (Table 1).

Table 1. Description of study participants

Type of Organization	Role and/or position of the interviewee
Research organizations	2 senior researchers, 3 junior and middle researchers
Farmers Based Organization	1 senior manager and 1 field outreach officer
Project-based organization	1 project director, 1 project manager, and 1 monitoring and evaluation officer
Non-Governmental Organizations	4 program directors, 2 field supervisors, 3 technical specialists
Public Sector	3 senior officers

The study identified two types of NGOs based on how they operate. The first type is project-based NGOs, which are organizations established to implement a program or project, often representing international NGOs or consortiums of organizations implementing the project. They exist only during the project lifecycle or the duration of that program. The second type is an NGO with a fixed structure and running multiple projects or programs. These organizations have formal structures and internal management procedures that move beyond a project management system.

To maintain the confidentiality of the organizations and sources of information, the results section does not include identifiers, including the specific names of SLM practices, extension methods, and respondents' job titles. Instead, it lists them by organization type and job category, as per Table 1.

Data were collected using in-depth interviews conducted in Portuguese, supported by analysis of documents from the organizations studied. The interviews aimed to capture

and explore participants' experiences and perceptions (Patton, 2015; Rubin & Rubin, 2012) of how they learn and use what they learn to improve their own approaches and guide interactions with stakeholders in SLM.

A question guide was developed and structured to capture participants' experiences and perceptions about SLM, their approaches to working with other actors in the system, and how they learn and create knowledge. Due to COVID-19 restrictions, a combination of phone, internet-based, and in-person interviews (Patton, 2015; Rubin & Rubin, 2012) was used.

The documental analysis provided information on the context in which the programs and projects were designed, such as policies that inform the implementation of the SLM programs. Additionally, the analysis of program activity reports provided information on each organization's implementation approach and stakeholder engagement strategy. The documental analysis included documents provided by the organization for the study. The documents used included project proposals, progress reports, and evaluation reports; organizational structure documents, fact sheets, videos, and newsletters; and national policies, programs, and regulations.

Qualitative data analysis followed established principles (Miles & Huberman, 1994; Saldaña, 2013). It begins during data collection, with initial steps to review and summarize the data. After fieldwork, the researcher analyzes interview transcripts to identify emergent themes, define codes, and develop the codebook. This study used a codebook structure with four elements: the name of the code, a short description of the code, the rules to apply the code, and examples of the codes. The codes were grouped into categories and emergent themes, with illustrative quotes selected.

2.3. Results

The result section first maps the stakeholders involved in SLM in Mozambique, their roles, and how they influence the SLM systems. Second, it describes the process for technology selection and how decisions about it are made. Third, it documents the interactions and relationships among actors in the system. Lastly, it explores how organizations and individuals learn, how actors' roles and relationships, and the process they follow for technology selection influence their ability to learn within this system.

2.3.1. The actors and their roles and participation in SLM

Reed et al. (2010) proposes criteria to categorize the stakeholders: their level of interest and influence, who is affected, and how they are affected. Minh (2019) distinguishes four groups of actors: the state (local and central agencies), research organizations, extension services (public and private), and value chain actors. In this study, actors include individuals or organizations directly involved in at least one phase of innovation design, communication, and diffusion. They are interested in and can affect or influence the SLM innovation system. On the other hand, the study excluded secondary actors who facilitate processes but are not directly involved or affected by decision-making. Examples include input suppliers, service providers (e.g., soil analysis, educational and training institutes, traders, market agents), and financing institutions. We do not discuss secondary actors further.

Table 2 summarizes the roles of different actors according to the respondent's responses and places the findings into two categories: 1) the *"official roles"* of different actors as perceived by the respondents and 2) the *"actual roles in practice"* of different

actors according to respondents' perceptions and experiences on how programs operate. We call these the roles in principle and the roles in practice.

The key findings of the table are as follows. Donors are the most powerful and influential players, setting the agenda for implementing SLM and influencing policy because they are the funding source. International NGOs are the main actors (on the ground) promoting SLM as they are flooded with donor funds. They are the immediate source of funding for many national and local NGOs and play a role in establishing national priorities around SLM promotion. In addition to their work in developing and identifying suitable SLM technologies, research organizations tend to be involved in promoting the adoption of SLM with donor funding.

Central government ministries are responsible for setting the SLM agenda and policies and coordinating the work of all organizations involved in promoting SLM. In practice, they are aware of all ongoing activities but have limited influence on what happens in the field. In some cases, government agencies receive funds from donors to implement their SLM projects in competition with international NGOs. Local government offices, which are supposed to coordinate the work of all actors operating in their jurisdiction, tend to be in the dark regarding plans put forth from above, and they are poorly funded and depend on the very donor funded SLM projects they are supposed to oversee. This puts them in an untenable situation.

Public extension is seen as a potentially important actor in the SLM innovation process, as it is represented throughout the country without being tied to a project cycle. In practice, however, due to funding constraints, the work of public extension is often linked to project funding that provides operational funds enabling extension workers to do their

work. Finally, despite the rhetoric that farmers are treated as heterogeneous with different needs and conditions, SLM programs appear to treat them uniformly, as if the same SLM technology package is suitable for all farmers. Farmers are purely on the receiving end of the innovation process and have no active role. Farmer organizations could be important in representing farmers' interests and negotiating with other interest groups. However, their financial dependence on other actors (donors, NGOs, and research organizations) leaves them with little influence on the system.

Table 2. Official and actual roles of different actors in the system according to respondents.

Actor in the SLM Innovation System	**Level**	**Characteristics and Roles of Aspects in the Innovation System**	
		Official roles (in principle) as stated by respondents	**Actual roles (in practice) as observed by respondents**
Farmers	Local	- Landowner and Manager - Heterogeneous group working in different conditions and contexts - Co-design SLM innovations	- Recipient and adopter of introduced innovations - Limited participation in the co-design process - Often consulted or informed about technology - Transcribed as a homogeneous group.
Government Organizations	Central	- Develop and monitor policy implementation - Coordinate SLM programs - Oversee agricultural development in Mozambique - Set priorities and policies for agricultural development - Monitor the work of organizations conducting agricultural research and development - Approve the work of international NGOs and monitor donor investments in the country	- Set priorities and policies for agricultural development - Develop and implement SLM programs - competing with NGOs - Aware of the work of international NGOs
	Province/District	- Coordinate all field interventions and monitor project results and impacts in target communities	- Unaware or limited participation in the work of NGOs - Financially constrained and dependent on NGO funds to carry out some activities

Table 2. (cont'd)

Public Extension	Extension and Advisory Services	- Provide technical assistance and advisory services to farmers. - Connect stakeholders in the agricultural value chain	- Similar to the official roles, - Limited capacity to assist farmers
Non-Governmental Organization	International with country representation	- Promote and transfer SLM innovations - Conducts action research on SLM - Facilitate institutional reforms	- Similar to the official roles, - Set the country's SLM agenda - Funding source for some national and local NGOs
	National Organization	- Promote and transfer SLM innovations	- Promote and transfer SLM innovations
Farmer-based organization	National/Province	- Promote and transfer SLM innovations - Linkage between farmers, policy makers, research and development organizations	- Sometimes acts as a NGO and competes with the local NGO - Financial dependence reduces their ability to influence the system
Research Organization	National/Province	- Research and identify technologies suitable for the different agroecological contexts - Coordinate agricultural research and establish a national database used by different stakeholders	- Similar to the official - Promotion and transfer of technology
Donor	International	- Source of funding for SLM interventions	- Fund SLM interventions - Set the SLM agenda - Supports or influences policy making on SLM

2.3.2. Selection of SLM Practices

All respondents agree that managing soil health and fertility is the key to sustainable agriculture and food security in Mozambique. As a result, all organizations have introduced SLM practices in their approaches. Some organizations focus primarily on increasing yields and transforming smallholder farmers into commercial farmers, addressing soil fertility as an important agronomic requirement for sustainable production. Others take integrated soil fertility management as their main goal.

Sources of Innovation

From the interviews, we can distinguish two primary sources of innovation. The first source is from local research experiments and trials, and this source is predominant in research organizations.

> *"We conduct on-farm and on-station trials, and our goal is to find the best combination of inputs that will increase yields and improve soil health." (R1, researcher)*

The second source is innovations from other contexts (often other regions, countries, and international research organizations) and the replication of innovations that have worked in different locations. Organizations often learn about innovation through exchange visits, research papers, and their network. This type of source is predominant in non-governmental organizations:

> *"We visited Zambia, and we saw that conservation agriculture, especially the use of rippers and permanent pits, produced good results, and we decided to introduce the same technologies in Mozambique."* (R6, NGO)

These two forms are not exclusive, and an organization can engage in both. In all organizations represented in this study (government, research, NGO, farmers-based organizations), the innovation was developed outside the implementation area or imported from another context. There is limited evidence that the final users of beneficiaries have participated in designing or selecting the innovation. The respondents agreed that farmers are involved after the program is designed and approved. Farmers are then informed about the *"new development project"* in their communities. The limited involvement of farmers in innovation can have an adverse impact on the adoption of innovations, as discussed below.

Some respondents suggested that opportunities for innovation were limited due to the need to adhere to static donor requirements. As one respondent from a research organization said, they must implement the donors' research agenda even if they have other ideas about how to innovate:

> *"They [the donor] are the ones advocating for the technology X and using the diffusion method Y. So, if you want to access their funds, you need to continue the research on that specific technology and use the approach they suggest. Otherwise, you will not get the funds."* (R11, Research organization)

As one of the researchers mentioned, *"Once the funds are over, we end the program, and we return to our own research agenda."*

Selection of the Technology

Interviews revealed two dominant modes for selecting specific SLM practices to promote. In the first mode of selection, there is limited participation or involvement of final users (i.e., farmers); the promoter organization selects the innovation packages and promotes them across the communities where they work. In this mode of selection, there is

pressure to show that the technology works, thus determining the nature of the relationship with other stakeholders and the learning process, as we show later in the section. In this mode of technology selection, promoters are oriented externally, either to the donor or to regional and international research groups, to focus on specific practices or approaches to land management.

The second mode of selection is a hybrid model. In this case, the organization identifies a set of innovation packages to test with the farmers. Throughout research trials and interactions with farmers, researchers and farmers decide together which technological package best addresses perceived needs. In this case, the researcher works with the farmers to test, select, and decide on the technology to be promoted and scaled beyond the research trials.

2.3.3. Interaction and coordination among actors in the system

Interaction that enables information exchange is a key element of learning in innovation systems. This section explores how organizations working in SLM interact and coordinate their activities. The results are organized around each group of actors (promoters and researchers), exploring the current perceived practices and expectations.

The Current Interaction and Coordination Environment

The respondents acknowledge that they are in contact with and constantly interact with other actors in the system, both formally and informally. The exception is the farmers, who interact in specific moments, often determined by the organization leading the program. Formal interactions are institutionalized and are often determined by existing protocols, agreements, or guidelines established by the government. Because most projects are funded by foreign donor organizations, existing government protocols for foreign

investment have led to regular interaction between government institutions, research and development organizations, and donors.

Organizations implementing SLM and other development programs are required to report their activities to local, provincial, and central governments. Reporting requirements include information on technology, target regions, and people or communities reached. In addition to the existing reporting mechanisms, promoters, researchers, and public institutions include other formal opportunities in their working plans to bring together other organizations, present the results, and discuss their activities together. Examples of events include field days, planning workshops, annual reviews, and planning meetings.

> *"At the end of each cropping season, we organize a field day. We invite farmers, organizations, academic institutions, and government officials. They have an opportunity to see the results of our technologies. We show the different technologies and validate the effectiveness of our technologies with farmers. They can see and compare the results from our demonstration plots."* (R11, research)

These events often are an opportunity for organizations to share the results of their activities, discuss and sometimes agree on future interventions, or align their interventions. Respondents also reported that the major players are trying to institutionalize such events into a community of practice.

> *"Since 2006, we have been trying to establish a national forum or national platform and have asked the Ministry of Agriculture to champion it (...) We tried to operationalize the National Conservation Agriculture Platform*." (R11, research)

While formal interactions are seen as platforms to share information and showcase interventions, informal interactions are strategic and intentional. Informal interaction is

important, and often, people working in SLM use it as the primary source for learning and adapting at the individual level. Individuals' needs and networking experiences often determine informal interactions. Most of the respondents rely on informal interactions to inform their activities and even access technologies or resources.

> *"In our project, we have a component of soil health, but I do not have experience in soil health. But I know [the name of the person of contact], he has been working with extension and conservation agriculture for many years, and I often reach out to him for advice."* (R8, farmer-based organization*)*

First, interaction occurs as a source of knowledge. Respondents acknowledge that they often seek their peers or individuals recognized as leaders in SLM. They share information and expertise and seek advice about technologies or practices: *"We adapted the protocols for CA trials, and several organizations have reached out to access [our] protocol or to ask for guidance on establishing CA trials"*. (R11, research). Second, informal interaction occurs to build synergistic effects among organizations. Individuals and organizations often interact to combine efforts and maximize individual interventions, with the expectation of sharing or reducing the costs by reducing duplication of activities. Furthermore, the interactions occur to help institutions to fill in the gaps or support activities considered relevant but not funded within their programs. For example, an individual can link his own land management program to a market development program:

> *"We do not have a component of markets in our projects, but we know that access to markets is important. I talked with [name of the organization] to see if they could expand their program to our communities or at least train one of our lead farmers*." (R9, farmer-based organization)

Third and last, interactions can facilitate access to technologies or resources.

> *“For example, we need to use prostrate cowpea varieties in our CA demonstration [as defined in the project demonstration plots protocol]. We do not have these varieties, and we do not have the resources to buy them. Usually, I ask [name of the person] from [name of the organization] and he will give us the seeds we need*.” (R8, farmer-based organization)

While these interactions allow them to exchange information and resources, from the quote above, there is the inference that there are often limited opportunities to adjust the innovation to the local context. Organizations perceive that they must be bound to the agreements they established when receiving the funds ("*we need to use prostrate cowpea").* They spend the resources to comply with this requirement and do not negotiate the possibility of changes and adjust to local conditions. The interactions and coordination in the SLM system are still weak. Most interactions between formal organizations (projects, research, extension, and government) are mainly to fulfill donors' requests. However, organizations are aware that they need to interact and work to establish communities of practice, such as the Conservation Agriculture Regional Networks.

Policy and Regulatory Framework in Sustainable Land Management

The respondents acknowledge that Mozambique's regulatory framework for SLM is weak. Policies are often outdated, non-existent, or not used for decision-making purposes. Respondents reported that there are no specific regulations or policies addressing SLM.

> *"It is difficult to accept that after more than two decades of working with CA [conservation agriculture], we still do not have a specific policy for CA. Only now is the government working on a law on fertilizer, but companies are producing and importing fertilizers"* (R20, research).

Furthermore, even if the policies are in place, implementation problems emerge. Lack of awareness and problems in interpreting policies limit the effectiveness and sustainability of SLM programs.

International donors often fund research and development programs, and these organizations must comply with donor policies and regulations. The views on donors' influence on program design and implementation vary. Some respondents argue that donors are rigid and have little room for change, limiting the capacity to learn and adapt to a funded project. Other respondents say that donors have changed and are now more open to learning from field experiences and adapting to the context, but it is not always easy since "They *are the donors, and they want to see the results."* (R11, research).

In addition, the respondents claim that there is no adequate feedback and accountability mechanisms. They reported experiences where organizations have negatively impacted communities. They worked in communities by introducing technologies that were not suitable for them or having exit strategies that did not address the community's needs.

> *We expect that the government will monitor the work of development organizations and, if necessary, introduce corrective actions. However, sometimes we are surprised to see what our sister organizations are doing in the field.* (Field Supervisor, NGO)

Respondents asserted that the government should be responsible for policy design and development, monitoring implementation, and overseeing the coordination among SLM stakeholders.

2.3.4. Social Learning

Interaction with the other actors provides opportunities to understand what others are doing and how they are performing and to identify similar areas of interest, strengths, and weaknesses.

The respondents identified three sources of information that enable learning. First, respondents identified research organizations as the primary source of technical knowledge. Secondly, the respondents identified NGOs and other local development organizations as sources of information and learning. Thirdly, the farmers. The respondents have different views on how they can learn from farmers. Some promoters believe that there is little they can learn from farmers: *"They are farmers; what can we learn from them?* (R2, research) From this perspective, there is the underlying assumption that only "trustable and valid" sources can be used as sources of learning and only organizations or individuals with "authority" in the field can provide moments or opportunities for learning.

In contrast, other respondents believe that continuous interactions with farmers are a source of knowledge and learning they use to change or adapt research and outreach activities. Through interactions with farmers, they believe they can improve protocols, adapt the technologies to the local context, and inform future interventions.

> *"We have seen that some communities we worked in use ridges, which provide a protective measure during floods. So, we have changed our approaches, and we are promoting the use of ridges in other areas with similar characteristics*." (R6, NGO)
>
> *"We have farmers' feedback meeting, and during the meeting, we discuss the previous cropping season and major lessons. Based on*

> *farmers' feedback, we adapted the field protocols. For instance, in one community, we found that mulching was not viable, and we looked for other practices to keep the soil covered in places where mulch is not viable."* (R11, research)

Interviews revealed that often learning occurs at the individual level. During repeated interactions, some organizations introduce changes at the organizational level, changing the organizational structure and planning to incorporate the learning outcomes and improve organizational performance. *"We have learned a lot from our experiences in the field, and our current strategic plan reflects what we have learned*…" (R10, NGO).

Interview data also suggest that learning is not a "natural" process arising from the interactions. There are institutional incentives and barriers to learning. Promoters find that learning will improve the existing organizational practices. However, effective collaboration and mutual learning are limited because the organizations still work in silos, compete for funds, and are conscious of power relationships among them. For example, field visits revealed that respondents from different organizations viewed the work of competing organizations working in the same area as inferior. They did not trust those organizations as a potential source of learning.

Moreover, because most funding schemes have a 3–5-year duration and specific targets, organizations focus more on reaching targets and less on learning to understand, adapt, and change their processes.

> *"We will do what they [donor] want. Otherwise, we will not have access to the funds. We need to speak their [donor] language, but once the funds and the project end, we move to the next project* [and/or donor], *or we continue with the previous practices* [before the project]. "(R13, research)

There are incentives to learn, and the respondents agreed that donors are the ones who provide incentives to learn. Since most SLM programs have three to five years of lifecycle, project implementers face two scenarios. In the first one, the new project aligns with their past experiences, and they design the project based on knowledge and learning from their previous experience to inform and improve their future work:

> *"We are implementing phase two of the project. In the first phase, we realized that farmers did not preserve mulch in the soils; in the second phase, we introduce cover crops".* (R6, NGO)

In the second scenario, the promoters apply for a specific call with pre-determined technologies or approaches, and it interrupts the learning cycle they were involved or engaged in previously:

> *"We apply to different funds; some donors accept that we use the grant to fund our activities. Other times, they do not accept it; they want a new project. In this case, we interrupt our normal programs or activities, but once the funds and the project are over, we move to the next project [and donor], or we continue with the previous practices [before the project]."* (R6, research)

This implies that the SLM project approach can either promote learning when the practices and knowledge are integrated into the promoter's agenda or can interrupt learning cycles by temporarily shifting the focus to the donors' needs. From this perspective, learning is a complex process. Learning can take different forms depending on the nature of the organizations, the personal attributes of the individuals leading the implementation of the SLM program, and the nature of relationships in the system. Learning may focus on acting on immediate concerns (e.g., crop selection, change of extension messages) or long-term and institutional changes (e.g., farmer engagement

protocols), where organizations will focus on the transformation of their approach and introduce systematic changes in the organization structure:

> *"We have introduced vulnerability assessment in all our programs…. in the vulnerability assessment, they [the farmers] are the only ones who can tell us what the impacts have been with respect to their livelihoods."* (Technical Specialist, NGO)

2.4. Discussion

In this study, we have examined how actors in SLM promotion learn and how they make decisions about innovation. The literature points out that there is a process of co-creation and co-learning in agricultural innovation systems resulting from constant interaction and collaboration among actors (Leeuwis, 2004 & Spielman, 2005). In addition, the literature also mentions that interactions and collaborations will ultimately determine how organizations and individuals learn in innovation systems (Klerkx et al, 2010; Speilman, 2009; Leeuwis, 2004). However, this research showed that the actors in the system have distinct and sometimes conflicting roles, which shape interaction and collaboration. Moreover, the actors who are considered most important (i.e., farmers) are often passive.

