Soybean Intensification-based Farm Typology for the Chinyanja Triangle

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Contents

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Introduction

Agriculture remains a cornerstone of the economies in Malawi, Mozambique, and Zambia, with maize and soybean being two of the most significant crops cultivated in these regions. Maize dominates the cropping systems and serves as a staple food in the region, while soybean is identified as a strategic crop for transformation of the food systems (Giller et al., 2011). However, yields and agrarian livelihood outcomes for both crops, and many others, are depressed due to several challenges, including poor soil quality, limited productive resources, increasing occurrence of climate extremes, poor access to financial and information services, market volatility, and the dominance of middlemen who reduce farmers' potential profits (Omondi et al., 2023; João Vasco Silva et al., 2023).

Smallholder farmers, who make up 75% of the population, are primarily oriented towards subsistence agriculture. African governments recognize the importance of smallholder farmers, as addressing their challenges means addressing the challenges of a large proportion of their population. Additionally, excess production from smallholder farms can significantly contribute to national economies. Therefore, it is in the governments' interests to re-orient farmers from subsistence to commercial agriculture, contributing to food imports reduction and production of raw materials for agro-industries (Li & Wang, 2016).

There is great heterogeneity in smallholder agriculture in southern Africa, evident at different scales – from individual farms to local communities and across regions (Chikowo et al., 2014; João Vasco Silva et al., 2023; Zingore et al., 2011). There occurs a region transcending borders of Malawi, Mozambique and Zambia, where communities are united by cultural and linguistic ties, the Chichewa people in the Chinyanja triangle (Amede et al., 2017; Omondi et al., 2023). Within this region, is considerable spatial variability in biophysical and socioeconomic dimensions. A systematic approach to understanding this diversity and how different types interact with local institutions and policies lays a foundation for evidence-based interventions and policy advice. At the same time, there also occurs distinct differences in these regions, considering national policies, as they belong to different countries. It will be important to explore how these differences can affect each country's trajectory. There are many ways to define typologies, including machine learning algorithms, participatory approaches and expert based models (Alvarez et al., 2018; Nyambo et al., 2019). Classification is carried out for a variety of reasons, including explaining variability in performance, targeting innovations, and providing a basis for policy formulation. Once critical variables are identified that can allocate farmers to a farm type within a typology, additional data can be added to the database to identify the farm type a specific entry belongs to. This enables additional farms to be allocated to a farm type at a lower data cost.

Farm typologies can be used to generate recommendations for input use, intensity of production (J. V. Silva et al., 2023), and even the platform used for extension advisory delivery. For example, a typology based on digital capacity of farmers would identify that some farmers are not able to access digital extension approaches, with this specific aspect varying per farm type. For a typology based on soybean production intensification, developed to guide intensification, not every farmer can benefit in the same way from the soybean intensification, based on their capacity and production goals. Appropriate support from national governments can improve the spatial distribution and promotion of soybean production and appropriate agro-industries in specific districts (Giller et al., 2011).

This comprehensive analysis will help to (i) uncover the heterogeneity among farmers in the Chinyanja Triangle in Malawi, Mozambique and Zambia, and highlight the unique characteristics that define each segment. By identifying distinct farmer segments, we can better (ii) tailor agricultural policies, extension services, and market strategies to meet the specific needs of each group. This segmentation will also provide insights into the challenges and opportunities faced by different types of farmers, thereby informing more effective and inclusive agricultural development programs. Ultimately, the goal is to contribute to the (iv) formulation of more nuanced and impactful agricultural policies that can drive sustainable growth and improve the livelihoods of maize and soybean farmers in these three countries, particular use of soybean production led commercialization.

The objective of this work is to:

(i)   Classify farmers into different categories according to aggregated biophysical and socioeconomic measures, representing functional and structural variables.

