Sustainable Intensification through Conservation Agriculture: Farm Typologies in Malawi's Mixed Farming Systems

A case for Kasungu, Malawi

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).


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Country background and research objective

Africa's agricultural productivity is low, compared to other parts of the world. In some cases, yields of main cereal crops such as maize have stagnated at less than 25% of potentially attainable yields. In Sub-Saharan Africa specifically, current agricultural practices are leading to soil degradation. The agricultural systems are generally characterized by small-scale, rain-fed farming practices that often involve minimal inputs. To address these challenges, the Sustainable Intensification of Mixed Farming Systems (SI-MFS) Initiative aims to create equitable and transformative pathways to improve the livelihoods of individuals involved in mixed crop-livestock systems. This initiative focuses on achieving sustainable intensification within specific agroecological and socio-economic contexts.

Malawi is one of the Sub-Saharan Africa Countries in SI-MFS that faces agricultural productivity challenges. The nation's crop yields, particularly for staple crops like maize, are relatively low. With an average farm size in Malawi of 0.71 hectares, agricultural practices are primarily geared towards cultivating crops for household consumption. Conservation agriculture (CA) is one of the option to improve crop production that is explored in Malawi. Within SI-MFS, experiments are currently being done to explore the potential for improving crop

This study contributed to the SI-MFS project and focused specifically on conservation agriculture (CA) experiments in the Kasungu region in Malawi, that were already running in SI-MFS. It evaluated the effectiveness of various CA practices in the maize-based farming systems of Malawi, assessing their potential to enhance resilience and sustainability. Additionally, the study investigated how different CA treatments can facilitate the further integration of livestock within smallholder farming systems, contributing to more sustainable mixed farming practices. Livestock can provide organic fertilizers in the form of manure. Livestock manure has provided supplementary advantages to improving soil quality and further closing nutrient cycles in agriculture.

This study addresses a research gap in the sustainable integration of crop-livestock systems. It explores the potential of CA in combination with various crop combinations and production systems such as rotation and intercropping to enhance agricultural productivity and sustainability in the region. We specifically looked at how CA can support further integration of livestock within smallholder farming systems in Malawi. Currently there is little evidence on the possible effect of CA on the support of livestock integration in smallholder farming systems.

The main research question was: How can the technical CA innovations proposed in Kasungu support the integration of crop-livestock in a sustainable way?

1. How can the current diversity in farming systems in Kasungu be characterized?

2. How does CA incorporating crop diversification practices influence the farm systems of small holder farmers in Kasungu with respect to food security, labour requirement and farmer's perception

Methodology

Study area

The study area in Malawi was the Kasungu District, located in the central region and plateau area of Malawi as highlighted in Figure 2. The climate in the region is characterized by a cool and dry winter season from May to August, with mean temperatures ranging from 17 to 27°C, followed by a hot and dry season from September to October, with average temperatures from 25 to 37°C. Kasungu receives 800 to 1000 mm of rain annually, modified by the area's complex topography .

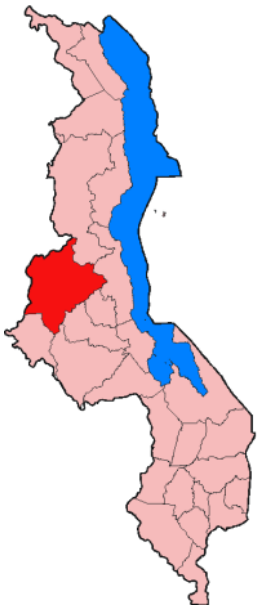

Figure 1. Map of Malawi with the Kasungu district indicated in red, and lake Malawi indicated in blue (Wikipedia, 2022).

Kasungu has by medium-textured sandy loamy soils susceptible to erosion and fertility loss, leading to declining crop yields. As a result, people have extended farming to progressively less suitable areas like steep hillsides further exacerbating erosion. Approximately 70% of the arable land is dedicated to maize cultivation each year. Legumes are also cultivated alongside maize as intercrops or on adjacent lands. In Kasungu, farmers also commonly cultivate soybeans (*Glycine max*) and groundnut (*Arachis hypogaea*) (Chimonyo et al., 2023). Irrigation practices are only implemented on a small scale (Mvula, 2017). Cattle density in Kasungu is relatively low with between 5 to 15 cattle/km^2. Animal product production and consumption are very low.

Due to their reliance on unpredictable rainfall, limited land size, limited use of agricultural inputs, and poor access to markets, many farmers struggle to meet their livelihood needs. Consequently, Kasungu consistently experiences food shortages at both the district and household levels (Chimonyo et al., 2023).