The discussion section will unfold the three points raised above: actors' participation, interaction and collaboration, and factors shaping learning regarding SLM in Mozambique.

2.4.1. The actors and participation in SLM

Organizations promoting SLM in Mozambique have myriad and sometimes competing roles. The roles are not permanent or fixed, and different institutions will play

different roles at different moments in the innovation systems (Bouwen & Taillieu, 2004). The actors in the system are consistent with Herman et al. (2013) and Spielman et al. (2006) categories of actors in the agricultural innovation system: research, government, non-governmental organizations, and farmers. Furthermore, the roles are similar to those played in Malawi's Conservation Agriculture System (Chinseu et al., 2022). They are explained by the categories of actors in innovation systems proposed by Herman et al. (2013): innovation brokers, institutional entrepreneurs, and knowledge creators.

Due to the competing roles and a weak collaborating and coordinating environment, we find "fragmented diversity" (Garforth et al., 2003). Multiple organizations often work in the same areas, with the same community or group of farmers, and often on similar technologies or innovations. The competing nature of the SLM organizations leads to a scenario characterized by misinformation, mistrust, and duplication of activities.

The role of farmers and donors in the SLM innovation systems is important. Schwilch et al. (2012) showed that farmers are key actors and that interactive systems where farmers are more active and participate in the discussion and co-design of technologies are more likely to produce effective and sustainable changes. Moreover, van Mierlo et al. (2013) showed that farmers often drive the SLM innovation systems. Contrary to this literature, we found that while farmers are involved in the system, they tend to be treated as passive recipients of technology, with limited or no participation in the selection and design of the innovation. The existing approaches to innovation design and selection are limited to and often led by research and development organizations.

The study showed that farmers are often treated as technology up-takers with a limited voice in co-designing and selecting the technology. Often, the identification of soil

problems and the need to innovate is determined by research and development organizations, which then develop a technological package intended to address the soil problem and support farmers' cropping systems. Despite the evidence that farmers' participation in all levels of decision-making is critical to technology adoption and uptake of SLM (Kilelu et al., 2013; van Mierlo et al., 2013), in Mozambique, the evidence shows that farmers do not participate in the innovation design and selection process; they participate at a later stage, often to validate the appropriateness of the technology.

The donors play an important role in the system; respondents perceive that donors have the power and capacity to influence decisions on what technologies will be promoted and how. The majority of SLM programs, including government programs, are donor-funded, and actors perceive that programs must comply with donors' needs and agendas. The role of donors in development has been widely discussed in the literature. Our results align with the findings of other studies (e.g., Chinseu et al., 2022; Ishaku, 2021), indicating that research and development organizations feel constrained to operate within the donors' boundaries.

2.4.2. Interactions and Collaboration

The Agriculture Innovation Systems literature focuses on the interaction between actors as a condition for learning (Leeuswis, 2004; Kilileu et al., 2013; Klerkx et al., 2012, & Schwilch et al., 2012). For the participants in this study, collaboration and coordination are key elements influencing SLM's success and sustainability in Mozambique. The study found frequent interactions among actors, often in formal settings such as meetings, training programs, and field days. Furthermore, it identified coordination challenges in a multistakeholder environment with multiple knowledge systems and interests. Concurrent

with Lininger et al. (2017), Schwilch et al. (2012), and Chinseu et al. (2022), we find that collaboration in Mozambique's SLM systems is limited or weak; it does not organically emerge from formal settings of interaction. Furthermore, Ishaku et al. (2021) found that a clear definition and distinction of roles (research and practice) will provide space for effective collaboration. As previously mentioned, organizations in Mozambique play similar and sometimes competing roles, thus limiting collaboration.

Most organizational relationships and interactions in Mozambique often respond to donors' requirements for more cooperation and collaboration between organizations. The current funding mechanisms have collaboration and synergies as requisites to access the funds (Spielman & von Grebmer, 2006; Schiller et al., 2015 & Stevens et al., 2013). While the donors perceive that collaboration will ensure the exchange of knowledge, sharing of resources (Schiller et al., 2015), learning, and ultimately accountability (Stevens et al., 2013), the practice of collaboration is still the focus of debate and controversy. The study results indicate that, in Mozambique SLM systems, collaboration is mainly developed to respond to the donors' requirements. Since the existing organizations compete for the same funding pool, it limits the opportunities to engage in strategic collaboration and learning opportunities.

Trust was found to impact collaboration significantly. In this study, ideological differences, misinformation, and perceptions of different organizations' capabilities (e.g., technical, knowledge, and resources) determine trust among organizations and, therefore, the intention to collaborate.

In addition, the absence of a coordination mechanism or a coordination authority impacts the likelihood and effectiveness of collaboration. van Mierlo et al. (2013) showed

that government institutions can play a role in coordinating innovation systems, either through policies that reinforce the need for coordination or ensuring that organizations are not overlapping activities. In Mozambique, coordination is one of the limiting factors in SLM. Often organizations work in silos and the coordination is limited to participation in a meeting where they share their activities and results. Moreover, the limited coordination leads to duplication of efforts, with multiple organizations implementing similar programs in the same locations.

2.4.3. Learning

While the AIS literature suggests that interactions should lead to learning and changes in behaviors and practices, Muro & Jeffrey (2008) argue that not all interactions result in the exchange of information and knowledge. Our findings indicate that interaction does not necessarily result in learning; instead, the type of interaction matters. We identified several factors that lead to learning, including trust in the source of knowledge, the relationship between actors, the existing institutional and organizational setting that enables learning, and the existing incentives for learning.

The study results indicate that organizations learn differently. Based on their ability to act on what they learn, organizations are divided into three categories: constrained learning, circumscribed learning, and innovative organizations.

Constrained Learning Organizations

These organizations show limited evidence of learning. Donor requirements often drive innovation, and the organizations working in SLM are trapped in satisfying these requirements. Learning usually occurs at the individual level and reflects on the interactions with farmers. The evidence of learning is limited to specific moments and

localized changes to address specific problems in the field. Learning is not systematically integrated into the project, program, or organization. Limited-learning organizations perceive learning as a *"donor demand"* and use monitoring and evaluation as a corrective measure and mechanism to access funds. Their project goals are to meet agreed targets. The farmer-based organizations, local development organizations, and most of the SLM projects implemented are constrained in this way and can only learn at the individual level.

Circumscribed learning organizations

In *circumscribed learning* organizations, learning occurs at the project level rather than at the organizational level. Learning is often the result of individual attributes of program managers who are trying new approaches and methods and adapting the technology to fit local contexts. They use learning to influence or inform future interventions and, with time, influence other program managers in using the products of learning, but often, these products are not systematized and integrated into the organizational structure. The *circumscribed learning organizations* have structures to collect stakeholders' feedback and use the feedback to change the approaches and methods and even to adjust some of the project or program goals. The *"farmers' research committee"* and *"farmers' feedback meetings"* are examples of mechanisms that circumscribed learning organizations use to collect feedback and incorporate it into project design. Research organizations and some NGOs fall within this group. These organizations show some characteristics of dual-loop learning but show that they are limited in implementing systemic changes at the organizational level; learning occurs more at the project and individual levels.

Innovative organizations

Innovative organizations have moments of feedback loops where the organization implements the land management activity or intervention, observes and reflects on the outputs, and introduces changes. First, the change occurs during the implementation of activities (single loop learning), where they identify areas for improvement during the monitoring and evaluation process. Secondly, they identify which areas can be further improved and integrated into the organization's structure and plans (dual loop learning). Some of the NGOs fall within this group. Innovative organizations have internal mechanisms for reflection and learning; they have a broader network of local, regional, and international partners and constantly seek improvement opportunities.

The Role of Monitoring and Evaluation

A common aspect of the three types of organizations is the monitoring and evaluation (M&E) structure. All mention M&E as being important, but each organization uses it differently. Constrained learning organizations often use M&E to meet the agreed targets. Similarly, circumscribed-learning organizations use M&E to check if the targets are met, but they go beyond and adjust the existing protocols and approaches, redefine the intervention, and inform future interventions.

Innovative organizations use M&E first to assess project implementation and how they are progressing towards the agreed objectives. Second, they use M&E to identify areas for improvement, which can be at the project or organization levels. Third, they use the M&E results to change organizational processes. These organizations have the characteristics of a dual-loop learning organization since they not only act on problems but also look for opportunities to engage in systematic organizational changes.

2.5. Conclusion

Learning is a key element in sustainable development and the key purpose of innovation platforms. Strategic collaboration and learning become critical in contexts with mounting land degradation problems but limited funding to address them. Despite the intention of creating a learning culture to promote sustainable land management, this study finds barriers to learning. We find evidence of learning primarily at the individual and less frequently at the organizational level. Institutional constraints and incentives limit learning, for example, due to perceived pressure to execute donor-funded projects precisely as designed, without room for adaptation. Some organizations perceive that there are factors limiting their capacity for learning, and other organizations do not perceive the need for learning as long as they are able to secure sources of funding.

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APPENDIX A. INTERVIEW GUIDE

Study Title: Learning in A Multi-Stakeholder Environment: The Case Of Sustainable Land Management in Mozambique

Section 1. Description of the organization and the scope of their work

1.1. Please give a brief description of your organization's mission and main programs/activities.

1.2. The focus of this research is Sustainable Land Management practices, and the questions are designed to understand your views and experiences with SLM interventions
   - How long have you been working in SLM?
   - How long has your organization been working on SLM?

1.3. Does your organization have any current project on Sustainable Land Management?
   - Where are the projects being implement?
   - What are the project's goals and expected results?
   - What SLM practices the project promotes?
   - How did the organization select the set of practices to promote?
   - Are the practices similar to all the communities and to all farmers targeted by the project? If not, can you explain the differences?

1.4. Who are the project's beneficiaries?
   - When and how are the beneficiaries involved in the project?
   - What strategies do you have in place to reach and work with farmers? Is the strategy similar to all farmers and communities targeted by the program?
   - Do you receive feedback from farmers? Can you provide examples of feedback you received?
   - Are there beneficiaries (either a community, group of farmers or an individual farmer) whom you consider as being a success case? What makes them a success case?

1.5. Source of information
   - From where do you get technical and agronomic information?
   - To what extent the technical and agronomic information respond to site-specific conditions?
   - If necessary, are you able to change or adapt the technical information to fit the local conditions? Can you provide examples of a time when you did change or adapt the information?

Section 2. Coordination between organizations

2.1. Are you aware of other organizations that have SLM programs?
   - What are they doing?
   - In what ways their work is similar/different from what your organization is doing?

2.2. Do you have a relationship with these organizations?
- Can you describe the nature of the relationship?
- Can you provide examples of moments you interact with them?
- The motives and outcomes of the interactions?

2.3. Have you ever experienced situations where other organizations started a similar program with the same target group as yours? If yes:

- The context
    - What challenges did you face, if any?
    - How did you address the challenges, if any?
    - What impacts did you think it had on farmers?
    - What could be done differently to change the situation?

2.4 Based on your experiences working in SLM, do you think that there are other organizations in Mozambique that can influence and or impact the performance of SLM programs?

- Which organizations?
- In what ways can/do they influence SLM programs? Can you provide examples?

APPENDIX B. STUDY CODEBOOK

Code/category	Description	Examples	Rules to apply
SC - Source of knowledge	How individual and organization learns or gather new knowledge	"We have been working with conservation agriculture in the last ten years, and we have changed some of our technologies." "There are moments a farmer asks a technical question, and I don't know how to answer. I use the internet to find the answer, and in my next visit, I will discuss the question and present solutions if it is a problem."	This code applies to the description of how the individual/organization learns and improves the own's performance. Includes SLM in general. Rule of exclusion: if describe the source of the practice/or innovation use the code Source of Innovation.
I – Innovation or practice	The land management innovation/practice used and/promoted by the organization	"We are promoting CA practices, our focus is mulching, crop rotation and intercropping. We don't use fertilizer in our approach"	This codes applies to the description of the technology the organization or the individual promoted/promotes. Does not include the naming of technologies promoted by others, or general description of the available technology
SI _ Source of innovation	Sources of innovation: place, time, moment, or institution from whom/where have learned about the practice/innovation. First contact or first exposure to the practice or technology	"We had the opportunity to visit Zambia, and we did see their experiences and success with permanent pits and rippers". "We work with the research institute, and they guide us about technologies that are suitable to the region we are working in." "We receive information about the technology from the Ministry of Agriculture."	Only for cases that describes the source of the technology used in the participants' organization/project.

WC - Working with communities	Involvement of farmers in the intervention	"We use the Farmer Field School approaches, and we have periodical group meetings." "We host field days, and it's an opportunity to get farmers and other organizations."	Apply to situations that describes how farmers where/are involved in the intervention
CwO - Communication within the organization	Internal communication and information exchange process.	"We have monthly meetings. During the meeting, we share what we have done, and we plan for the following month" "We usually receive the plan and the targets from the supervisor, and we develop weekly plans to reach the target that was defined by the senior management."	Applies only to the organization's internal communication processes: email, reports, meeting etc.. If it mentions communication or participation in meetings outside the organization or meeting in which other organizations participated use code: 1. CwO _Communication with other: or Co if was meeting to share experiences or discuss policies, programs (ex. Workshops, conferences, etc) 2. Co_Collaboration – if the outcome was collaboration, agreement to partner or work together.
CwO _ Communication with other organization	communication process between organizations	"We don't have a formal mechanism to communicate with other institutions. Often we use the field days to show what we have been doing and to get some feedback from other organizations." "I don't know. I believe that they [top managers] communicate with other organizations. But as extensionists working in the field, we don't talk to each other, and	Applies to description of communication process between organizations, describes how organizations share or exchange information. Excluded informal communication

		we don't know what other extensionists are doing." "I know that the Government of Mozambique signed an international convention in Conservation Agriculture. But we don't know what commitment was made and how can we work with the government to reach the country's target"	
CwC - Communication with communities/farmers	Communication and engagement with farmers/communities and the feedback process	"We introduce the technology and during the meetings we ask them what technologies they did like, what problems they have. If it is something we can solve at our level, we will do. If not, we take to them [top managers]" "we use group meeting or farmers field schools to talk with the farmers"	Methods used to reach the farmers, get farmers feedback and disseminate the practice
PO– Policies	Describes the existing policies and regulation environment or national programs relevant to SLM	"There is the National Fertilizer Policy" "The Strategic Plan for Agriculture Sector mentions land management"	
EP - Existing policies	Existing policies in Mozambique influencing SLM approaches	"There are policies and national guidelines but sometimes is conflicting." "I know that the Government of Mozambique signed an international convention in Conservation Agriculture."	

APPENDIX C. EXAMPLE OF A CONTACT SUMMARY SHEET

Type of contact: Middle level researcher	Interview date: 27.10.2020 (3:00 AM)
Written by: Angela Manjichi	Today's date: 27.10.2020 (2:00 PM)

1. Main issues or themes that struck you in this contact	
Issues/themes	Quotes
i. Selection of Innovation	
The process of innovation design/selection seems to be top-down. Farmers are not involved or are involved during the adaptability trials or validation phase	
ii. Process of learning	
- Provides evidence of "learning": but not clear when learning takes places and who should learn. - It seems that learning is linked to farmers- they need to learn about the new technology. - Using of learning centers and innovation platforms - Participatory assessment of fertilizer blends	"It is difficult to talk about learning. I see learning when we try to adapt the crops to the local conditions"
iii. Factors hindering or promoting learning	
- Coordination/competition between organizations, problems to establish partnerships. - Learn from sources they trust…trust takes time. - Learning only happens with scientific evidence [focus on technology impact/result from trials and not on the process and how to make it effective]	"We decided to partner with a soil Lab in Maputo [Maputo is about 1100 KM away from Chimoio] we don't think our labs in Chimoio are capable of running the tests we want"
- Acknowledge of multiple sources of learning and/or valuing local knowledge (issue of trust and validity of knowledge) - Idea that farmers practices will always be proved wrong or unproductive.	"Researchers learn more from scientific evidence and little from the interaction with farmers" "In all our trials we have a "control treatment" that basically replicates farmers practices and they see the difference between our practices and what they do"
2. What information did I get and what did I failed to get	
Did get	*Failed to get*
Evidence of interaction with farmers and other stakeholders and examples of such interactions (innovation platforms, learning centers)	
What is critical in learning	Clear description of how he/she uses farmers' feedback -
	What does it mean "context specific"- from the interview it seems that there is

	specific according to farmers and specific according to the existing knowledge on the agro-ecological zones?

3. What is interesting, salient, or important in this contact?

The idea that researcher cannot learn from farmers or from non-academic/technical sources. Knowledge to be valid and contribute to the learning must be scientifically valid.
There are some "power" struggles and mistrust issues among individuals/organizations. Each of the individuals trying to prove that his/her technology is the most important, tendency to under look what other organizations are doing.

The idea of producing fertilizer blends to blends specific for each zone ---- surprised with the amount of soil samples they have collected and the purpose of having specific fertilizer recommendations.

- But there is little linkage with other management programs – blends without mulching/cover crops

Farmers are still passive actors in the process, while there are interactions it seems that the interaction targets more farmers' behavior change and less on researchers.

4. New questions or topics to explore in other interviews.

- What is "context specific" or local conditions in the interviewee perspective?
- Provide examples of how the individual or the organizations addresses/deals with farmers' perception/feedback?
- Collect evidence of learning

APPENDIX D. EXAMPLE OF A DOCUMENT SUMMARY FORM

Document type: Progress Report	Date received: March 7, 2021
Name of the Document: Agro-ecology Based Aggradation – Conservation Agriculture (ABACO) Progress Report	Date analyzed: 15 Jun 2021
Analyzed by: Angela Manjichi	

Significance of importance of the document
The document provides the sample of how organization report their activities and helps to understand the extent in which they use/can use report for learning purposes. The report shows how the organization implemented the SLM activities, what activities are most important, what were the major output/outcomes, and what factors influenced (or not) the decision to use one or the other approach/strategy.
Brief Summary of Contents
The report provides information of main project activities and the output from October 2013 to August 2014. The report focuses on: 1. capacity development activities – training of farmers, undergraduate students. In addition, the development of experience exchange with other stakeholders in the target region 2. On farm trials – mentions broadly CA technologies without a distinction of which technologies were tested and in which condition there were tested. 3. Participatory Rural Appraisal for CA It highlights the main constraints for CA adoption, namely: access to adequate equipment, agro-chemicals and draft animal power. In addition, it pinpoints problems that some technologies can bring. E.g., Use of mulch can affect negatively the women in the target regions, *"Time allocation and transport of organic materials which is done primarily by women appears to conflict with other activities"*
Main insights
- The report acknowledges the need for more information and integration of "the technical, institutional, socio-economic and biophysical factors in designing innovations." - As a progress report it did not show how they have incorporate "finding" from previous report and it does not show how have - Checklist of project's activities without the consideration of the type of adjustments needed. - Interestingly the report states that *"field observation clearly shoes comparative advantage of conventional systems to CA in all treatments. Maize plant growth in conventional was much more vigorous than in CA plots. The difference was much higher in unfertilized plots*" - For instance, the report states that "several NGPs have been promoting different CA systems with multiple and confounding effects with many cases mislead farmers". It is not clear if and how the project addressed this issue, they only recommend the "adoption of systems approach" -----→ explore in the interviews.

CHAPTER III

PROVISION OF SUSTAINABLE LAND MANAGEMENT EXTENSION AND ADVISORY SERVICES IN SUSSUNDENGA: VIEWS AND PERCEPTIONS OF THE EXTENSION WORKERS

Abstract

Development and diffusion of sustainable land management practices dominated the agricultural production and food security interventions, with extension services transferring these practices to the farmers. Simultaneously, extension systems are under institutional changes, shifting to demand-driven extension models and placing learning at the center. The study aimed to understand the learning among extension workers in sustainable land management in Sussundenga, Mozambique. The study results show two providers of sustainable land management advisory and extension services: NGOs and public extension. The study results indicate that public and NGO extension systems have different approaches to promoting sustainable land management. Collaboration, coordination, funding schemes and farmers' participation in technology selection weakens learning in the current sustainable land management advisory and extension services. While formal learning process is perceived as the most important, social learning plays an important role in the success of sustainable land management. However, social learning is constrained by limited opportunities and incentives to integrate this learning into broader sustainable land management advisory and extension systems.

Keyword: agricultural extension, information needs, knowledge management, Mozambique

3.1. Introduction

In the last three decades, Sub-Saharan Africa has seen rapid growth in agricultural technology development, including high-yield varieties, fertilizer, mechanization, irrigation, and land management practices. Despite advances in agricultural technology development, research on adoption indicates that uptake of such innovations is low or occurs at a slow pace (Adato & Meinzen-Dick, 2002; Glover et al., 2016). Several factors account for the low adoption, and the models of diffusion and adoption of technology indicate that awareness and knowledge about the technology play a critical role. In most Sub-Saharan countries, extension services are the primary source of agricultural information and knowledge.

Agricultural extension and advisory services are widely recognized as essential in promoting and supporting the diffusion and adoption of innovation in agricultural systems and facilitating interaction and connections between actors in the agricultural value chain. The role of extension and its effectiveness and impact received a great deal of attention in the research and policy agenda for agricultural development, resulting in major reforms of national extension systems throughout sub-Saharan countries (Davis, 2008).

Within the reforms, two major aspects dominate the discussion. First, the transition to agricultural knowledge and information systems (AKIS) and initiate the discussion on integrating multiple actors and their role in the knowledge systems (Leeuwis & Art, 2004). The integration of the Agricultural Innovation Systems (AIS) approach moved beyond knowledge and information sharing and acknowledges that multiple actors are involved in the process of creation, diffusion, and utilization of innovations (Klerkx et al., 2010).

Second, the transition to AKIS called for the transformation into pluralistic extension systems. With multiple providers of extension services, countries started the

decentralization process and extended to the privatization of extension services. Within this transformation, countries started to reframe the role of the state as a provider of extension, shift from supply to demand-driven extension, and integrate the farmers with a more active role in the extension systems (Garforth et al., 2003; Klerkx, 2020).

In theory, the reforms led to a paradigm shift from the traditional and often top-down extension to a more participatory and collaborative one (Leeuwis & Aart, 2004; Birner et al., 2009). The traditional technology transfer model assumes a linear process and acknowledges extension as the link between researchers and farmers. However, it is limited in exploring the active nature of such interactions. Agricultural Innovation Systems (AIS) recognize the interactions (Davis & Suleman, 2016) and the *interaction with knowledge generation* (Anderson & Feder, 2007) as critical elements of extension systems' effectiveness. Agriculture innovation systems continue to recognize extension as essential in agriculture systems and reinforce the role of interactions between actors (including extension workers) and the need for learning and integration of learning outcomes into existing extension systems and methods. The learning process is intended to increase the ability to provide relevant agricultural advisory and extension services to the farmers and other users of sustainable land management extension services.

In theory, the AIS framework and the paradigm shift imply that the extension workers engage in active learning through interactions with multiple stakeholders. Despite these paradigm shifts and the (shifting) role of agricultural extension and advisory services, limited studies show the transition to AIS and how extension workers perceived, adapted, and integrated the paradigm shift into their work. Studies on agricultural extension tend to focus on the effectiveness of extension methods (Davis, 2008; Klerkx et

al., 2013), the impact of extension (Ragasa & Mazunda, 2018), and the organization and management of extension systems (Anderson & Feder, 2007; Davis, 2008).

This research will use extension workers' experiences in Sustainable Land Management (SLM) in Mozambique to examine how the paradigm shift in extension plays out in practice. First, it explores the factors extension workers perceive as limiting or enabling their ability to promote SLM practices to the farmers. Second, it explores the learning process among extension workers by answering the questions: How are extension workers learning? How do they integrate the learning experiences when designing and managing sustainable land management extension and advisory services?

3.1.1. Conceptual Framework

This paper uses the best-fit framework (Birner et al., 2009) to analyze the provision of sustainable land management extension and advisory services (Fig. 3), the role the advisory services play in it, and how learning within the advising service occurs. The best-fit framework integrates the agricultural extension systems within the broader agricultural innovation systems. The framework acknowledges the pluralistic systems, the interactive nature of extension systems, and the need to adapt the agricultural extension to the local context and develop an extension system that best fits the local context (Birner et al., 2006; Davis, 2008). The best-fit framework proposes four characteristics of extension systems: governance of extension systems, management, capacity, and advisory methods (Birner et al., 2009; Davis, 2020). Birner et al. (2009) argue that external conditions affect the extension system, including the policy environment, the overall capacity of extension providers, and the farming systems and socioeconomic conditions.

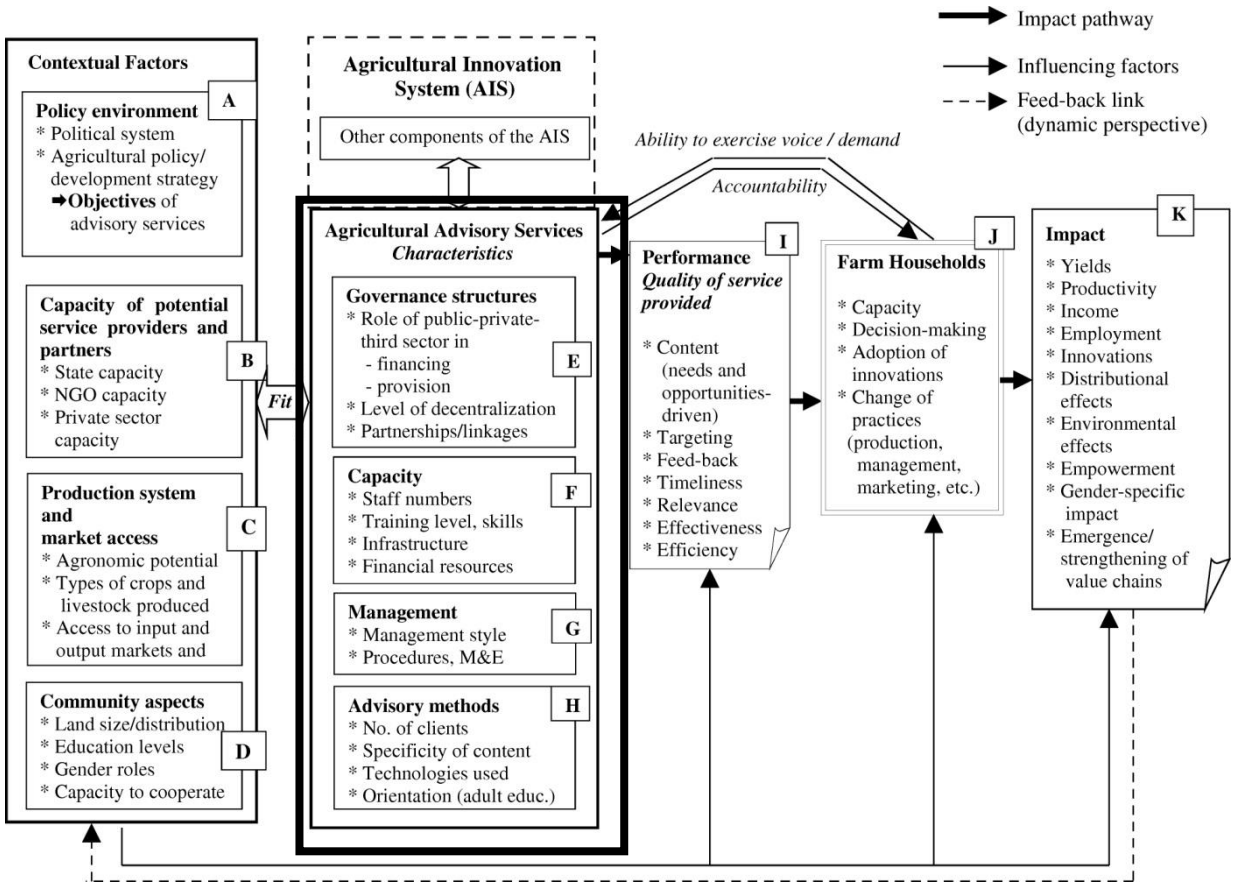

Figure 3. Best fit model, highlighting the model elements addressed in this paper (source: Birner et al., 2009)

This paper will analyze the characteristics of sustainable land management extension and advisory services and apply the following parts of the model to sustainable land management, as displayed in Figure 1: the governance structures (E), the capacity (F), management (G), and advisory methods (H).

Extension and advisory services programs and projects usually share the same governance structure and capacity. At the same time, advisory methods are distinct and related to innovation. There is evidence that farmer-centered (Fisher et al., 2018; Adolwa et al., 2018) and group-based methods (Adolwa et al., 2012) are more effective in providing SLM extension and advisory services.

The paper focuses on agriculture advisory systems, how extension workers perceive and view their work, their interactions with other actors, and what factors shape learning. Other elements of the model, particularly the contextual factors (policy environment, production system, market access, and community aspects), are not addressed systematically in the paper.

Agricultural innovation systems and pluralistic extension systems

Agricultural extension systems are the entire set of organizations that support and facilitate knowledge-sharing and technology transfer in agricultural and natural resources systems (Anderson & Feder, 2004; Leeuwis, 2004). Extension services help people involved in agriculture access information and skills necessary to improve their farming systems and ultimately improve their livelihoods (Davis, 2008; Birner et al., 2009).

Most extension systems in developing countries are pluralistic (Davis, 2008), where multiple organizations provide extension services. Anderson and Feder (2004) argue that the nature and type of information farmers demand should determine the landscape of organizations in a pluralistic system. Furthermore, Davis and Heemskerk (2012) state that pluralistic extension supports a demand-driven approach to extension. In this pluralistic model, different providers of extension services will offer differentiated services to the various farmers' groups with different needs (Klerkx et al., 2016; Davis & Heemskerk, 2012).

The government, the private sector, and non-governmental organizations are the leading providers of extension services (Anderson & Feder, 2004; Davis, 2008; Davis & Heemskerk, 2012). The *public extension services* provide information perceived as a public good, general, and non-excludable (e.g., market systems, agronomic practices, etc.) and

specialized information (e.g., fertilizer recommendation). *Private sector extension follows two distinct types*. The first is when the information is perceived as a market good, and farmers pay a fee to access the information. The fee can be paid by the government or other funding organizations (Rivera & Suleiman, 2009) or by the farmers themselves (Anderson & Feder, 2004). The second is when the information is specialized (input or output products), and the private sector (primarily companies supplying inputs or companies involved in contract farming) provides specific information without cost or subsidized cost to increase the sales or the usage of a specific technology. The last provider is the *third sector* (Anderson & Feder, 2004), which in the Mozambique context primarily refers to extension provided by NGOs. However, it can also include farmers' groups, churches, etc.).

Anderson and Feder's (2004) categorization imply that each provider has its own niche and supplies a particular set of practices or agricultural information required to satisfy the needs of the niche. However, the experiences in African countries show a different scenario. For example, Ragasa et al. (2016) and Davis (2008) showed that different types of organizations providing extension services often target the same goods, products, and clients. Developing countries' most common services and products related to land management are conservation agriculture, fertilizer, and soil amendment practices (Branca et al., 2013). Often, these products and services are defined by donor organizations' existing funding mechanisms and priorities.

The Characteristics of Extension Systems

The best-fit model (Birner et al., 2009) proposes four elements to analyze the characteristics of extension systems: governance, organization and management, capacity, and advisory methods*. Governance of extension systems* explores the different providers

and their roles, the financing mechanism (Birner et al., 2009), and the institutional arrangements and coordination (Davis, 2020). The *organization and management* explain how the providers organize, manage, and implement extension and advisory services. The *capacity* describes the ratio of extension workers to farmers and extension workers' skills and competencies. Lastly, the *advisory method* describes the methods utilized to deliver information to the farmers (Birner et al., 2009; Davis, 2020).

Learning in Extension Systems

The Birner et al. (2009) best-fit framework builds from the Agricultural Innovation Systems model, assuming that the chain actors interact and learn from each other. In agricultural innovation, extension workers constantly interact with farmers, researchers, and stakeholders in the agricultural setting (Davis & Suleiman, 2014). Through these interactions, information flows, and extension workers continuously update their knowledge and improve the messages they send to farmers.

Klerkx and Proctor (2013) distinguish two types of knowledge in land management advisory services: codified or explicit knowledge and tacit or implicit knowledge. Codified or explicit knowledge refers to more systematic, formal, and transferable knowledge. Tacit knowledge is informal, context-specific, and often derived from one's own experiences (Klerkx & Proctor, 2013). Extension workers engage in the learning process through interaction with stakeholders and existing institutional frameworks (e.g., training); therefore, extension workers have tacit and codified knowledge of land management.

3.2. Methods

The study uses a case study research design (Creswell, 2013). For this study, we identified the provision of SLM extension and advisory services in Sussundenga District, Mozambique, as a case study. Sussundenga district is located in Manica Province in the Central Region of Mozambique. Recognized as an important agricultural production region, Sussundenga District has received significant investment in agriculture, with particular emphasis on programs in sustainable land management, including conservation agriculture, agroforestry, and integrated soil fertility management. Sussundenga has two major seasons: the dry season from May to September and the rainfall season from October to April. It is located in the Agroecological Zone R4, characterized as a humid subtropical region with an unimodal rainfall season and altitude between 200 and 1000 meters above sea level. The soil types are predominantly oxisols (Maria & Yost, 2006).

3.2.1. Sample and Sampling Strategy

The study's target population is individuals working in organizations providing SLM extension and advisory services. In Mozambique, extension services are provided mainly by government-based and non-governmental organizations (Cungara & Thompson, 2018). The private sector also provides extension, but it is often related to farmers growing specific crops under production contracts.

The data from the Sussundenga District Office indicates that the district has 44 extension workers in the government agricultural and advisory services. In addition, a mapping exercise identified five non-government organizations with active projects in Sussundenga providing extension and advisory services. These organizations tend to have

5-7 extension workers per district. During the data collection phase, it was not possible to register the exact numbers of NGO extension workers in the Sussundenga District.

The study sample included individuals from public and non-governmental organizations (Table 3). The study excluded private sector extension, which does not provide sustainable land management extension services in Sussundenga.

Three major categories of individuals were defined. The first group is the senior managers of agriculture and extension services. The senior managers are mostly involved in designing and planning advisory and extension services policies. The second group is the extension supervisors, who are mostly responsible for managing and coordinating the implementation of extensions at the district or field level. The third group is the extension workers, who are responsible for implementing the extension activities and daily interaction with farmers.

Sampling for the Survey

The survey reached the extension workers in the Sussundenga District. Data from the District Services of Economic Activities (the state organization managing agricultural extension at the district level) indicated that 44 extension agents work in the public sector. The survey was distributed to all the public extension workers, and 29 responded. The survey was distributed to the NGOs working in Sussundenga, and five extension workers in the NGOs responded to the survey. The study aims to illustrate and describe the provision of sustainable land management extension and advisory services and does not draw a comparison between extension providers.

Sampling for the qualitative interviews

A purposive sampling strategy was used for the qualitative interviews. A combination of selection criteria and critical cases was used to identify the study participants (Creswell, 2013 & Patton, 2014). The criteria used to select the extension workers included gender (we included all the female extension workers) and working experience (only extension workers with more than five years of working experience). The sample sizes in the qualitative data were determined using the theoretical saturation approach (Collins, 2010; Creswell & Creswell, 2018) and consisted of identifying new participants and conducting the interviews until no new information was gathered with each additional interview. A total of 27 in-depth interviews were conducted with the key extension personnel and program managers. Twenty people from the public extension services and seven from NGOs responded to the in-depth interviews. This represents nearly half the government extension workers in the district and about 15-20% of the NGO extension workers.

Table 3 summarizes the study sample size. The information is disaggregated by gender and the study participant's role in sustainable land management extension and advisory services.

Table 3. Study Participants

		Public Sector		**NGO's**		
	Code	**Male**	**Female**	**Male**	**Female**	**Total**
Survey						
Extension supervisors		1	0	0	0	1
Extension workers		23	5	5	0	33
Total		24	5	5	0	34
In depth interviews						
Senior Managers	SM	4	0	3	0	7
Extension supervisors	SU	1	0	2	0	3
Extension workers	EW	12	3	1	1	17
Total		17	3	6	1	27

3.2.2. Data Collection

Survey

A Likert-scale survey was used to collect extension workers' perceptions of the organization and coordination of extension systems. The survey aimed to understand extension workers' views on capacity, methods, and management of sustainable land management extension and advisory services.

In-depth interviews

In-depth interviews were conducted with the extension workers, supervisors, and senior managers. Prior to the interviews, the existing documentation on the country's policies and strategies on agricultural extension, monitoring and evaluation reports, field reports, and any other relevant extension material was reviewed. These documents helped provide context for the interviews and guided both the formulation of questions and the interpretation of responses.

The in-depth interviews aimed to explore the views and perceptions on the organization and planning of extension activities (individual and organizational level), the communication process (with supervisors, peers, and farmers), interactions with other actors in the system (other extension providers, other organizations) and knowledge management and learning. The interviews provided the first moment to immerse and familiarize with the data.

At the end of each interview, a memo was produced with the main insights, areas that needed to be better understood or areas that seemed important to address in future interviews, and a general overview of the process. For instance, through the interviews with the extension workers, a common topic that emerged was the number of farmers

adopting technology as a metric of their performance. By exploring the concept of adoption in SLM, we found that adoption is perceived differently by extension workers within and between organizations. Despite the importance of the theme, this is not explored in detail in the study since it was outside the scope of the study.

3.2.3. Data Analysis

Descriptive statistics (frequency, mean, and standard deviation) were used for the survey data to describe the extension agents' perceptions of the constructs in the study (socio-demographics, advisory methods, and organization and planning of extension services). The survey findings provide background to set the stage for the qualitative analysis of the in-depth interviews.

The qualitative analysis of the in-depth interview data consisted of three steps, following Saldana's (2016) coding and analysis process. The interviews were transcribed using the online software oTranscribe and then reviewed, corrected, and uploaded into the MAXQDA software. The transcription and the review process provided the second moment to immerse in and explore the initial themes and follow-up questions. The second step consisted of coding the data. An initial coding process was then developed, resulting in the codebook (DeCuir-Gumby et al., 2011). The codebook was applied to the data set to develop categories and identify emergent themes. The third step consisted of integrating and writing the results. The qualitative data analysis was an iterative process, and the three steps were continuously revised and refined.

3.3. Results

This section presents the perceptions of extension workers on factors shaping the interactions and learning when promoting sustainable land management practices. The

results are presented in three parts. The first part presents the socio-demographic characteristics of extension workers in the Sussundenga District and the capacity and methods used in sustainable land management extension and advisory services. The second part presents the findings on the organization and management of extension services. The third and last part presents the knowledge creation, management, and learning processes within advisory and extension services. The presentation of results integrates the survey responses and the analysis of the in-depth interviews, demonstrating the thoroughness of the research process.

3.3.1. Characteristics of Extension Workers

Table 4 presents various characteristics of extension workers and their work in Sussundenga District.