Research steps

An extensive survey was conducted by the International Institute of Tropical Agriculture (IITA) in 2023 among 232 households in Kasungu. This was used to describe the reference situation of the farms and to develop a farm typology. We used a Principal Component Analysis (PCA) and Hierarchical Cluster Analysis (HCA). We identified three distinct farm types representing variations in farming practices and socio-economic conditions.

“Mother trials”, were setup in 2023 on 44 farms. They were managed by farmers selected by CIMMYT to represent the diversity of farms in the Kasungu region. The 2023/2024 growing season was the first year in a three-year experiment exploring the impact of different CA treatments on yield performance and feed availability. The purpose of the mother trials was to inspire smallholder farmers to adopt the

proposed innovations. Towards the end of the growing season, field days were organized to allow local farmers to observe the mother trials. Most fields in Malawi are initially ridged, but they were levelled before the start of the treatments to ensure a weed free start. Additionally, model farmers are provided with the necessary inputs and are carefully instructed on the timing of the various management practices to be applied.

All 44 farmers participating in the experiment were classified according to the typology developed and were interviewed about their perceptions and experiences regarding their involvement in the trials. They were also asked to rate the CA practices.

To better understand their attitude and perception, three focus group discussions (FGDs) were conducted. These discussions aimed to explore potential differences in the perceived challenges and opportunities among the three determined farm typologies. Insights and citations from these FGDs, combined with relevant literature, were utilized to contextualize, and interpret the study's findings.

Qualitative research methods such as interviews and focus group discussions are employed to assess farmers' perceptions of the innovations.

Results

Farm Types

Three distinct farm types were distinguished in the Kasungu region. They were identified based on similarities in key agricultural and socio-economic characteristics. The three clusters are composed as follows: Farm Type 1 (64 households), Farm Type 2 (126 households), and Farm Type 3 (42 households).

Farm Type 1 - High resource endowment & Intensive management (64 households)
Farm Type 1 is characterized by relatively large land holdings, with an average area of 2.42 ha. It owns the largest herds and 77% of the total land is in a crop rotation. Their inputs use is high (basal and top-dressing fertilizers) and they achieve the highest maize yields, on average 3.3 t/ha. This group aims at maximizing productivity.

Farm Type 2 - Moderate resource endowment & Balanced practices (126 households)
Farm Type 2 occupies an intermediate position, with an average land area of 1.05 ha and moderate values for TLU and input use. This group has a balanced approach to farm management, with crop rotation practiced on 86% of the total land and maize yield averaging 1.5 t/ha. These farms exhibit a moderate level of investment in both land and inputs, which translates to balanced, though not maximized, productivity.

Farm Type 3 - Low resource endowment and Low-input farming (42 households)

Farm Type 3 represents the smallest farms, with an average land area of 0.38 ha. These households own least animals and they apply the least amount of fertilizer and other inputs. Maize yield is the lowest, averaging 0.9 t/ha. Crop rotation and the use of improved seed varieties are limited in this group, reflecting a lower level of resource availability and input use.

Resource Endowment of CA Trial Households

A majority of the households (91%) reported owning livestock, with a variation ranging from 0 to 11.8 TLU. The average cultivated area per household was 4.1 hectares, varying from 0.8 hectares to 18 hectares. This variation in land size underscores the diverse agricultural capacities within the group. This showed that the farmers who participated in the research trials belong to Farm type 1 and 2. The farmers selected for the CA trials were required own a minimum land area to accommodate the trial.

CA and food security

All farmers interviewed expressed confidence that the innovation they were experimenting with could improve their food security.

The farmers cited several reasons for their belief that the CA practices could enhance their food security:

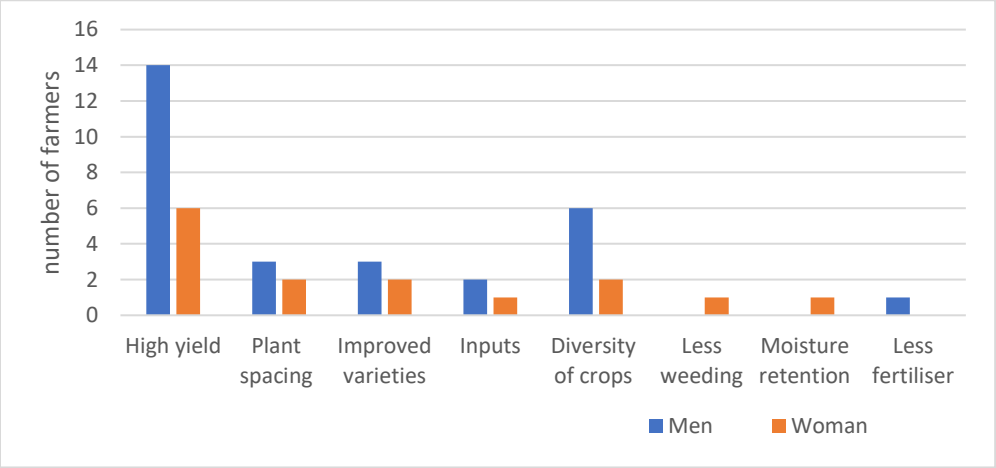

Figure 2. Reasons that farmers indicated for improved food security.

Most farmers highlighted increased yield as the primary reason for improved food security, as they observed higher yields from the trial plots compared to their other fields and improved plant spacing techniques. The second most mentioned reason was related to the provision of inputs, both improved varieties and fertilizer by CYMMIT, which is not part of the innovation itself but rather a supportive measure. Other reasons cited by individual farmers were more closely related to the specific technologies of Conservation Agriculture (CA), such as reduced fertilizer usage which would indirectly reduce the costs for the farmer. The reasons that were mentioned by only one farmer, appear to be more context-specific, reflecting the unique conditions of their individual farming systems.

CA and labour requirements

Most farmers (77%) reported that maintaining the trial plots required more labour than their usual practices, such as creating more ridges, more labour for planting and applying mulch. A small group of farmers, 11%, indicated that the labour requirements were similar to their previous farming methods. These farmers acknowledged that while the initial stages of CA might require more effort, the labour demand tends to balance out over time, especially with reduced weeding. Another 11% of the farmers reported that the CA practices required less labour compared to their traditional methods. They replaced manual weeding with herbicides and mulching reduced weeding after planting.

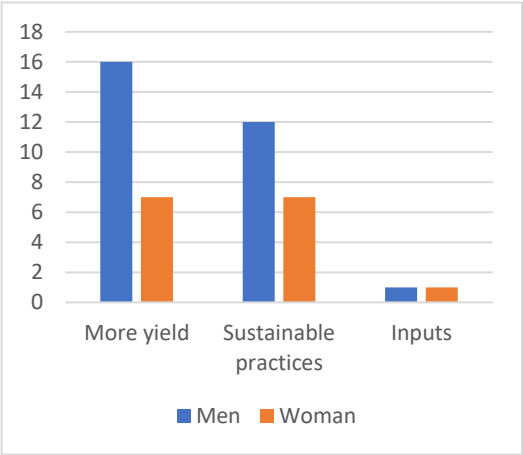

Figure 4. Benefits mentioned during the interviews based on the CA trials in.

During the focus group discussions all groups consistently ranked CA as generally requiring more labour than their traditional farming practices.

Perception of CA

The perception of smallholder farmers towards Conservation Agriculture (CA) was assessed through field trials where farmers implemented CA principles.

Benefits of CA

The primary benefit of CA identified by interviewed farmers was a yield increase (Figure 4). Sustainable practices, such as mulching and intercropping, were also recognized as beneficial by 43.2%. Only 2 of respondents mentioned the use of inputs.

The FGDs consistently ranked yield increase as the most important benefit.

Challenges of CA

Many farmers identified more than one issue. Several challenges, including late planting, lack of training, insufficient inputs, and delayed input delivery, were a direct result of the late project start up rather CA itself (Figure 5). Apart from these challenges, labour and drought, though unrelated to CA, were the most frequently mentioned issue.

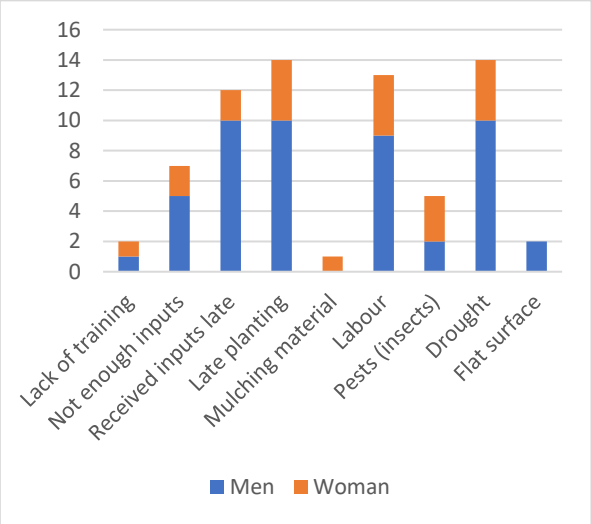

Figure 5. Challenges mentioned during the interviews on the CA trials.