Table 4. Characteristics of extension workers

	Category	**Public Extension (n=29)**	**NGO (n=5)**
Gender	Male	24	5
	Female	5	0
Age (years)	Average	29	44
	Min	22	26
	Max	52	47
Working Experience	0 – 5 years	20	2
	6 – 10 years	2	1
	11 – 15	3	2
	16 – 20	2	0
	More than 20	2	0
Academic Level	Primary Education	1	0
	Technical and Vocational Agricultural Education	23	2
	Secondary Education	1	2
	Higher Education	3	1
	Preferred not to answer	1	0
Client base size	Number of farmers per extension worker (average)	336.4	212
	Number of farmers groups per extension worker (average)	18.9	1

Table 4. (cont'd)

	Farmer Field School	23	4
	Farmer to Farmer extension	11	5
Extension	Group meetings	26	5
Methods	Individual visits	29	5
Used	Mobile Phone	16	0
	Audio-visual (radio, television, pamphlets, etc)	8	2

The survey data indicate that the average age of extension workers is 29 years old in public extension and 44 years old in NGO extension. Most extension workers have less than five years of professional experience in agricultural extension and have technical and vocational education.

The qualitative findings indicate a diverse academic training background among the extension workers. Most workers have a background in agriculture and natural resource management; some have more generic academic training (e.g., study area administration and management). Most of the sample studied at a College of Agriculture and Natural Resources, but most indicated they did not study soil management specifically.

> *"I have an education in Forestry from [name of the academic institution]. I saw the advertisement for hiring extension workers; I applied and was successful. I have been an extension worker for the last five years, assisting farmers and providing advice in agricultural production."* (Public, extension worker 2)

Supervisors and senior managers of public and NGO extension services recognize the diversity in the academic background of extension workers. They recognize the importance of academic training and how different backgrounds can influence the provision of sustainable land management. Public and NGO extension services provide training and induction to new extension workers to level the knowledge among extension workers. NGO provides training specific to the SLM programs, while public extension

provides more general extension training. Furthermore, in public extension, the training is not systematic, and for example, the training and induction of newly hired extension workers have been halted due to limited resources.

On average, one public extension worker assists 18.9 farmer groups and 336 farmers[1]. The qualitative data indicate that the existing ratio of extension workers to farmers is low in public and in NGO extension. The extension workers agree that working with a large group of farmers influences their work since extension workers cannot visit and equally assist all the farmers under their supervision. Public extension workers find it more difficult since they lack the resources to assist all the farmers. In some cases, extension workers confirmed that they are forced to visit farmers who live close to the extension officers or in easy-to-access locations.

3.3.2. Land Management Practices

All extension workers (public and NGO) confirmed that they have experience and have been involved in programs promoting sustainable land management practices. Extension workers are often involved in conservation agriculture, agroforestry systems, soil health and fertility management, and fertilizer promotion (Table 5). Conservation agriculture is the most common SLM practice promoted by the public and NGO extension. The use of fertilizers is the second most common approach and is used mainly by public extension workers. Some but not all NGOs also promote fertilizer use.

The qualitative data show that the difference between NGOs lies in their understanding of what constitutes sustainable management. For some NGOs, *"fertilizers are not sustainable since they do not mimic natural soil processes or are aimed at improving the*

[1] In this study we count each individual farmer as opposed to farm households.

natural [soil] processes. The use of fertilizers leads to dependency" (NGO, Senior manager). In contrast, other NGOs perceive that fertilizer is necessary to support soils in recovering and achieving optimal conditions. Later in the paper, it is discussed how these differences affects the collaborations, and the learning among extension workers.

Table 5. Survey data on public extension workers' views on soil problems and management

	Public Extension (n=29)	**NGO (N=5)**
Soil Problems		
Low fertility	17	5
Erosion	15	0
Soil salinity	2	0
Leached Soils	0	3
No major problem	2	0
SLM approaches		
Conservation agriculture	29	5
Agro-forestry systems	17	2
Soil health and fertility management	11	0
Fertilizers	27	0
Most important SLM Practice		
Mulch	11	5
Cover crop	6	5
Intercropping	20	5
Crop rotation	25	5
Legume	13	1

The extension workers agree that they have limited information about the soils in their communities and promote the same practices to all farmers, communities, and locations they work in, regardless of differences in soil types, farmers' characteristics, and existing conditions.

Extension workers listed five practices when asked to prioritize SLM practices according to their importance and relevance to farmers' context: mulch, cover crop, intercropping, crop rotation, and legumes. Extension workers agreed that farmers would likely use these practices without significant resistance. While mulch is considered an

important practice, extension workers agree that the practice is often not applicable in some contexts, especially in places with high livestock activities and problems of termites.

The extension workers explained that these practices are not complex and can be easily applied; they serve different contexts and endowments of farmers' resources and do not require additional investments (land, labor, or financial). In addition, farmers explained that the integration of legumes (either as cover crops, in intercropping or in crop rotation) could result in an additional source of income:

> *"The price of cowpea is good. It is easy to convince the farmer to integrate cowpea into their cropping systems. The price is good, so they will get money for cowpeas and can use maize for household consumption. Not only that, but after two or three cropping seasons, they [farmers] see the benefits of cowpea in the soil"* (Public, supervisor)

Qualitative data show contrasting views on the relevance of specific practices in a particular context. Some of the respondents argue that some of the practices are not feasible for farmers to use. For example, most extension workers consider permanent pits and mulch as practices unsuitable for some farmers' contexts and farming systems. One of the extension workers mentioned that *"permanent pits require a lot of physical work. For small areas, it might work, but for larger areas, it won't; some people call it dig and die"* (NGO, extension worker*).* In relation to mulch, the extension workers argue that it is difficult for farmers in some regions to keep mulch in the soil due to scarcity and the attack of pests. The respondents indicate that in some areas, farmers use crop residues to feed the livestock, and in termite-prone areas, it is challenging to keep residues in the soil. In addition, residue and other biomass for use as mulch are scarce. Some farmers who agreed

to host a mulch demonstration plot found they had to purchase residues to maintain their agreement with the extension office because their own supply was insufficient.

3.3.3. Extension Methods in Sustainable Land Management Advisory Services

Extension workers use a variety of extension methods to reach the farmers and promote sustainable land management practices. The survey results indicate the most common methods used to disseminate sustainable land management interactive approaches include farmer field schools, farmer-to-farmer extension (e.g., Lead Farmer), group meetings, and individual visits.

The qualitative data showed that public and NGO extension workers use different methods when promoting land management practices. The public extension tends to use group-based methods, especially farmer field schools. In contrast, NGOs often offer extension services to respond to specific projects. NGOs tend to use more farmer-to-farmer approaches. Public extension workers asserted that FAO influenced the use of farmer field schools. The FAO is a major organization promoting the integration of conservation agriculture in the country's smallholder farming systems and prioritizes farmers field schools as the primary extension approach. These lead to the inference that the donors can determine the use of extension methods they perceive as the most effective.

Interview data suggest that public extension workers continue to use principles from the more top-down modified training and visit approach even under the guise of the farmer field school setup. The extension workers acknowledge that farmer field schools are more appropriate for promoting sustainable land management and pointed out that the major advantage of the farmer field school is the opportunity to analyze and discuss the outcomes of conservation agriculture plots in the farmers' group. Still, running a farmer

field school demands financial resources that often are not available to public extension workers. In this situation, the approach reverts to simply informing farmers what to do.

The data shows that mobile phones are an important extension method. *"With mobile phones, it is easy to submit the same information to more farmers, and the farmer can easily respond and ask questions."* (Public, extension worker 12). The study results show that extension workers use mobile phones to send land management information, respond to farmers' questions, monitor the demonstration plots, and facilitate access to input and output markets. Extension workers reach out to individual farmers through SMS, but these are not used often due to the inability to share images and connect to groups. The WhatsApp application is used more often, and the particularity of the application is the ability to share images and create groups divided by interest (e.g., communities, type of crop, traders, etc.).

3.3.4. Organization and Management of Sustainable Land Management Extension and Advisory Services

Organization of Extension Systems

The study findings show differences in sustainable land management extension and advisory service organization. The senior managers in the public sector stated that the annual goals and the crops, farmers, and technologies to be targeted are generally defined at the ministry level and submitted to the province for implementation.

The structure of extension services varies between NGOs. It is determined by the funding, size, and scope of the project, including the number of farmers, districts, and provinces reached by the project. There is a consensus among NGO extension workers that their organization is flexible and allows them to participate in the decision-making.

The respondents stated that NGOs use different approaches to recruit and engage with extension workers. Some NGOs hire extension personnel, while others work with public extension workers. Respondents noted that the approaches have advantages and disadvantages. NGOs hiring their personnel have less dependence on public extension and, in principle, can reach farmers who are often not reached by the public sector (they have the resources). However, there is the perception that this system is not sustainable and results in low accountability. Extension workers are hired only for the duration of the project. Once the project is over, they move to different projects (at the same or a different organization), locations, or communities.

In contrast, NGOs working with public extension workers argue that the major advantage is that they build local capacity, as public extension workers are trained and can continue to provide SLM extension services even after the end of the NGO's project. However, there is the claim that it overburdens extension workers. Extension workers are involved in several NGO SLM projects and tend to prioritize the NGO with "*better resources and incentives*" (NGO, Senior Manager 3). Furthermore, the extension workers must simultaneously deliver the activities and results defined in the NGO project and the one defined by the Ministry of Agriculture.

Planning and Management of Extension

When asked about planning and management activities, the study participants agree that the organization and planning of extension activities are important elements for the success of SLM dissemination programs. The extension workers defined two moments for planning and organizing the extension activities. The first moment is during the program's design, when the technologies, the target population, and the extension methods are

defined. This moment is usually not related to the agricultural cycles but to the funding cycles and opportunities. The second moment is during the planning and implementation of extension activities. These moments are aligned with the agricultural cycles (either after harvesting or before the beginning of a cycle (before planting)) and are often designed with the intent of learning from the previous cropping cycle and adapting to future cycles.

The extension workers agree that there are limited opportunities to participate in the design of sustainable land management programs and projects, and often, their experiences are not valued or integrated into the broader decision-making and organization of extension services (Figure 4).

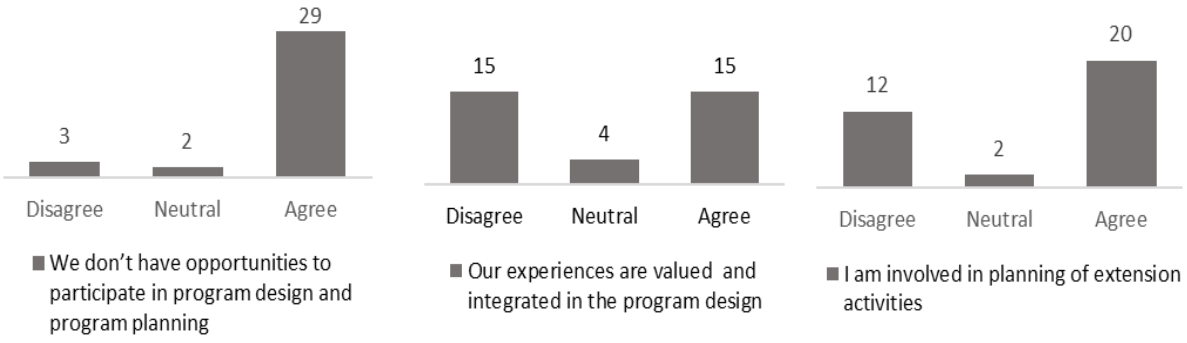

Figure 4. Survey results on extension workers' perception on the planning of sustainable land management programs

The study findings show mixed perceptions of using extension experiences and involvement in designing and planning extension activities. Some extension workers agreed they do not participate in the program design. The data from the in-depth interviews show a strong perception that extension workers have limited participation in designing and planning extension activities. Usually, the extension workers *"receive the plans, with the targets from project managers. My responsibility is to ensure that I meet the targets."* [NGO, extension worker 5]. Public and NGO extension workers agree they are not

involved in the project discussion, selection of technologies, and farmers' outreach approaches.

The study participants asserted that sharing experiences is important. However, the study participants have mixed perceptions of how their experiences in the field are used to support the planning and design of activities and programs at the organizational level. One extension worker said: "*We are still working with conservation agriculture and promoting [the practice]. Based on our experiences with the farmers, we know the practice will not work. But we are still promoting it. It does not make sense that we continue to work with something farmers refuse to accept*" (Public, extension worker 1).

The major implication of limited integration of extension workers in program design is that often, there is the perception that the technologies being promoted are not relevant to the local context. The extension workers perceive that it may affect the communication and relationship with the farmers since *"we insist on a practice that the farmers already told us will not work*." [NGO, extension worker 5] The study participants agree that they often receive a technology dissemination plan with the technologies, targets, and dissemination strategies, and often, there is limited opportunity to provide feedback or change the plan. In contrast, a group of extension workers, both from the Public and NGO, perceive that the feedback they provide to the extension supervisors and managers is integrated and supports the definition of priority areas.

> *In phase 1, we reported that using mulch was not efficient. In phase two, they [program managers] have adapted and introduced alternatives to mulch. It is good because now I can present options to the farmers*
> (NGO, Extension worker 2)

The perception that their experiences are integrated into program design is prominent among NGO extension workers with more years of experience. This implies that age, years of experience, and the extension provider (NGO vs. Public) influence the individual perception and degree of participation in planning, organization, and decision-making. Senior extension workers often have their suggestions integrated into the planning and organization of extension services.

Extension Services Delivery Approaches

A theme emerging from the data is the orientation of sustainable land management extension services. Both public and private sector extension workers agree that in Susundenga, the SLM extension and advisory services tend to follow a target-oriented approach instead of focusing on goals or results.

The target-oriented approach has implications for learning and integrating experiences with farmers in sustainable land management programs. Since the extension organizations' major concern is the number of farmers reached, they tend to overlook the technology dissemination process. Organizations tend to neglect or ignore moments of learning. For example, organizations do not explore what is working, in which context it is working, why it is working, and what can be done differently. Most of the reflection questions are absent when planning extension services. The extension workers focus on reaching the defined target regardless of farmers' interest, context, or need for the technology. Under the target-oriented approach, any "failure" to reach targets is first attributed to the lack of resources to reach farmers and secondly to the farmers: "*Some farmers are stubborn, we go there, we show the technology, and they do not use it. They*

receive the package, seed, fertilizer and other but they will do their own thing" (Public, extension worker 12)

The study examined the decision-making processes in sustainable land management to understand the management styles. The extension workers identified two specific moments in which decisions are made: annual planning and periodic meetings (weekly, biweekly, or monthly). These two moments are considered moments where extension workers can contribute to planning extension activities. The annual planning meeting is the largest and involves the entire organization, whereas the periodic planning meetings target a smaller group and are specific to extension workers and supervisors.

While all the participants stated that, in principle, the organizations are supposed to have a participatory approach to decision-making, in practice, it is not the case. There are mixed views on what participation is and what the level of participation should be. Some respondents argue that they consider the decision-making participatory because they are involved in planning and implementing the extension field activities. They further explain that they meet to plan for extension activities, and during the planning sessions, they share with their peers what they have done, define and learn from each other, and improve the work with the farmers.

In contrast, the other group thinks the process is not participatory. For this group, there is a lack of engagement and involvement of stakeholders in the decision-making process: *"Often we [extension workers] transfer the technology, neither the farmer nor we [the extension workers] are involved in the selection of the technology."* (Public, extension worker 4). Furthermore, they explain that often, participation is passive, with extension workers acting as recipients of information but not actively participating in or influencing

the decision-making process. For this group of respondents, the annual planning meeting is *"where they [program managers] inform us about the plans for the upcoming year."* The public extension workers and senior managers asserted that the lack of involvement and participation is more visible in the public sector since *"the decision is made at the ministry level and then [relayed] to the province and districts" (Public, Senior Manager 3)*

Coordination and Collaboration

Coordination and collaboration across organizations emerged as important factors when promoting SLM practices. All respondents agree that several organizations work in the same communities and promote similar SLM practices.

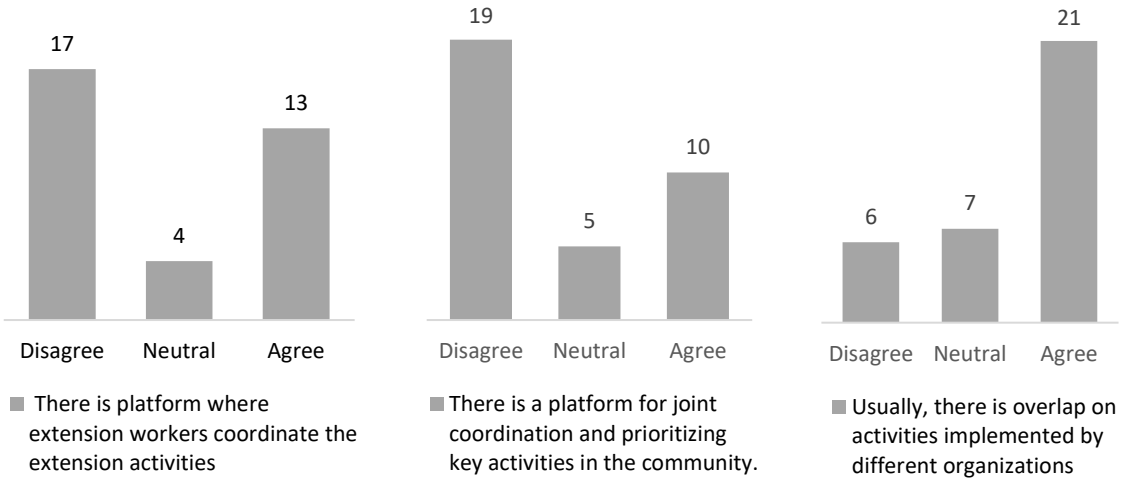

Figure 5. Extension workers' perceptions on coordination and collaboration with other organizations

The study participants also asserted that coordination is important to ensure better use of resources and facilitate communication with farmers. For example, participants perceive that with better coordination, organizations can share resources, identify areas where there is an overlap, and distribute them evenly. The study found mixed perspectives and views when asked about the existing coordination in the SLM extension and advisory services (figure 5). Extension workers agree that there is an overlap in activities promoted

by different organizations. They say that many organizations promote *'conservation agriculture'* and that different organizations often target or work with the same group of farmers and promote similar technologies.

The study participants agree that they know what other organizations are doing in the field, and they agree that their knowledge about that is often informal, usually through communication with farmers or by seeing others' organizations work *"during field days."*

Extension workers have different opinions on the platform for coordinating extension activities across extension organizations. Some extension workers consider the annual planning meeting a platform for coordinating activities. In contrast, others perceive the annual meeting as a forum to share information and less for coordination.

Furthermore, the study participants asserted that there is limited coordination between different organizations when promoting sustainable land management practices. The extension workers asserted that the limited coordination has implications for their work. First, extension workers perceive some duplication of efforts *since "we [different organizations] work with the same farmers, and sometimes we promote the same practice."* Secondly, extension workers agree that the lack of coordination leads to conflicting messages. There is no mechanism to oversee the messages and their relevance to the context.

The coordination question is perceived as necessary, and both the public and NGOs perceive that the public sector should be responsible for coordinating SLM extension activities. Furthermore, there is a consensus among the respondents that there should be standardized practices and a better alignment of interventions.

3.3.5. Knowledge Creation and Learning Among Extension Workers

There is a general understanding among extension providers that the provision of advisory services in land management is context-specific and requires specific knowledge – *"we need to know the types and conditions of the soil in each community"* – and is dynamic and changes over time:

> *"The soil condition has changed. In some communities, I see that fertility is declining; in others, there is erosion; and in some [communities] where we have promoted conservation agriculture, you can see some improvements. It was not like this five or ten years ago"* (NGO, Extension Worker 5).