The FGDs, also mentioned the project related issues as the main challenges.

Motivations to continue with CA

The intentions of farmers to continue CA practices, after the trials ended were diverse, but they primarily centered on increased yield and new knowledge on improved agricultural practices gained during the trials.

In the FGDs, the motivation to continue with CA was also increased yield as the top motivator, followed by soil fertility and food diversity and security. For medium-resource endowed farmers, the priority was more income and gaining knowledge,

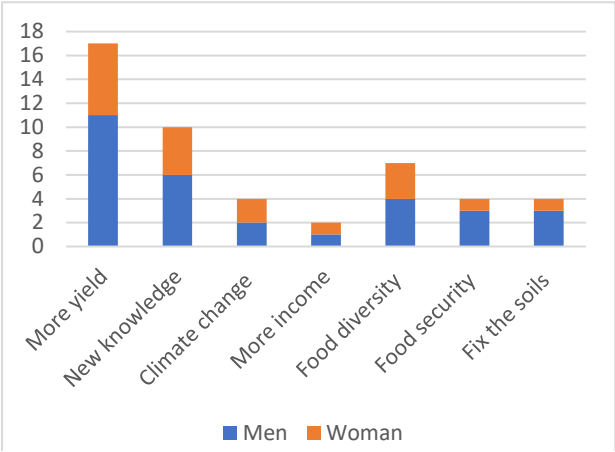

Figure 6. Motivations to continue with CA mentioned during the interviews on the CA trials.

The perception of smallholder farmers towards CA is generally positive, with clear benefits such as increased yield, improved soil fertility. However, challenges such as increased labour requirements, remain a significant obstacles for full CA adoption. It is important to recognize that some of these challenges, particularly those related to input provision and planting timing, are not inherent to CA but stem from the logistical aspects of the project. Despite these challenges, many farmers expressed a willingness to continue with CA, motivated by the tangible improvements in yield and soil health.

Discussion

The findings of this study underline the complexities of implementing CA practices across heterogeneous farm types, as well as the diverse benefits and challenges experienced by farmers.

Three farm types were defined, based on a pre-trial survey amongst 232 farm-high, moderate, and low-resource endowed. The selection of farmers hosting the trials was geared towards the high and moderate resource endowed farms and therefore the results only apply to those two groups and not to the low resource endowed farm.

Resource-rich farmers tend to adopt and benefit from agricultural innovations more readily than their lower-resource counterparts due to better access to inputs and capital (Hazell et al., 2010; Wiebe et al., 2017). Conversely, low-resource endowed farms faced barriers such as limited land and inputs, which hindered their ability to fully implement CA practices. Addressing these disparities is crucial, as resource-constrained farmers are often the most vulnerable to food insecurity and environmental degradation (Chikafa et al., 2023). The variability in Tropical Livestock Units (TLU) further highlights the differential integration of livestock into farming systems. Livestock ownership was positively associated with nutrient cycling

through manure application, a benefit largely unavailable to low-resource households.

The role of external support, such as the provision of improved seeds and fertilizers, was critical in enhancing yields during the trials.

The labour-intensive nature of CA was a significant barrier to adoption for the largest part of the farmers. This was counteracted by using more herbicides in some cases.

Farmers' perceptions of CA were generally positive, with many citing increased yields and better soil health, as key benefits.

Conclusion

This study underscores the importance of CA in addressing key challenges faced by smallholder farmers in Malawi, including low agricultural productivity, food insecurity, and soil degradation. Low-resource endowed farms were not included in the trials, interviews ad FGDs. The findings indicate that:

- CA can enhance crop yields if it is combined with additional inputs, such as improved seeds and fertilizer.
- Targeted approaches to needs of diverse farm types are crucial for adoption.
- Labour use and input requirements are the main challenges and constraints for adoption.
- Crop-livestock integration is an opportunity, but is especially achievable on medium and high resource rich farms, which already have some livestock.

In summary, while CA holds promise as a sustainable intensification strategy, its successful implementation requires addressing socio-economic barriers, enhancing training and support mechanisms, and fostering resilience against environmental challenges. Future research should explore long-term impacts, scalable solutions for low-resource farmers, and strategies for mitigating trade-offs between crop and livestock demands.

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