This respondent asserted that working in sustainable land management requires continuously updating skills. The respondents agree that land management requires a constant and continuous knowledge update addressing the different agroecological conditions, soil types, and farmers' context. Furthermore, extension workers agree that farmers' experiences and knowledge should influence decisions about the technology, reemphasizing the need to promote relevant and valuable technologies to the farmers' context. As one program manager (community-based organization) explained:

> *"Farmers know their soils. Once, we promoted using fertilizers in a community with fertile soils. It was hard to convince them of the need for fertilizer because they did not perceive soil fertility as a problem."*

Extension workers agreed that extension services should continuously update extension workers' knowledge of land management because farmers' and scientists' soil knowledge is dynamic and continuously updated. Without updated knowledge, they fear that they will be unable to promote the new land management practices.

Land management knowledge systems require learning methods that account for and value multiple sources of knowledge (e.g., scientific versus local) and the capacity to integrate these sources of knowledge when developing extension messages. The interviews identified two forms of learning: informal and formal. Formal learning is achieved through participation in a formal training setting.

The first source of formal learning is an educational program provided by an academic or training organization that leads to a degree. The second source is the capacity-building training offered by extension organizations. Similar experiences are also observed in the NGO extension:

> *"We have a training curriculum in conservation agriculture. All the extensionists working on the project [name of the project] are trained. Every year, the extension participates in at least one training related to conservation agriculture or a new practice we want to introduce. For instance, if we introduce an herbicide, the extension worker will first be trained on using, managing, and handling herbicides, and then they can promote the practice."* (NGO, senior manager 2)

Informal learning is achieved mainly through interactions with peers, farmers, and other stakeholders in the system. First, the extension workers argued that interacting with peers is helpful once they share and can relate to their peers' experiences: they face the same adversities. They can quickly learn how their peers *"work and how they overcome challenges and can translate into our contexts."* A small group of extension workers asserted that farmers are a source of knowledge and that they learn from them. This group of extension workers asserted that they need to promote technologies that are relevant and useful to the farmers' context because *"Farmers know their soils, and they see if what we*

teach makes sense to their context or not. As an extension worker, I need to understand the local knowledge and adapt my message to fit in" (Public, extension worker 8).

Understanding farmers' knowledge about soil and existing local land management practices helps extension workers improve the content of the message and adapt or select the practice that best suits the local context. It is important to mention that the ability to select a practice is restricted to the practices in the technology package promoted by the organization. Extension workers can only recommend technologies within the ones existing in the organization's SLM technology package.

For example, based on what an extension worker had learned from farmers, the extension worker said, *"I will not promote mulch in a community with termite problems"* (Public, extension worker 8). The extension workers agree that understanding the local knowledge helps to make the technologies more relevant to the farmer.

While the perception is that it is important to understand and integrate informal learning outcomes, the respondents agree that the integration often occurs within the boundaries defined in the SLM Program. Some extension workers are constantly analyzing the alignment between the program goals and approaches with what they learn from farmers, peers, and other stakeholders. These extension workers identified two scenarios in which extension workers align project goals and farmers' knowledge. In the first scenario, the project goals are aligned with the farmers' knowledge and perceptions of soil management. In this scenario, learning is easy, and the extension workers need to unpack the project messages and align them with the farmers' perceptions. Usually, farmers perceive the problem and understand that technology will help them solve it. For example, extension workers agree that farmers are willing to use fertilizer to increase the yields of

their crops, and they are observing an increase in interest in farmers buying fertilizers, even in small quantities.

In the second scenario, there is a conflict between the project goals and farmers' knowledge and perceptions of the soil. In this scenario, there are two contrasting approaches. In the first approach, the extension workers will dismiss, invalidate, or ignore the farmers' knowledge and promote the technology regardless of its relevance or fitness to the local context.

Similar examples were raised on promoting mulch in areas where it is challenging to keep mulch in the soils. Despite knowing that much is not ideal for some regions (for example due to termites), mulch is continuing to be promoted. Another example is the use of permanent pits. Extension workers explained that most farmers perceive digging permanent pits as excessively labor-demanding and find it challenging to use the practice. The extension worker argued that in this context, they continue to promote the practices even when they have learned that the practice is not suitable for farmers' conditions.

Furthermore, extension workers perceive that pushing a technology that farmers have not validated will affect their relationship with farmers since they expect to see their experiences and needs reflected in the programs. The farmers will not trust an extension worker who continues to promote a practice they feel they cannot adopt. A consequence of the lack of trust is the difficulty in promoting SLM practices and showing their benefits.

The second approach is to accept farmers' knowledge and locally adapt the SLM practice. Extension workers will discuss suitable options or incorporate the farmers' knowledge and needs with their supervisors. The capacity to influence the organization and incorporate the experiences of extension workers and farmers varies from

organization to organization. Public sector extension workers infrequently discuss and suggest adaptations to existing practices since they tend to be less involved in decision-making. In NGOs, integrating farmers' experiences will vary and depends on the organization's culture. For example, the NGOs providing SLM extension as a component of a specific SLM project tend to have less involvement of extension workers; they tend to be *"dogmatic organizations since they have to comply with their proposal and cannot deviate from targets without the approval of donors." (NGO, supervisor 2).* At the same time, NGOs with in-country offices and more established organizations will incorporate extension workers' and farmers' experiences into the organization.

> *"Our extension workers constantly mentioned that in some communities, the use of mulch was ineffective, some communities would use the crop residues as livestock feed, and other communities had problems with termites. We adapt the practice: we change to cover crops in communities with mulch problems, and mulch is not mandatory in communities with livestock production"* (NGO, Senior Manager 3).

The organization's objectives also affect the inclusion of farmers' and extension workers' experiences and needs. For example, senior managers and extension supervisors perceive that, in some instances, it is necessary to persist in promoting a particular practice regardless of the feedback of extension workers and farmers. There is the assumption that the farmers' limited understanding of sustainability often leads them to use unsustainable practices. Thus, it is necessary to insist on specific practices and or messages.

> *"We know that farmers are skeptical towards using fertilizers [chemical fertilizer], but we also know that without fertilizers, the soils will not recover or produce sufficient to fulfill farmers' needs. We continue to promote and insist on fertilizer. Slowly, farmers are seeing the benefits and reassessing their understanding."* (Public, senior manager 1)

An interesting aspect emerging from the interviews is the use of the Internet as a source of information and learning. Extension workers acknowledged that they frequently use web-based sources seeking information and answers to farmers' questions:

> *"Often, the farmer has a specific question, and I cannot ask the researcher or the Agriculture Officer in the district office. I search on the internet, and I can quickly assist the farmer*." (Public, extension worker 14)

A follow-up on Internet use showed that extension workers seek information without observing the context or specific conditions. One of the respondents explained, "*For example, if a farmer asks about the fertilizer dosage, I will search the Internet for something like the quantity or dosage of the fertilizer"* (Public, extension worker 11). Additionally, extension workers seek information in Portuguese and narrow their online searches to websites from Portugal or Brazil. "*I often consult the Embrapa [Brazilian Agricultural Research Corporation] website. They [Embrapa] have a lot of information on soils, crops, irrigation, almost everything on agricultural production" (Public, extension worker 16).*

3.4. Discussion

This study aimed to understand the perception of extension workers about the factors that limit or enable their ability to promote SLM practices to farmers. Second, it explored the learning process among extension workers involved in SLM's extension and advisory services. The findings confirm those from previous studies of extension services in Sub-Saharan Africa regarding how they are organized and managed (Davis, 2008), the skills and competencies of agricultural extension workers (Landini, 2021), and extension

methods and coverage (Muchai et al., 2014; Davis, 2008; Giller et al., 2011; Baah-Ofori & Amoakohene, 2021).

The study's unique contribution lies in its exploration of the learning process of extension workers in the context of sustainable land management. It delved into the sources of information, uncovering a mix of formal sources (such as information from researchers), web-based sources, and informal sources (including peers, farmers, and individual networks).

The study shows that extension workers face challenges integrating multiple sources to build knowledge on land management and inform better decision-making on the diffusion of sustainable land management practices. The study findings indicate that (i) extension workers have access to multiple sources of information, (ii) the institutional setting in Mozambique is rigid and limits the extension workers' capacity to integrate multiple sources of knowledge into learning and organizational decision-making processes, and (iii) there is limited evidence of social learning or learning that goes beyond the (traditional) formal structures of learning. While there are opportunities for learning, the existing systems discourage social learning, thus limiting opportunities to integrate local context and extension workers' experiences with the farmers to improve future interventions on SLM. Extension workers can improve individual activities but are not transferred or integrated into the organizational structure.

3.4.1. Sources of information

Extension workers rely on formal and centralized forms of information and knowledge sharing. Training programs are the primary source of information. The participant organizations and extension workers acknowledge training programs as

necessary in building knowledge since they have access to the most recent information, have access to the experts, and can easily clarify concepts and generate a common understanding among extension workers.

Landini (2021) and Klerkx and Proctor (2013) reported similar findings on training, and Davis et al. (2008) linked the effectiveness of extension to participation in training programs (short and long-term).

The use of the Internet and Web-based materials as a source of information is growing among extension workers. Extension workers use websites as ad-hoc mechanisms to access information in the short term. Extension workers use web-based sources when they cannot access information through organizational channels (e.g., technical reports). Klerkx and Proctor (2013) reported that websites are an important source of information for land agents in the Netherlands and England. However, there is little discussion of the relevance and challenges of websites in the context of Sub-Saharan Africa, where there is limited availability of technical materials that are context-specific and relevant for the different farmers' contexts.

In Mozambique, the use of websites raises challenges. First, there is limited online information on soil and land management related to the Mozambique context. Extension workers use what is available and often is not the appropriate information for a given context. Extension workers extend their web search to other countries to respond to the first challenge. Due to language barriers, they tend to seek information from Portuguese websites, often from European (Portugal) and Latin America (Brazil) countries. The situation in these countries is different from that in Mozambique. This leads to a scenario in

which the extension worker uses and disseminates information that is not relevant to the farmers' context in Mozambique.

3.4.2. Interactions and construction of knowledge

A significant argument in natural resource management, including land and water management, is that the presence of multiple actors, multiple sources of knowledge, and the interactive nature of the systems will lead to learning among the system actors (Klerks & Proctor, 2013; Garforth et al., 2003) and therefore to improvement of management practices and sustainability. The study confirmed multiple providers of sustainable land management extension services. Multiple organizations often offer similar services, promote the same practices, and have cases of overlapping extension activities.

Furthermore, the study findings confirmed that different organizations are disseminating contradictory messages related to the same SLM topic. The study did not find evidence that extension workers try to learn from each other or coordinate their efforts. These findings are similar to those of Dougill et al. (2019) and Brown et al. (2018). Spielman et al. (2009) and Davis & Hermskek (2012) argued that a pluralistic extension system leads to demand-driven extension, where the providers work to integrate and address farmers' needs. However, although there is a diversity of organizations that promote sustainable land management in Mozambique, the study did not find evidence of demand-driven extension in sustainable land management; rather, the top-down and supply-driven approach dominates the promotion of SLM practices.

The study found evidence that individual extension workers constantly interact with the farmers, and they make simple adjustments to address the farmers' and communities' specificities and pressing problems raised by farmers. However, within the

boundaries of the specific sustainable land management project, there is little scope to include farmers' needs. In reality, the programs remain supply-driven in the sense that they tend to address the donor's development agenda. Extension workers are oriented to help farmers and have a demand-driven mentality, but the setting of the SLM program does not allow it.

First, extension workers are required to push for the technology identified by the experts as relevant to the context without necessarily addressing farmers' concerns. Secondly, extension workers' performance is measured by defined targets (e.g., farmers reached) and not necessarily by the impact and changes at the farmer level.

3.4.3. Learning

Learning has been described as an important element in improving natural resources management (Klerks & Proctor, 2013; Blackmore, 2007; Schwilch, 2012). Two types of learning have been described as important in sustainable land management: formal learning and social learning. The study results indicate that formal learning is considered valid in sustainable land management in Mozambique. Interviewees agreed that extension workers' academic level and participation in training programs indicate knowledge and learning. For example, extension workers with a high academic level are perceived as more knowledgeable.

The importance of formal education in the provision of extension has been explored by Davis et al. (2008), who recognized the important role formal training has and called for improving the training curricula in agricultural education institutions. Findings from this study suggest that while formal education is essential, extension workers and managers should understand that academic level is not a prerequisite for effectiveness in promoting

sustainable land management. First, many extension workers with higher academic levels are in non-agricultural or non-natural resource areas. Secondly, even for extension workers with more schooling, years of experience in the field and exposure to on-the-job training opportunities played a more significant role in knowledge acquisition. Extension workers with field experience have interacted more with farmers and undergone more social learning. They are conscious of farmers' contexts and try integrating their needs into their work.

Despite the evidence of social learning and how it impacts the provision of sustainable land management extension, the study found that the integration of social learning into organizations is limited. Two factors discussed in the first essay of this dissertation limit the integration of social learning into the organization. First, social learning is circumscribed to the project lifecycle. Second, the perception that these adjustments need to be validated by researchers or senior technical officers and that researchers will not be open to informal and local knowledge restrain extension workers from using informal learning.

The rigid nature of SLM programs limits or reduces the opportunities in which extension workers can capitalize on social capital and use what they learn to enhance the promotion of sustainable land management practices.

3.5. Conclusion

This study examined the experience of extension workers in Sustainable Land Management (SLM) in Mozambique to understand how the paradigm shift in extension plays out in practice. The study suggests that the provision of sustainable land management still follows a top-down and supply-driven approach, where technologies, communities,

and goals are defined before entering the target communities. Extension workers are oriented to help farmers, but the organization setting does not allow for a more participatory delivery of extension services.

This paper shows that sustainable land management extension systems prioritize formal learning and less informal learning. However, while extension workers engage and perceive the relevance of informal learning, the system needs to provide opportunities to integrate and improve from informal learning. The study identified the barriers to learning, and those predominant are the lack of coordination and collaboration between extension providers, the organization of extension services, and the perception that only scientific and technical knowledge are trustworthy. The study revealed that in the current setting, extension workers have limited influence in the system, they still work under the traditional transfer of technology approach.

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CHAPTER IV

FARMERS' PERCEPTIONS AND KNOWLEDGE OF SUSTAINABLE LAND MANAGEMENT PRACTICES IN SUSSUNDENGA, MOZAMBIQUE

4.1. Introduction

The condition of agricultural land in sub-Saharan Africa is declining, affecting the livelihoods of millions of African households and threatening food security in African countries. (Tully et al., 2015; Kuria et al., 2019). As an important production factor, improving land conditions, soil health, and fertility remains vital in achieving food security in sub-Saharan African countries. As a strategy to address food security and hunger in Sub-Saharan African countries, there is increasing investment in sustainable land management (SLM) activities that improve land and soil health has been the focus of agricultural research and development (Hurni et al., 2015; Emerton & Snyder, 2018)

In sub-Saharan Africa, governments made substantial investments in sustainable land management to support smallholder farmers in increasing agricultural yields and household income. However, the investment in sustainable land management has yet to result in the rapid and extensive adoption of these practices, posing a significant challenge. On the contrary, research indicates that the adoption of land management practices remains low (Andersson & D'Souza, 2014; Asfaw & Neka, 2017; Glover et al., 2016). This highlights the urgent need to understand the factors hindering the adoption of sustainable land management practices.

Studies that address the low adoption of agricultural technologies are numerous and address a variety of issues, including the socioeconomic drivers influencing farmer behaviors (Kassie et al., 2015; Teklewold et al., 2013), farmers' perception of soil

conditions (Assefa & Hans-Rudolf, 2016), impacts of SLM on ecosystems (Hurni et al., 2015). Furthermore, Emerton and Snyder (2018) pointed out that while these studies provide insights into adoption behaviors, they lack a holistic perspective on the farmer decision-making process on land management. For example, Assefa & Hans Rudolf (2016) showed that farmers develop land management strategies based on their perceptions and local understanding of soil problems. This underscores the crucial role of farmers' knowledge in shaping land management decisions. The present paper focuses on understanding farmers' knowledge about their land and how farmers' knowledge informs their response to external SLM interventions and decisions on land management.

Barrios and Trejo (2003) showed that farmers have relevant information and knowledge on soils and assess the compatibility of their knowledge and technical knowledge when making a land management decision. Farmers acquire knowledge of soil and land management through farming experiences, social interactions, and interactions with the environment. The literature has a vast list of examples of how people build knowledge and use it to support their land management decisions (Abera & Belachew, 2011; Eze et al., 2021; Gutiérrez García et al., 2020). For instance, Ajayi (2007) linked farmers' perception of soil characteristics as a determinant factor in adopting modern technologies. He found that farmers adopted practices to improve soil health in response to their perception of soil health as the factor limiting their crop yields. Teshome et al. (2016) showed that the perceived soil attributes and tenure systems determine farmers' investments in sustainable land management.

Despite the evidence supporting local knowledge and perceptions, these are often neglected during the decision-making process and developmental interventions (Barbero-

Sierra, 2018; Vanlauwe et al., 2015). However, the integration of local knowledge can bring significant benefits to land management systems. These systems, defined as socio-ecological systems (Richelle et al., 2018; Liniger et al., 2011), are dynamic, multifaceted, and knowledge-intensive, with multiple sources of knowledge informing land management decisions. By incorporating local knowledge, interventions can better address the social systems, including the existing perceptions, and create land management innovations that are compatible with the existing local knowledge while addressing the soil's ecological characteristics and properties (Schneider et al., 2012).

This research aimed to understand the knowledge and perceptions of farmers about land conditions and how these perceptions inform farmers' responses to external interventions and decisions about land management. The following research questions guided the study:

- How do farmers perceive and describe soil characteristics? What are the soil characteristics that farmers perceive as important?
- What management practices do farmers use as a result of their perception of soil characteristics?
- Are the practices used by farmers consistent with the measured plot soil analysis results?
- How do farmers perceive the SLM practices being promoted by external organizations?

4.1.1. Conceptual Framework

This study combines ethnopedology (Barrera-Bassols & Zinck, 2003), learning, and farmers' behavior (Leeuwis, 2004) theories to understand how farmers assess, decide, and manage their soils. Local soil knowledge is the existing knowledge in a community; it is acquired through years of interaction with the social and ecological environments (Barbero-Sierra et al., 2018; Gutiérrez García et al., 2020). Local knowledge (used interchangeably with traditional, indigenous, and farmers' knowledge) is specific to

communities; it is dynamic and influenced by social and cultural capital (Gutiérrez García et al., 2020)

Farmers build their knowledge systems from generation to generation based on their experiences and learning from others. Based on these knowledge systems, farmers have developed a perception of what is true and what works in their context and environment (Ekossa et al., 2018., Barrera-Bassols et al., 2006). Further, farmers use local knowledge to develop strategies to address, manage, and cope with problems in the system (Kome et al., 2018; Barbero-Sierra et al., 2018).

Local knowledge will determine how local communities and individuals assemble and manage the available resources (Barrios & Trejo, 2003; Dawoe et al., 2012). Thus, farmers' interest in innovation is related to the "rightness" of the innovation and how it resonates with farmers' belief systems and resource situations. For example, Kelly and Anderson (2016) have shown that a conflict between scientific and local knowledge reduces the likelihood of acceptance and utilization of scientific knowledge and reduces the success of SLM interventions.

Sustainable Land Management

In the last two decades, developing countries have seen a rapid expansion of interventions to improve the condition of agricultural lands. Sustainable Land Management (SLM) is a term referring to the *"adoption of land use systems that, through appropriate management practices, enables land users to maximize economic and social benefits from the land while maintaining the ecological support functions of the land resources*"(TerrAfrica, 2009). Sustainable Land Management has been promoted as a strategy to address land degradation, secure livelihoods, and ensure food security.

Liniger et al. (2011) identified three main principles of sustainable land management: increased land productivity, livelihoods, and improved ecosystems. Considering these principles, research and development organizations have identified and promoted several practices addressing land conditions in Sub-Saharan Africa. A review conducted by Branca et al. (2013) identified four main categories of sustainable land management promoted in developing countries (Table 6).

Table 6. Sustainable Land Management Practices in Developing Countries

Group of practices	Description
Agronomic	Practices with a focus on crop management. Examples of practices include cover crops, intercropping, crop rotation and fallow
Organic Fertilizer	Practices with a focus on maximizing the use of organic fertilizer and reducing the use of inorganic. Example of organic fertilizer include manure.
Soil Management	Practices to reduce the disturbance of soil. Minnimum tillage including zero tillage, ridge tillage and strip or zonal tillage
Water Management	Practices utilized to control the water movement. Examples of water management include terrace and contour farming,
Agroforestry	Farming systems combining wood perennials and agricultural crops.

Adapated from Branca et al.(2013)

Implementing sustainable land management practices is expected to have several benefits, including higher and more stable crop yields, increased system resilience, reduced production risk, and enhanced livelihoods and food security (Liniger et al., 2011; Branca et al., 2013).

Despite the evidence of benefits and investments in Sustainable Land Management, there is limited evidence of uptake and adoption of sustainable land management practices among smallholder farmers in Sub-Saharan Africa (Kassie et al., 2015; Branca et al., 2013; Guiller et al., 2015; Hurni et al., 2015). The low adoption levels of SLM resulted in a discussion about the SLM approaches and the extent to which the promoted SLM practices reflect the context-specific needs (Baudron et al., 2012; Andersson & Giller, 2012; Kuria et

al., 2019; Emerton & Snyder, 2018). Furthermore, there are arguments that the promotion of SLM follows a "blanket approach" (Andersson & Giller, 2012), where promoters adopt a prescriptive approach without an understanding of the local conditions, farmers' heterogeneity, and farmers' local land management practices (Giller et al., 2015; Vanlauwe et al., 2015).

Promotion of Sustainable Land Management in Mozambique

In Mozambique, soil degradation has been linked to farmers' traditional farming practices (Chichongue et al., 2020). The extensive slash-and-burn practices (Serrani et al., 2022), the limited access and utilization of soil management technologies, and the susceptibility to severe climatic events (droughts and floods) resulted in soil degradation and vulnerability of smallholder farming systems in Mozambique (Rafaela et al., 2022) and jeopardizing the livelihoods of Mozambican smallholder farmers.

In response, agricultural research and development organizations have invested significantly in SLM, emphasizing conservation agriculture (Nkala et al., 2011) and integrated soil health and fertility management (Ricardo Maria et al., 2017). Conservation agriculture (CA) and Integrated Soil Fertility Management (ISFM) focus on improving agronomic practices to improve soil health and increase agricultural yields. The difference between CA and ISFM relies on the guiding principles. Conservation agriculture focuses on the three principles of 1) no-till and reduced till, 2) permanent soil cover, and 3) crop rotation (Giller et al., 2015). A point of divergence among the CA scholars is the use of inorganic fertilizer alongside the three components, with some stressing its importance and some not. The ISFM principles address the inclusion of fertilizer, recommending (i) the

combination of organic inputs and inorganic fertilizer and (ii) the use of improved germplasm (Vanlauwe et al., 2015).

Similar to other Sub-Saharan African countries, there is limited evidence of adopting sustainable land management practices (Chichongue et al., 2020). The existing literature on the adoption of SLM in Mozambique tends to focus on the farmers' socio-demographic characteristics (Chichongue et al., 2020), agronomy and adaptability of SLM practices (Thierfelder et al., 2016), and access to information and extension services (Kondylis et al., 2016; Khainga et al., 2021). Limited studies focus on the technology's fitness for the local context.

Learning and Farmers' Behavior

Leeuwis (2004) proposes a simple model to understand the farmers' dynamic and complex decision-making process. The model assumes that farmers' decision-making is a cyclic process informed mainly by the social and agro-ecological environment. According to Leeuwis (2004), farmers continuously assess the innovation and use the feedback they receive from the agro-ecological (e.g., increase in crop productivity) and the social world (e.g., recognition in the community).

The decision to utilize an innovation is a complex and interactive process determined by social pressure, social practices, and the perceived response from the socio-ecological system. For instance, Ryan et al. (2003) shows the factors, including the connectedness to the resources, social status, and farmers' identity. Moreover, the decision reflects farmers' context and the extent to which the innovation aligns with the farmer's context (Brown et al., 2017).

First, farmers' technical and social practices shape the construction of knowledge. Technical practices relate to the technical skills and knowledge the farmers have developed and apply in their daily management activities. Often, farmers assess the complexity of the innovation and the skills required for successful implementation of the practice (Pannell et al., 2006). Moreover, the farmers' technical skills support an assessment of the associated risks and uncertainty that innovation brings into the farmers' system (Leeuwis, 2004; Pannell et al., 2006). Social practices refer to how people interact and relate to other community members, as well as the associated behaviors that are culturally accepted (Leeuwis, 2004).

Second, farmers act based on social relations and social pressure. The decision to utilize an innovation involves the individual and the community. The farmers might adopt a practice to keep or establish relationships in the community (e.g., improve the relationship with extension agents or follow a farmers' association practice). Burton (2004) further argues that farmers often seek recognition as "good farmers" and will decide based on how the practice or innovation will change their identity and position in the community. Ultimately, they might adopt the most popular practices (Ellison & Fudenberg, 1993).

Lastly, continuous interactions with the ecological system (multiple processes of experimentation and observation) lead to the development of a belief system and knowledge about soil health and land management (Barrera-Bassols & Zinck, 2003). Furthermore, farmers develop a perception of the soil's response to external stimuli. The belief systems inform them of what makes sense and what is true (Leeuwis, 2004), and they will use the belief system to assess new knowledge and innovations and make decisions about it. Any intervention needs to understand the existing belief systems and

develop innovations responsive to and fitting into the farmers' belief systems. Failing to understand the belief system can result in limited acceptance and adoption of innovations.

4.2. Methods

4.2.1. Study Area

The research was conducted in the four administrative posts in Sussundenga District, Mozambique: Dombe, Muhoa, Rotanda, and Sussundenga Sede. The district was purposefully selected due to its history with SLM interventions dating from the colonial era and the importance of the district in the country's agriculture. The district is recognized as an important agricultural production region and has received significant investment in agriculture, including sustainable land management, with particular emphasis on investments in conservation agriculture, agroforestry, and integrated soil fertility management. This paper uses the general term SLM as an umbrella term that may include one or more of these more specific approaches. As a result of external interventions, farmers in the district have been involved in several SLM projects and reported using a mix of SLM practices and approaches (Khainga et al., 2020). The study used a broad definition of SLM practices and included any practices developed to secure the ecological properties and functions of the soil while providing socio-economic benefits.

The agroecological conditions (e.g., rainfall, temperature, and soils) favor the development of agriculture; however, low productivity, usually associated with soil conditions, limits the growth of the agriculture sector. Furthermore, the El Niño effects make the district susceptible to cyclic drought and floods. To overcome the constraints of declining soil fertility, cyclic drought, and flood, farmers shift their agricultural production between highlands in the humid season and lowlands in the dry season.

4.2.2. Data Collection

The research used qualitative approaches (focus groups and semi-structured interviews) and soil analysis to understand farmers' perceptions, experiences, and knowledge about land management. The data collection process had three important phases. The first phase, the community entry, consisted of contacting the extension coordinator in each location. This phase aimed to introduce the researcher, explain the purpose of the study, and identify the focus group participants. The second phase was the focus group discussion, and the third phase was the semi-structured interview, including soil sampling.

Sampling

A purposive sampling strategy was used to identify the study participants. The criteria for selecting the study participants were sex (male and female farmers), years of experience in agriculture (farmers with more than five years of farming), and wealth status (poor and wealthy farmers). The principal selection criterion was farming experience. For the study, the experienced farmers are knowledgeable people (Patton, 2015; Davis & Wagner, 2003) in the community who can provide information about soil health and land management practices. A limitation of starting with the community's experienced farmers and then expanding the sample with a snowball approach is the possibility of excluding marginalized groups (Cleaver, 2001). This is because experienced and well-established farmers may most frequently identify others similar to them. To overcome this limitation, the initial recruitment criteria included experienced poor and female farmers. As an indicator of wealth, the number of plots (where farmers with less than two plots were

considered poor) and household source of income (where farmers who rely only on crops, without livestock production, were considered poor) were used.

Focus group discussion

The focus groups aimed to understand the local land problems, the history of land use, the land problems in the communities, the existing knowledge, and the extent to which the knowledge on land is shared among the community members. Two criteria were used to determine the composition of the group of experienced farmers: sex and farmers' wealth. The extension worker in each location proposed the names of the people he believed fulfilled the criteria. All the individuals identified by the extension workers were invited to the focus group.

Six focus group discussions were conducted in Dombe and Mohua. Logistical challenges associated with COVID-19 restrictions prevented the focus group from being conducted in Sussundenga-Sede and Rotanda.

Three focus groups were established in each location: one with male farmers, one with female farmers, and a mixed group with male and female farmers. The size of the group varied, with an average of seven people in each group, ranging from five to eleven. The sequence of focus groups varied. For example, Dombe was the first location to host a focus group—data collection was initiated with the mixed focus group and then the male and female farmers. During the discussion with female farmers, new information was gathered that was not shared during the mixed focus group. For example, women in Dombe were more specific when describing the changes in the soil after floods, identifying areas with soil problems, and describing how the problems impact their livelihoods. Based on this experience, in Muhoa, the approach was changed, and the data collection started with

the male and female farmers' focus groups, which then joined in a larger mixed group. The discussions were richer, and it was possible to use examples from other focus groups and discuss areas of consensus and divergence. The areas of divergence were then explored during the semi-structured interviews. In addition, during the focus group, follow-up questions were used to identify the experienced farmers who would be interviewed individually.

Semi-structured interviews

A total of 52 farmers, including all the focus group participants, were interviewed individually. Each semi-structured interview took approximately 45 minutes and was conducted in the farmer's plot. In Dombe and Muhoa, the additional experienced farmers were identified during the focus group. Due to COVID-19 restrictions, it was not possible to host a focus group in Sussundenga-Sede and Rotanda. In those communities, the extension agent introduced the researcher to the community leaders and the farmers' association president, who introduced her to some experienced farmers. The rest of the sample was then identified through snowball sampling.

Soil Sample

After each interview, the researcher visited the plot with the farmer. During the visits, farmers showed the characteristics they use to classify their soils. Soil samples were then collected and submitted for analysis. Due to budget limitations, it was only possible to analyze soil samples from 27 of the 52 farmers. Two soil samples were collected for each farmer, one from the bad and one from the good soil, as perceived by the farmer. The samples were then sent to the laboratory and analyzed separately. Soil samples were

collected in two layers: 0-15 and 15 -30 cm deep. Each sample was analyzed separately. The soil analysis results were drawn from the soil layer 0-15 cm deep.

4.2.3. Data Analysis

The focus groups and the semi-structured interviews were transcribed verbatim, and memos were produced. The transcriptions were coded and analyzed for patterns. Similar codes were grouped, and themes emerged for each group of codes. The data analysis was conducted in MAXQDA, and the function Compare Cases and Groups was used first to compare cases within each community and then to compare the groups represented by the four administrative posts.

The purpose of soil analysis was to understand to what extent farmers' perceptions of soil quality reflect the measured soil condition and, second, to understand if farmers' land management practices are consistent with the needs of site conditions. The texture and color of the soil were determined during soil sample collection. The soil samples were then sent to the soil laboratories at Eduardo Mondlane University in Maputo. The following parameters were measured and used for analysis: electrical conductivity (EC), soil pH, organic matter (MO), total organic carbon (CO), total nitrogen (N), ratio C/N, and available phosphorus (Table 7).

Table 7. Soil Analysis Parameter

Soil Parameter	Description
Electrical Conductivity (EC)	Concentration of salts in the soil
Soil pH (pH)	Provides soil acidity levels. To measure the pH it was used the water method.
Soil organic matter (SOM)	The soil organic matter affects the soil properties and increases soil fertility
Soil organic carbon (SOC)	Organic carbon that can be oxidated by soil microorganisms
Total Nitrogen (N)	Measures the organic and inorganic concentration of Nitrogen in the soil

Table 7. (cont'd)

C:N	The ratio C/N determines the organic matter decomposition velocity
Phosphorus (P)	Phosphorus available to the plants

4.3. Results

4.3.1. Farmers' Characteristics

Farmers in Sussundenga district generally have at least two farm plots in distinct locations. Usually, one of the plots is located in the lower areas and close to a water source, and the other plots are in the upper areas or areas with limited access to water. Farmers in Sussundenga have diversified cropping systems and produce mainly maize, legumes (particularly beans and soybean), sesame, and vegetables. Legumes, sesame, and vegetables are produced as cash crops, while maize is produced for household consumption. Maize and legumes (beans and soybean) are usually grown in upper areas with limited water access, and sesame is produced in marginal areas considered to have low fertility. Vegetables are often produced in lower areas or areas close to water sources. The size of the sampled plots varies from 0.5 to approximately six hectares. Gender and economic status are the main factors determining the size and number of plots in the household. Poor and female farmers tend to have fewer, smaller, and poor-quality plots.

In all the communities in the study, we found two groups of farmers: farmers native to the community and farmers who migrated to the community. When farmers were asked about their reasons for migration, searching for agricultural land was one of the main reasons. Some farmers abandoned the land in their previous community due to declining soil fertility, while others sought communities with large agricultural areas available.

Migration patterns provide insights into soil learning and knowledge creation. Farmers native to the community explained that they learned about soils through interactions within their social network and through experimentation. The same applies to farmers who migrated. This group of farmers, who moved from nearby communities (within 45 km and with similar agroecological conditions), brought knowledge and continued to learn through experimentation, observation, and interaction with neighbor plots. An aspect observed with farmers who migrated is that they often transferred and adapted knowledge from their previous community to their new one. The proximity between communities made it possible to transfer and adapt previous knowledge to the new local context. In addition, these farmers continue to gather new soil information and learn about soil conditions, local adaptation, and soil management approaches. For example, some farmers explained that they first experienced using tomato plant health as an indicator of soil quality in the new community. They learned that some soils are not suitable for tomato production, even when adding inorganic fertilizer.

4.3.2. Farmers' Evaluation of Soil Quality

The farmers interviewed use five main characteristics to assess soil quality: crop yields, the color of the soil, the texture of the soil, plant health, and vegetation. When combining these characteristics, farmers distinguish and describe three types of soils: good, poor (or bad), and average. For farmers in the study, good soils tend to be more fertile, dark in color, have a balanced clay and sand content, and have high water retention capacity. Farmers perceive good soil as highly productive soil and suitable for a wide range of crops. As one farmer explained:

> *"[the plot] will give good yields. You can plant bananas, maize, tomatoes, or sesame. All crops will produce well. While the other plot [with perceived poor soil] will only produce sesame [the crop is perceived as producing in poor soils] or you will have to add fertilizer to secure production*" [male farmer, Dombe]

In contrast, bad soils are those with low productivity, light color, high sand content, low water retention capacity, and suitability for a limited type of crop (e.g., sesame, groundnut). For farmers in the study, "In this [poor] soil, you can only produce sesame. Other crops, such as maize or beans, will not produce well." (Male farmer, Munhinga).

The third category is average soils. The criteria for classifying the soils are subjective and often related to farmers' priorities. For example, farmers were not consistent when distinguishing average soils from deficient soils. One group of farmers classifies sandy soil as "bad soil" and only suitable for groundnut production. In contrast, another group classifies sandy soils as average quality because they can produce good yields of groundnuts.

A characteristic noted as an indicator of soil quality is the ability to manage and plow it. Although the farmers in the study agreed that good soil should be easy to manage, they had different perceptions when using this characteristic to assess soil quality. Some farmers perceived their soils as bad but easy to plow since they have a high sand content. Other farmers argued they had good soils but were challenging to manage or plow due to the high clay content.

When discussing what soil characteristics were considered important when classifying the soils, farmers indicated that perceived crop yield is the most important characteristic of soil quality. The study finding indicates that using crop yields is subjective

since most farmers do not have good measurements of their plots. Very few farmers know the size of their farmlands, so they can only calculate their yield very roughly. Only those members of the farmers' association could indicate the area of their plots, but only for plots within the association area. Farmers use a variety of criteria to assess a plot's productivity, including the income from the plot and the quantity of bags harvested in each plot. Regardless, the inability to measure plot size leads to inaccuracy when assessing the crop yield and, thus, inaccuracies when comparing soil quality across plots and deciding on investing in plots.

The color of the soil is the second most important indicator of soil quality. Farmers distinguish three main colors of the soil: black, red, and white (Figure 6). The soil color characteristic is often associated with sand and clay content. The soil color that farmers call "white" is light brown. The most important characteristic of white soils is the high content of sand. Farmers perceive white soils as bad because 'few crops can grow well in this soil' (Male farmer, Munhinga). The white soils have low fertility and cannot retain water. While white soils are perceived as bad soil, farmers indicated that the soil had the favorable characteristic of being easy to plow.

Farmers generally perceive dark soils (red and black) as more fertile and suitable soils. The most important attributes of red and black soils are the reduced sand content and the high-water retention capacity compared to white soils. Farmers classify black and red soils differently, and the classification is context specific. In some locations (e.g., Dombe), black soils are classified as good soils, while in other locations (e.g., Muhoa), red soils are better when compared to black.

Figure 6. Soil color described by farmers. From left to right: black, red and white soil.

Understanding the different soil types is crucial for farmers, and they have own classification criteria (Table 8). Red soils, often considered the most fertile, have less sand content than white soils, retain water well, and are easy to manage and plow. Black soils, the second most preferred, have a higher clay content and can be challenging to manage during the rainy season. The perception of black soils varies among communities, with some considering them highly fertile and others rating their fertility as medium. The quality of black soil is typically associated with high clay content, high water retention, low workability during the wet season, and, therefore, difficulty in plowing. Farmers who struggle with soils high in clay content tend to classify them as medium-quality or poor soils.

Table 8. Farmers' characterization of soils

Color of the soil	Characteristics of the soil	Fertility	Local Name
Red	Balanced sand content Good water retention capacity	Relatively high fertility	Ndjica, njiwo, ivurinondimo
White	High sand content Low water retention 'Soft soil'	Low fertility	Cepe
Black	Low sand content High clay content 'Hard soil'	Varies from community to community	Njecha

Farmers further explained that their knowledge about the color of soil is changing. Farmers in Dombe explained that after the cyclone and the floods, they observed the appearance of "new white soils." Farmers explained that these soils result from water and soil movement during floods. Furthermore, they explained that the "new white soil" is more fertile than the other three soil colors in Dombe.

Plant health is a third characteristic used to assess soil quality. Farmers said they observe how a given crop grows in a plot. One of the crops that they usually use to assess soil fertility is tomatoes. Farmers argue that in bad soil, tomatoes will not grow well. Farmers assess the plant's vigor and tomatoes' plant health. Usually, weak plants will have unhealthy roots. Moreover, because the signs appear in the roots, farmers link tomato plant health to soil health.

Vegetation serves as a tangible indicator of soil quality (figure 7). Farmers note that the presence of certain weeds, such as *Striga asiatica*, can signal poor soil conditions. The occurrence of *Striga asiatica,* for instance, often leads to low yields, particularly in maize. This clear correlation between weed presence *and soil* quality underscores the importance of vegetation in soil assessment.

Figure 7. Example of plants used as indicator of soil quality. Striga asiatica (left) is an indicator of a bad soil and specifically for maize. Syzygium spp (right) is a tree used as indicator of fertile soils.

When selecting plots or deciding about crops to grow, farmers tend to look for vegetation indicators of bad soils such as Striga: "*If you have a plot with red witch [Striga asiatica], maize will not grow, even if you add fertilizer. You will spend a lot [of resources] trying to control the red witch"* (female farmer, Sussundenga-Sede). In contrast, farmers perceive legume shrubs and trees (for example, Afzelia sp. and Albizia sp.) as indicators of fertile soil.

4.3.3. Farmers' Plot Conditions

The soil analysis of physical properties indicates that Sussundenga soil textures vary from sandy clay loam to clay, with a few samples described as sandy. The results of the soil analysis (table 9) indicate that the soils in the four locations are overall acidic (pH range lower than 7), non-saline (EC-lower than 0.5), with low levels of total nitrogen (T lower than 0.5), low levels of soil organic matter (SOM lower 2%), soil organic carbon (SOC lower than 1%) and a low C: N ratio (less than 2).

Furthermore, for a larger number of soil samples, the amounts of phosphorus available are almost indistinguishable from zero, with only two samples with 3.79 and 1.1 mg/kg of phosphorus available.

Table 9. Measured soil properties of farmers' plots, by location and farmer's perceived soil quality

Location	Farmers Class	pH		EC(mS cm^{-1})		SOC (%)		SOM (%)		N (%)		C:N		Lab Class
		Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	Mean	Median	
Dombe	Bad soil	4.61	4.43	0.15	0.15	0.44	0.32	0.75	0.54	0.12	0.08	4.81	4.04	Low fertility
	Good Soil	4.57	4.49	0.15	0.15	0.36	0.20	0.66	0.43	0.09	0.09	4.61	2.43	Low fertility
Muhoa	Bad soil	5.04	4.74	0.16	0.13	0.52	0.30	0.89	0.51	0.11	0.09	7.51	2.40	Low fertility
	Good Soil	5.10	4.71	0.25	0.20	0.47	0.30	0.80	0.52	0.12	0.11	4.24	2.73	Low fertility
Rotanda	Bad soil	4.93	4.7	0.15	0.2	2.4	0.2	4.13	0.34	0.24	0.075	4.92	2.82	Low fertility
	Good Soil	4.78	4.725	0.16	0.17	1.07	0.786	1.83	1.349	0.19	0.135	8.20	5.40	Low fertility
Sussundenga Sede	Bad soil	4.85	4.725	0.16	0.175	0.47	0.392	0.81	0.674	0.1	0.091	4.68	4.058	Low fertility
	Good Soil	4.74	4.64	0.13	0.11	0.43	0.329	0.74	0.561	0.1	0.089	4.2	3.052	Low fertility
All locations	Bad soil	4.8	4.71	0.15	0.175	0.88	0.308	1.51	0.526	0.14	0.091	5.36	3.332	Low fertility
	Good Soil	4.79	4.685	0.17	0.185	0.53	0.318	0.92	0.569	0.12	0.101	5.03	3.154	Low fertility

Overall, the soil analysis indicates that the soils in Sussundenga are poor, with soil acidity and organic matter as the limiting factors. The soil test results indicate that farmers' perceptions about plot quality are not consistent with the plot-measured conditions. While farmers perceive their plots as good, the laboratory results indicate that they are acidic and often have low fertility.

4.3.4. Farmers' Management Practices

All farmers in the study recognize that the condition of their soils is changing, and the fertility in their plots is declining. All farmers stated that they are managing their soils to address the declining soil fertility and secure yields to sustain their livelihoods. Farmers indicate two main reasons for the change in soil conditions. The first reason is continuous farming and how it "*washes away or buries the 'manure[2]'*" (Male farmer, Dombe).

The second reason farmers point out is the occurrence of weather events, particularly heavy rain and floods. For farmers, floods move soils, changing the soil characteristics:

> *"The floods bring sand and soil from other areas and mix with our good soils. After IDAI [flood event that occurred two years before data collection], we see that our soils have changed, and now they look more like Njecha [local name of soil], with more sand and small stones."* (Female farmer, Dombe)

Farmers use a variety of soil management practices to address their soil conditions. The most important practices farmers indicate are leaving crop residues in the field, deep plowing, fallowing, crop rotation, intercropping, and farmyard manure.

[2] Farmers use the term manure to indicate nutrients in the soil.

Crop residue is a common practice among study participants. All the participants agreed that after harvesting, they leave crop residues in the field since it "*will add manure [nutrients] to the soil"* [female farmer, Dombe]. Deep plowing is the second most mentioned land management practice. Farmers argue that deep plowing will *"bring the buried nutrients to the surface*." The study findings indicate that deep plowing is common to farmers with access to animal traction or mechanized agriculture.

Farmers with more than one plot will practice fallowing**,** and they affirmed that fallowing is an important practice because it enables the plot to "*rest and store manure [nutrients]."* Farmers further stated that fallow farming is declining, and they indicated that factors such as intensive cropping practices and limited availability of agricultural land influence the practice. Farmers who have fallow agriculture as a soil management practice agree that they are only able to let the soil rest for a cropping season (usually a year) due to land scarcity. They understand that the current fallow time is not sufficient:

> "*In the past, I would leave this plot to rest for a minimum of 3 years and move to other areas, but now all the areas are occupied, and I cannot move as I used to. I need to produce. I need to divide the plot in two, but [if I do that] I will not have sufficient food in a small area." (Male farmer, Dombe)*

Lastly, farmers agree that they use crop management as a soil management approach. They have identified crop selection, crop rotation, and intercropping as the most used practices within crop management. For example, farmers will produce sesame in poor soils while producing vegetables and legumes in good soils. Furthermore, farmers agreed that crop rotation is a common practice, and farmers rotate crops to manage soil fertility:

> *"Beans are good for the soil; they add manure [nutrients], so after I harvest tomato, I will have green beans*" (female farmer, Munhinga).

> *"I always add fertilizer in tomatoes, and maize needs manure. So, after tomatoes, I will plant maize so the maize can use the fertilizer remaining in the soil*" (male farmer, Muhoa)

These quotes indicate that farmers perceive the combined effect of multiple practices and decide how to combine them best to increase the perceived effects of soil management practices. Furthermore, the study findings indicate that farmers use crop management practices with a short-term economic returns' perspective instead of the long-term effects on soil quality. Using sesame on poor soils or crop rotation using vegetables and maize indicates farmers' decision on short-term returns rather than long-term soil quality. Sesame and tomatoes are classified as cash crops and have no positive effect on soil properties.

When asked about fertilizer use, all farmers indicated that they know that fertilizer is good for crops, but very few use it. Farmers who use fertilizer asserted that they only use fertilizer in vegetable production, usually to ensure that they will have good yields and increase the yields. As mentioned by a farmer, "*If you do not add fertilizer to tomatoes, you will not produce anything. Tomatoes give you money, but they want fertilizer.*" Farmers preferred and accepted fertilizer as they perceived it would provide immediate and satisfactory results. Farmers also indicated that fertilizer is not easily accessible due to its high cost and the distance to agro-dealers.

During the interview, the farmers were asked, *"If you have a bag of free fertilizer, where would you apply the bag*?" All the respondents stated that they would use the bag of fertilizer in vegetable production, followed by legume production. When asked why these two crops, farmers mentioned good prices and access to markets.

> "*Tomatoes have good prices, and they sell very fast. I do not need to go to the city to sell tomatoes. People from the city travel here looking for tomatoes. During the harvesting, you see people with trucks buying soybean and cowpea [legumes]. However, [selling] maize is difficult; the price is not good – you do not get 10 meticals[3] per kilogram. With soy soybean, you can get 20 to 30 meticals; cowpea, 50 meticals or more; and tomatoes, 250-500/mt/box"."* [Female farmer Muhoa]

Farmers further explained that they would apply the fertilizer to their good soils. For farmers, applying fertilizer in good soils implied an *"increase in crop yields"* and more products to sell and generate household income. They explained that they would not apply it in the bad soil because it is not productive, and adding fertilizer would not significantly change crop yield. Farmers with only one soil type asserted that they would use the fertilizer in their cash crops *"because sesame and beans give you money"* (male farmer, Muhoa). Interestingly, the farmers mentioned that they would rotate the cash crop with maize and that the residual effect of the fertilizer applied on the cash crop would benefit the maize.

4.3.5. Farmers' Perceptions of Promoters' Practices

The study participants asserted that they receive information about sustainable land management from two significant sources: internal sources (e.g., relatives, friends, and neighbors) and external sources (extension services provided by projects and by the public sector). Farmers agree that information from relatives and neighbors is the most important source. Furthermore, farmers agree that external organizations provide a wide range of practices and expose them to innovation in sustainable land management.

[3] Metical is Mozambique's currency. At the time of the interview, the average exchange rate was US$1 = 68 meticals.

The study findings indicate a disconnect between promoters' and farmers' goals and principles when selecting the SLM practice. There is a broad understanding that the promoters' major objective is soil conservation, while farmers tend to prioritize short economic returns and household income. The promoters' approaches are expected to improve returns over time, just not immediately. From farmers' perspectives, some practices promoted by external organizations add costs (mostly labor), and some benefits are not observed in the short term. Farmers face the trade-off of conservation and economic returns in the short term.

Table 10 lists all the practices identified in the study area: the practices farmers cited as being promoted by external organizations and the practices farmers use on their own plots outside the field trials or demonstration plots. Furthermore, farmers perceive the need to improve their soils; however, some of the practices would imply changes in their production systems, including temporary reduction of production that they say they cannot afford.

Table 10. Farmers' perceptions about the SLM practices promoted by external organizations

Practice	Promoted by External Project	Projects' rationale for promoting the practice[1]	Used by Farmers[2]	Farmers Perception about the practice
Crop Rotation	Yes	Crop rotation systems with one legume crop. Legumes will fix nitrogen and support soil's nutrient cycle	Yes	Farmers perceive the practice as good for the soil. It helps soil to restore its fertility. Its major advantage occurs when there is the application of inorganic fertilizer and a residual effect of fertilizer (e.g., crop rotation of tomatoes and maize). *"After planting tomatoes, we plant maize or beans. They [maize plants] will use the manure [used interchangeably with fertilizer and nutrients] from tomatoes and will grow well*." (Female farmer, Muhoa)
Crop residue	Yes	Promoters encourage leaving crop residue and they perceive it is an entry point to the promotion and adoption of permanent soil cover (e.g., mulch)	Yes	Most farmers already leave crop residue as a traditional practice. Farmers perceive the crop residue as beneficial to the soil, which becomes *"more dark and richer in nutrients."* (Male farmer, Dombe).
Use of legumes	Yes	Legumes in a monocropping system. The legume can fix nitrogen, supporting the nutrient cycle	Yes	It is good for the soil and a good and reliable source of income. The major legumes promoted (soybean, cowpea, common bean) have market demand.
Grass hedges	Yes	To address soil erosion	Yes	Used mostly to address soil erosion. Farmers understand that using vetiver and other grasses helps to retain the soil and reduce the water movement during the raining season.

Table 10 (cont'd)

Fertilizer	Yes	To address soil fertility in the short term. Important to add micronutrients to the soil. Usually used in combination with other practices (e.g. intercropping and permanent pits)	Yes	Farmers perceive the practice as good for the soil and for the crops. It is costly and used mostly in cash crops. Fertilizers are most effective for vegetables (tomatoes in particular) and beans. Fertilizers are used to secure high yields regardless of soil condition. "*When you plant beans and you apply fertilizer, beans will grow well, the same if you plant tomatoes. All the crops will grow well when you apply fertilizer." (Male farmer, Muoha)*
Intercropping	Yes	Promoters are introducing intercropping with a cereal and a legume crop (to fix nitrogen) and when possible, with perennial legumes.	Yes	A limited group of farmers use the practice. Farmers perceive that intercropping is only appropriate when cultivating a specific crop. Some farmers perceive the maize and legume intercropping system as detrimental to legumes. *"The bean doesn't grow well in intercropping. Only maize grows well" (Male farmer, Dombe)"*
Compost	Yes	Promoted by few organizations, mostly organizations promoting organic and green fertilizers.	Yes	Used by a limited group of farmers, in small areas and mostly in vegetable production. Compost is good for the soil but requires time and resources to prepare the compost. Farmers provided the example of a compost requiring ingredients such as milk to support fermentation.
Farmyard Manure	Yes	To add organic matter and nutrients to the soil. Promoters explained that farmyard manure is a good source of macro-nutrients.	Yes	Mostly farmers with access to animals apply farmyard manure. Farmers believe that for some soils, the application of manure is the only way to secure production; without the application of farmyard manure, soils are not productive.
No till	Yes	To reduce soil disturbance, to maintain soil structure, support soil ecologic and biological processes, and create a growth condition for the soil microorganisms.	No	Farmers believe that nutrients are buried in the soil, and they need to revolve the soil and bring nutrients to the topsoil. As a result, they are skeptical of no till.

Table 10 (cont'd)

Mulch	Yes	To permanently cover the soil and add organic matter to the soils. Supports water retention and creates growth environment for soil microorganisms. In the long term improves soil structure, and soil fertility.	No	Farmers perceive that keeping mulch adds work for them due to scarcity of vegetation to source the mulch.
Ripper	Yes	Ripper tool attached to a tractor or oxen team is used during the land preparation and planting. Ripper is used to pen the lines and launch seed into the soil. The use of ripper reduces the soil disturbance and reduces the labor necessary during land preparation and planting.	No	Needs mechanization, and perceived a relatively complex
Permanent Pit/basin	Yes	The permanent pit reduces the hand hoe farmer's production cost. The largest investment occurs during the opening of the pit. Once opened, the farmers will use the same pit and add inputs to the pit. Reduces land preparation costs and costs with inputs, because farmers continuously apply inputs to the same pit, and considering the residual effects, with time the pit will restore the fertility level, gradually reducing the need for fertilizers.	No	Difficult to use, requires extra physical effort and good planning. Farmers believe that for smaller areas, the use of permanent pit is good because the level of effort is manageable. Issues are raised when discussing the expansion of permanent pit to larger areas. *"You have to open the pits during the dry season, the soils are dry, and it is difficult to dig the pits with the size they told us."* (Male farmer, Munhinga)

Table 10 (cont'd)

Green cover	Yes	To be used as replacement for mulch. After harvesting, the soil will continue covered with a legume crop, with a foliage structure that keeps the soil fully covered.	No	It is relatively new. Farmers are still evaluating the practice.
Deep plow	No		Yes	To bring the nutrients to the topsoil.
Fallow	No		Yes	Farmers with more than two plots use this practice; others perceive land as too scarce.

The acceptance of soil management practices by farmers is heavily influenced by their individual perception of soil conditions. This perception, in turn, is shaped by their existing knowledge and practices. For instance, farmers who perceive their soils as fertile are less likely to adopt new soil management practices unless they demonstrate high yields and quick returns (such as fertilizers) or align with their existing practices (such as crop residue or mulch) without incurring additional costs.

Farmers who perceive their soil as good do not understand the relevance of focusing on soil conditions. While these farmers perceive that soil conditions are declining in the community, they do not see the urgency to improve as long as they perceive hat they are able to maintain their soil's condition. The farmers perceive their soil as productive and associate any decline in production with events such as floods and pests.

Furthermore, farmers' acceptance of a given practice further depends on how appropriate they perceive the practice and if it is compatible with their knowledge. For example, many organizations promote intercropping, and the study finds mixed perceptions about the practice. Farmers with a bad assessment of intercropping tend to think it is not suitable for their conditions; there is the misperception that only a few crops will benefit from intercropping. Furthermore, farmers believe managing multiple crops in an intercropping system can be difficult and expensive. For example, farmers asserted that intercropping results in managing multiple planting times, having to manage pests of different crops (and the need to purchase different pesticides), and weeding at different times (requiring more labor):

> "Each crop has its own cropping season. For example, this is the time [interviews were conducted in late February] when we have a lot of fall armyworm [a pest predominant in maize], and if we plant maize,

> we will get low yields. Even if we plant maize and beans [in intercropping], maize will not develop well. (Male farmer, Sussundenga-Sede).

Farmers with a positive assessment of intercropping tend to link the practice to farm management rather than soil management. For example, this group of farmers argued that intercropping is a good practice because farmers can save on labor and reduce some costs (weeding, pest management, etc.). As one farmer stated, "I do not have to weed as much as I did before" [male farmer, Mohua]. Furthermore, depending on the crop selection, farmers perceive that intercropping can provide, simultaneously, a source of protein and a source of carbohydrates, supporting the household nutrition goals: "You can get curry and xima [stapple food, typical maize-based porridge] (Female farmer Sussundenga-Sede).

The farmers in the study agreed that crop rotation is a good soil management practice. As pointed out by farmers, the most important advantage of crop rotation is the possibility of maximizing the residual effect of fertilizers. Farmers said that when selecting crops in rotation, they tend to select crops according to their importance in the household (consumption and income generation) and how to maximize the residual effects of fertilizer in the soil. Crop rotation using tomato-maize and maize-sesame is very common. Farmers' selection of crops is distinct from the crop selection promoted by external organizations. The external organizations often promote crop rotation and intercropping using cereals (e.g., maize) and legumes (e.g., beans). The principle is that legumes have the capacity to fix nitrogen and improve soil fertility. In comparison, farmers tend to think about yields and increasing the household's sources of income and food.

The farmers recognized that external projects led them to introduce innovations to the local practices. For example, farmers mentioned that crop rotation is common in their

communities. Still, they did not consider the type of crop (legume or cereal) in a rotation system: "*I would use maize and sorghum in rotation. The project told me to use beans. Now, I do maize and beans, and I can see that things have improved. I get more bags of maize" [male farmer, Sussundenga].* Another example of innovation is the use of mulch. Farmers mentioned that retaining crop residue in the field is a common practice, and they leave the residue in the field until the next cropping system. However, when discussing mulch, farmers explained that the project frequently requires permanent mulch in the field. From farmers' perspectives, a major limitation of mulch is the decomposition rate; mulch decomposes quickly, especially in areas prone to termites. Farmers explained that in some demonstration plots, farmers had to collect or buy more grass to ensure permanent cover. Thus, applying mulch would add costs to the farmer's household. Farmers recognized that projects have introduced green cover and cover crops, which was seen as a variation of using mulch as permanent cover. Most farmers in the study are assessing the practice.

The study reveals a significant gap between the practices advocated by external organizations and those actually adopted by farmers. While promoters often work under the conservation lens, focusing on medium- to long-term economic gains and soil health benefits, farmers are more likely to invest in and adopt practices that yield immediate economic gains. This disparity underscores the need for a more nuanced approach to agricultural interventions that takes into account farmers' short-term economic needs and their understanding of soil degradation issues.

4.4. Discussion

Limited studies address farmer knowledge and perceptions about land management in Mozambique. The existing studies tend to focus on the adoption of land management practices (Grabowski & Kerr, 2011; Mapila et al., 2012; Lalani et al., 2016; Chichongue et al., 2020); the impacts of SLM on farmers' livelihoods (Nkala et al., 2011); and the role of extension agents on the adoption of sustainable land management (Kondylis et al., 2016). This study aimed to fill this knowledge gap. The study focuses on how farmers classify their soils, what management practices they perceive as compatible with the condition of their soil, and what sustainable land management practices farmers adopt to respond to perceived deficiencies in soil quality and health.

The study's first research question asked how farmers classify their soils. The study's findings indicate that farmers use a variety of characteristics to describe the quality of their plots. Farmers assess crop yields, soil color, sand content, and vegetation as important characteristics when classifying soils by quality. Similar results have been found elsewhere (Essougong et al., 2020; Kuria et al., 2019; Nord, 2018), where farmers distinguish their plots as good or bad depending on the location of the plot (Emerton & Snyder, 2018) color of the soils and crop yield (Essougong et al., 2020). The ability to work and manage the soil has been defined as a soil quality indicator farmers use (Nord, 2018). However, no clear distinction exists on how soil manageability is utilized to classify the plots. We find a diversity of perceptions of soil manageability. For example, farmers classified plots with high clay content as good soils but difficult to manage during the rainy season.

While farmers' classification provides an initial assessment of soil condition and insights into soil structure and water retention capacity (by associating with clay and sand content), the assessment of soil by farmers is insufficient to accurately indicate the soil condition (Berazneva et al., 2018) as farmers do not integrate indicators usually associated with soil quality, such as organic matter, infiltration and drainage, soil depth, and aggregation (Arshad & Martin, 2002).

The study found similar findings to Assefa & Hans-Rudolf (2016). Farmers in Sussundenga recognize that soil fertility in their plots is declining, and they utilize various sustainable land management practices to address soil degradation. Based on farmer descriptions, two groups of SLM practices were identified: practices to control erosion (e.g., grass strips, contour planting) and practices to manage nutrients (e.g., fertilizer, deep plowing). These groups of practices are similar to the ones identified in the review conducted by Nord et al. (2022).

When selecting a technology or practice, farmers identified its main attributes. The first attribute is the economic return. Farmers are more likely to select SLM practices that provide high yields and economic returns in the short term. The second attribute is the cost of technology. Farmers will select and invest in practices that require fewer resources (labor and the cost of materials). The third attribute is alignment with existing knowledge or farmers' traditional practices. Farmers will accept practices that are similar to the practices they already know (e.g., crop rotation, crop residue) and will reject the practices that are contrary to their system's beliefs and knowledge (e.g., no-till or minimum tillage). The fourth attribute is the perceived ease of application or use of the technology; complex

or labor-intensive technologies are less likely to be used (Emerton & Snyder, 2018; Vanlauwe et al., 2015).

Farmers tend to use the attributes together and ultimately assess the technology's costs and benefits (Cordingley et al., 2015). For example, farmers perceive fertilizer to be costly, but it will provide a high yield and quick economic returns. To secure income, the farmer will use fertilizer in cash crops (Mapila et al., 2012; Emerton & Snyder, 2018) and not in crops used for household consumption or crops with low economic value. In contrast, farmers perceive that permanent pits are labor-intensive, and despite documented benefits to the soil, farmers are less likely to use the permanent pits.

The farmers' beliefs about tillage are entirely at odds with the principles of SLM that the programs are trying to instill. Farmers tend to engage in tillage, especially deep plowing, as they perceive that the soil nutrients are buried and that plants can only access them if the nutrients are close to the surface. In fact, farmers are skeptical of some practices, such as permanent pits, not only because of their high cost in terms of labor but because the practice implies the "burial" of fertilizers and nutrients deep in the soil where, according to their beliefs, plants will not access them.

The soil analysis showed two interesting findings. First, the laboratory analysis showed that farmers' plots are poor, contradicting farmers' perceptions of good soils. Secondly, the soil analysis indicated that the soil is acidic. The farmers did not mention soil acidity as a limitation. Assefa and Hans-Rudolf (2016) found similar results in Ethiopia. A major implication of soil acidity is that it limits the availability of nutrients, including the absorption of nutrients and phosphorous (Agegnehu et al., 2021).

Furthermore, the study findings indicate that promoters also miss addressing soil acidity in the short term. The promoters are disseminating primarily organic amendment practices to manage nutrients (table 5), and while these practices can address soil acidity in the long term, in the short term, soil acidity can limit the immediate benefits of some of the practices in places since the current acidity levels inhibit the accumulation of nutrients in the soil and the plant nutrients absorption. Vanlauwe et al. (2015) showed similar results in Sub-Saharan African countries and argued that SLM interventions in Sub-Saharan Africa fail to address some immediate soil problems. For example, using lime in the short term is effective in addressing soil acidity, but the practice is not promoted.

The second key finding concerns the drivers of the decision to use land management practices. Farmers tend to prioritize production objectives, economic returns, and improving livelihoods rather than soil conservation, with few exceptions to practices addressing soil erosion, where conservation plays an important role. The economic return as a driver of farmers' decision to use sustainable land management practices has been documented by Berazneva et al. (2018), Cordingley et al. (2015), Emerton & Snyder (2018); Grabowski and Kerr (2013), and Vanlauwe et al. (2015). With the principle of economic returns, farmers tend to invest in plots that they perceive as having good soils since they perceive that these plots will provide the maximum yield when properly managed. Farmers will not allocate scarce resources to poor soils, anticipating low returns.

Berazneva et al. (2018) argue that farmers are more likely to invest in technologies addressing what they perceive as yield-limiting factors based on their perception of soil quality and yield determinants. Because farmers use crop yield as the main soil quality indicator and many of them perceive their soil as good quality, they tend to attribute the

production shortfall to other factors and not to soil quality (Berazneva et al. 2018; Essougong et al. 2020).

Lastly, the study findings confirm that farmers select practices aligned with their belief system, context, and compatibility with existing practices. In some instances, farmers' belief systems conflict with the promoters' principles on sustainable land management practices that make sense in their context. For example, from Table 6, tillage and deep plowing are common practices among farmers, contradicting the messages disseminated by promoters to reduce tillage and soil disturbance. Farmers understand that tillage will create a good seedbed and increase the nutrients in the topsoil. Farmers fail to understand that the perceived benefits are short-term but will result in soil degradation over time. This suggests that the organizations working in SLM should understand the existing beliefs.

One possibility is to identify sustainable practices at least partly aligned with these beliefs. Furthermore, farmers are unfamiliar with soil testing and have never had their soil analyzed. The study findings indicate that in cases where the farmers' beliefs are not sustainable (e.g., deep plowing), organizations should provide evidence (using soil analysis) showing the sustainability issues around farmers' practices.

Currently, the projects do not take such approaches. Regardless of farmers' management purposes, promoters are "pushing" for conservation practices and investing in practices that primarily focus on long-term benefits to soil health and miss integrating farmers' short-term economic and livelihood improvement goals.

4.5. Conclusion

This study analyzes how farmers in Mozambique classify their soils and what management strategies they adopt to address perceived soil conditions. The study indicates that farmers use crop yield as a major criterion for assessing soil quality. Although this provides an initial assessment of the soil, it is not sufficient to indicate the soil condition. Farmers fail to include organic matter, soil depth, aggregation infiltration, and drainage in their assessment parameters. To address the perceived soil condition, farmers employ a variety of land management practices, both local and introduced by promoters. They focus on practices that will increase yields in the short term and invest in plots that are perceived as good and productive soils. When selecting the practice, farmers define the attributes of the practice and continuously assess the extent to which the practices are aligned with their belief systems, tending to neglect practices contrary to their beliefs. Lastly, farmers react to external organizations by analyzing the alignment with their practices and the perceived complexity and cost of the practice. The study finds a disconnection between farmers' interests and the approaches of external organizations to land management. Farmers tend to focus on short-term economic and livelihood improvements, while external organizations focus on medium- to long-term conservation and livelihood improvement. The study also acknowledges that there is a common ground between farmers and promoters; they both seek improvement of soil health and increase crop yield; the difference is in the priorities and approaches each group adopts to accomplish the goals. Understanding the belief systems of farmers and the attributes they use to classify and select a technology is important when developing sustainable land management interventions to help ensure that practices fit the local context.

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APPENDIX. FARMERS INTERVIEW GUIDE (IN PORTUGUESE)

Study Title: Farmers' perceptions and knowledge of sustainable land management practices in Sussundenga, Mozambique (in Portuguese)

Entrevista qualitativa aos agricultores no distrito de Sussundenga
Comece por se apresentar ao agricultor: seu nome, e de onde vem, e porquê a razão da entrevista. Peça autorização para gravar a entrevista. De seguida leia a nota de consentimento abaixo e após a leitura pergunte se o agricultor aceita ou não ser entrevistado. Somente entreviste os agricultores que aceitarem participar no estudo.

Consentimento para participação em pesquisa
Você recebeu uma solicitação para participar de um estudo. Este estudo tem como objectivo principal perceber como é que os agricultores no distrito de Sussundenga classificam os seus solos e como é que eles fazem a gestão dos solos, para aumentar a produtividade, ter melhor produção, agrícola.
Sua participação nesta pesquisa é voluntária. Você pode se recusar a participar da pesquisa ou sair da pesquisa a qualquer momento, sem penalidades. Se por qualquer motivo não quiser responder a uma pergunta especifica você é livre de recusar a responder. Se não quiser responder pergunta por favor diga, e iremos saltar a pergunta.
As suas respostas serão mantidas confidenciais e ninguém será capaz de identificar a si ou as suas respostas, e ninguém saberá se você participou ou não neste estudo. No final da pesquisa, você será questionado se está interessado em participar de uma entrevista adicional [por telefone ou pessoalmente]. Se você optar por fornecer informações adicionais, como seu número de telefone, sua resposta só será utilizada pelo pesquisador. No entanto, nenhum nome ou informação de identificação seria incluído em nenhuma publicação ou apresentação com base nesses dados, e suas respostas a esta pesquisa permanecerão confidenciais.
Caso tenha dúvidas sobre a pesquisa, você pode entrar em contato com Ângela Manjichi (número de telefone: 816254595 ou 877254595) a qualquer momento.
Ao concordar em ser entrevistado significa que o estudo, incluindo as informações acima, foi descrito oralmente para você e que você concorda voluntariamente em participar.
Concorda em participar do estudo:

Sim Não

Guião de Entrevista

A. Informação Da Zona

A.1. Localidade:
A1.1. Povoado/aldeia/bairro:
A.2. Código da entrevista:

B. Informação geral

B 1. Fale nos um pouco de si:

- Género (não precisa perguntar, só anote se é homem ou mulher)
- Idade?
- É o chefe do agregado? Se não, qual é a sua relação com o chefe do agregado? (cônjuge, mãe, filho, etc.?)
- Quantos membros tem o agregado e qual é a sua relação consigo?
- Há quanto tempo vive nesta zona?
- Caso tenha se mudado para a zona, há quanto tempo se mudou e porque se mudou?

B.2. Quais são as fontes de renda no seu agregado?

- E quem no agregado está envolvido nestas actividades? *[se por exemplo diz emprego pergunta quem tem emprego na família, se diz agricultura quem faz agricultura, pecuária quem faz a pecuária?]*

B.3. Tem telefone? Se sim qual é o número:

C. Informação sobre solos

Nota: Este trabalho procura entender os diferentes tipos de solos que existem na comunidade e ver como a comunidade faz a gestão dos mesmos.

C.1. Quais são os tipos de solo que conhece? Estes solos existem na sua comunidade? (Nota: Procure saber os nomes locais de cada solo e explore os seguintes aspectos)

C.2. Quais são as características destes solos? (Nota: Procure saber os nomes locais de cada solo e explore os seguintes aspectos)

- Cor
- Textura
- Capacidade de retenção de água
- Presença de certos tipos de plantas/microorganismos
- Nome local do solo
- Outras caracteristicas?

C.3. Como classifica estes solos? São bons ou maus?

C.4. Qual dos solos é mau e o que faz com que o solo seja mau?

C.5. Qual dos solos é bom e que faz com que o solo seja bom?

D. Gestão dos solos na machamba do camponês

D.1. Quantas machambas possui? Sabe qual é a área de cada machamba?

- O que produz na sua machamba? Quem é responsável por cada cultura/machamba

[*Se for um agregado casado, explore para cada machamba, quem no agregado está envolvido na gestão das machambas. Se é o marido ou a mulher*]

D.2. Qual dos solos tem na sua machamba?

- Faz alguma coisa para melhorar ou manter a qualidade de solos?
    - Se sim o que faz?
    - Se não, o que o impede de fazer algo pelos solos?
    - Os solos que tem são bons para algum tipo de culturas? Que culturas?

D.3. Põe adubos ou estrumes nas suas machambas? Se sim, que tipo de adubo ou estrume usa e porque usa adubos/estrumes?

D.4. Se sim em que culturas ou parcelas aplica o adubo ou o estrume?

D.5. Acha que a sua forma (estratégia) de gestão de solos está a funcionar?

- O que faz com que funcione (ou não funcione)?
- Dada a situação actual o que é preciso mudar?

E. Perceção sobre degradação dos solos

E.1. Quais são os problemas que os solo aqui na comunidade tem? Seus solos também tem o mesmo problema?

E.2. O que causa os problemas do solo?

E.3. Faz alguma coisa para resolver estes problemas?

- Se faz algo, o que faz? É o mesmo para todas as machambas ou diferente? Se é diferente por favor nos diga o que faz em cada tipo de solo e porque faz?
- Se não, porque não faz? Existe algo que gostaria de fazer, mas não consegue fazer para melhor gerir os solos? O que é? Porque não consegue fazer nas suas machambas?

E.4. Se tiver algum problema com seus solos, sabe monde ir buscar informação ou ajuda?

- Se sim, já alguma vez teve que recorrer a ajuda para um problema específico de solos?
- Se sim, pode dizer o que aconteceu? Qual era o problema, a quem pediu apoio/informação, e qual foi o resultado obtido.
- Conhece pessoas na comunidade que fazem algo para melhorar ou manter os solos? Sabe o que é que eles estão a fazer? *[se sim procure saber o nome e onde fica a pessoa, esta pessoa deve ser entrevistada]*

E.5. Sabe o que é matéria orgânica? Se sim, acha que é bom ou mau para o solo? [*Explique que matéria orgânica são restos de planta sou animais que ficam no solo]*

E.6. Já ouviu falar de erosão de solos? Existem locais aqui na comunidade com esses problemas? Se sim, como fazem para resolver o problema de erosão?

E.7. Que tipo de informação precisa para lhe melhor gerir os seus solos?

F. Acesso à informação e formações

F.1. Como é que aprendeu a manejar o solo?
F.2. As formas de gestão do solo mudaram?

- Em que solos mudaram?
- E como é que mudaram?

F.3. Já recebeu informação ou treinamentos sobre como melhorar os solos?

a. Caso sim pergunte: que tipo de informação recebeu? Quem deu a informação?
- Está a implementar alguma das técnicas aprendidas? Se sim quais? E o que faz continuar a utilizar as técnicas
- Caso não esteja a usar as técnicas, quais são as razoes que o fazem não usar as técnicas?
- Sabe onde obter informações se quiser saber como melhorar o seu solo? Caso sim, onde?

b. Caso não, pergunte de onde ele aprende novas formas de cuidar do solo?

F.4. É membro de alguma associação/grupo de produtores?

a. Porque decidiu ser ou não ser membro da associação?

Muito obrigada pelo seu tempo. Gostaria de pedir a sua permissao para colher uma amostra do solo nas suas parcelas. Vamos usar uma sonda para tirar uma pequena quantidade de solo, estas amostras ser~ao enviadas para o laboratorio e serao analisadas e teremos informacao do snutrientes que existem no solo.

Procure a amostra do solo da machamba do camponês. Colha uma pequena amostra do solo armazene no recipiente próprio. Não se esqueça de catalogar com o número do respectivo produtor. Tire fotos do local. Use o LAndPKS para fazer uma caraterização do solo com os agricultores

CHAPTER V

CONCLUSION

This dissertation is an introductory exploratory study on innovation systems and learning in Sustainable Land Management Systems in Mozambique. It builds on the work of Spielman et al. (2009) and Klerkx and Begemann (2020). It uses an interdisciplinary approach to understand the interactions between stakeholders and learning processes in Sustainable Land Management in Mozambique.

The first essay explores organizations and individuals promoting sustainable land management to learn and make decisions about the SLM innovations in Mozambique. The essay builds on the assumption that there is a participatory design of SLM innovations and interventions and that organizations prioritize learning from experiences and interactions with farmers and other actors to design and implement SLM programs. The study unveils a scenario where SLM innovations and interventions are influenced by the perception of donors' requirements with limited opportunities to integrate other sources of knowledge (e.g., farmers' knowledge) and opportunities for organizational learning. We find evidence of learning primarily at the individual and often determined by individual attributes. Learning is less systematic and less frequent at the organizational level. Institutional constraints and incentives limit learning due to perceived pressure to execute donor-funded projects precisely as designed, without room for adaptation. Some organizations perceive that there are factors limiting their learning capacity, and other organizations do not perceive the need for learning as long as they can secure funding sources.

Extension services play a pivotal role in disseminating and transferring SLM innovation. Recent approaches have shifted towards a participatory approach and demand-

driven extension services, moving away from the top-down and supply-driven approaches that have traditionally characterized extension provision. The second essay aims to understand how this paradigm shift in extension plays out in practice when promoting SLM in Mozambique. The results reveal a concerning trend where the provision of SLM extension services still largely follows a top-down and supply-driven approach, with limited involvement of extension workers and farmers. Despite their orientation to assist farmers, extension workers are often relegated to the role of passive agents in the process. They operate under the linear model of technology transfer and are unable to integrate their experiences in extension design, as these are typically defined during the project design and approval stages.

The last essay explores how farmers build knowledge and make decisions about land management. The study results reveal three important insights. First, farmers use their criteria to assess soil conditions. While these criteria are useful, they are not sufficient to indicate soil conditions. Second, farmers have their own belief systems on the land and have defined a set of innovation attributes they use to select the land management practice. Lastly, farmers prioritize short-term economic results and invest in plots they consider good to secure agricultural yields and livelihoods. Often, promoters of an extension worker are unaware or tend to ignore farmers' belief systems and do not include them when selecting and promoting SLM innovations.

Overall, the dissertation research results show that the promotion of SLM in Mozambique is defined by (i) the perception of donors' priorities and funding schemes and (ii) the influence of international NGOs that can attract donor funding and fund the

activities of local organizations. These factors result in competition between several organizations, leading to overlapping roles, limited collaboration, and limited coordination.

The dissertation research also unveils a disconnection between the different actors in the system. While the actors agree that land management is important and urgent in addressing food security and improving rural livelihoods, the approaches and priorities on SLM vary among the stakeholders. Of particular importance are the differences between promoters and farmers. Farmers prioritize innovations that secure short-term economic returns, while promoters focus on long-term soil conservation. Often, promoters' goals conflict with farmers' immediate needs, leading to a lack of acceptance and limited adoption of land management innovations.

5.1. The Broader Implication for the Promotion of Sustainable Land Management

The study shows that stakeholders understand that addressing sustainable land management is critical for sustainable agricultural production and food security in Mozambique. The study highlights areas of agreement between actors in the systems. It unveils conflicting perspectives on selecting and utilizing SLM practices, often determined by short-term economic returns versus medium to long-term soil conservation benefits. The dissertation research results suggest four areas that decision-makers must address when addressing SLM interventions in Mozambique.

First, the current scenario of promoting and diffusing sustainable land management practices occurs without information on soil conditions. Organizations promoting SLM do not conduct soil analysis to understand site-specific conditions and introduce practices that address soil-specific conditions in the short and long term. Farmers also make decisions based on their perception of soil conditions, and while farmer perceptions are valid, they

do not provide sufficient information about soil conditions. Promoting SLM innovations significantly depends on the provision of soil analysis. Organizations can identify practices that best fit the site-specific conditions, and farmers can make decisions about their soils based on the measured condition and quality of their soils.

Second, the system requires better coordination and participation of local government organizations in implementing activities at the community and local levels. Government agencies operate in the dark, are often uninformed about the different programs, and have limited space to influence the projects. The lack of involvement of local government agencies results in the overlap of SLM activities, targeting the same communities and farmers and leaving others without access to SLM innovations, jeopardizing the sustainability of such projects since government agencies and public extension are responsible for continuing to promote the NGO-led innovations after the end of the NGO project.

Third, organizations and donors should maximize and institutionalize opportunities for informal learning. The study shows that promoters, extension workers, and farmers most value informal learning. However, these should be considered in the design and implementation of the SLM program, which tends to include opportunities only for formal learning. Furthermore, farmer knowledge, perceptions, and adaptations should be addressed and integrated into the design of SLM programs and extension methods. Integration of farmers' knowledge and perceptions is vital when designing such programs since farmers use their belief systems and what makes sense to them when selecting and utilizing innovations. Furthermore, farmers have developed their own innovation

attributes to assess the SLM innovation, which should be identified and integrated into SLM interventions.

Finally, promoting SLM in Mozambique still works under the assumption that SLM interventions operate solely under donor requirements without room for adaptation, limiting the opportunities to integrate organizations' and farmers' knowledge and experiences. In addition, the target orientation approach of projects and the indicators used to measure the success of such interventions lead to a scenario where organizations focus more on reaching the targets instead of promoting adoption and impacts at the community level.

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