Materials and methods

Project, site selection and data sources

The farmer segmentation study was carried out as a component of the OneCGIAR Initiative on Excellence in Agronomy, under the Deliver Work Package and the Chinyanja Triangle Soy Use Case. The Soy Use Case was implemented to explore opportunities for smallholder farmers in the Chinyanja Triangle to utilize soybean as an entry point to intensification for transformation of their livelihoods. The project was implemented under partnership between the CGIAR institutions, CIMMYT, IITA, ICRAF-CIFOR, national agriculture research departments Malawi's Department of agriculture research services (DARS), Mozambique's Instituto de Investigação Agrária de Moçambique (IIAM), and Zambia's Agriculture Research Instititue (ZARI), as well as an international NGO, Solidaridad as the demand partner.

Study area

The Chinyanja Triangle comprises a geographical area spanning Malawi, Mozambique and Zambia and inhabited by communities who share the Chinyanja language and culture (Amede et al., 2017). Farmer surveys were carried out in five districts, namely Kasungu and Lilongwe in Malawi, Angonia in Mozambique and Chadiza and Katete in Zambia.
Design and management
Data was collected in a dedicated exercise to define farm typologies as part of the Excellence in Agronomy Initiative. Information on policy environment, including national subsidy and other relevant data was collected from national documents.
Extensive surveys were carried out across six districts in three countries to collect data from farmers in geographical regions. The study was implemented including farmers who are part of the Chinyanja Soy Use Case and registered with the NGO Solidaridad. These consisted of 60 farmers per country. These farmers are soybean-oriented, market oriented, and capacitated in soybean intensification strategies. The study included 60 additional farmers who live in the same districts as the intervention farmers but are not registered with Solidaridad. The latter are not necessarily invested in soybean production. A third category of farmers were from a different district, where Solidaridad also works but the Chinyanja Soy Use Case was not in place. Therefore, a total of 180 farmers per country and 540 farmers across the three countries were included in the study.

Data collection

Data was collected in July 2023 in the three countries. The questionnaire was designed in English and translated to Portuguese for Mozambique. However, after enumerator training, a lot of the questionnaire administration was carried out in Chinyanja language in all three counties, by trained enumerators who are native speakers.
Data was collected using android devices on the survey platform ONA.
Categories of data collected included structural (household composition, labour, farm size, productive equipment, crop types, livestock and other non-agriculture equipment ownership) and functional (production practices, input use, crop yields, market channels, and income sources) variables.
Data analysis
Data analysis and visualization was carried out in R (version 4.3.3). Data was pooled from the three countries to create one composite data set. Farm typology construction was conducted in a stepwise manner. Data dimensionality was reduced to a few, non-correlated synthetic components using a Principal Component Analysis (PCA) using the ade4 package. Principal components exceeding an eigen value of 1.00 were retained. Scree plots testing confirmed cumulative percentages of variance of PCs selected. The reduced dataset was subjected to hierarchical clustering.
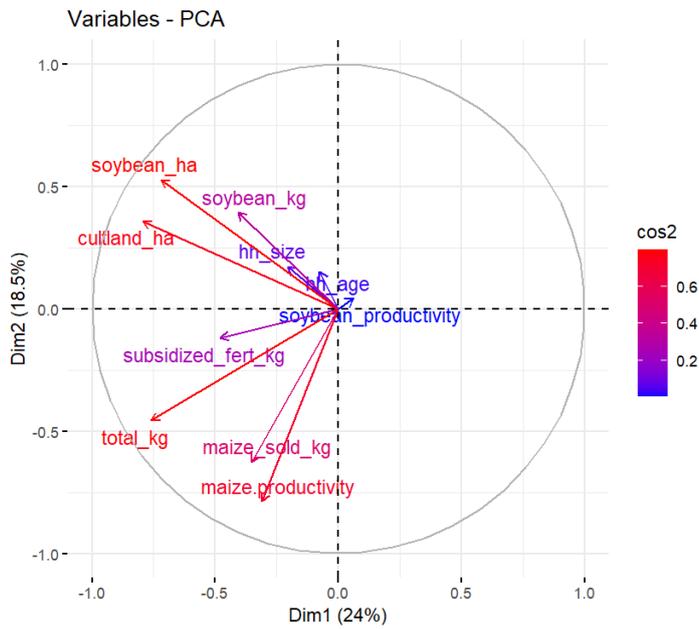
Results

Figure 1 Output of the PCA: circle of correlation. Directions and lengths of arrows within the circle shows the strength of the correlation between variables.
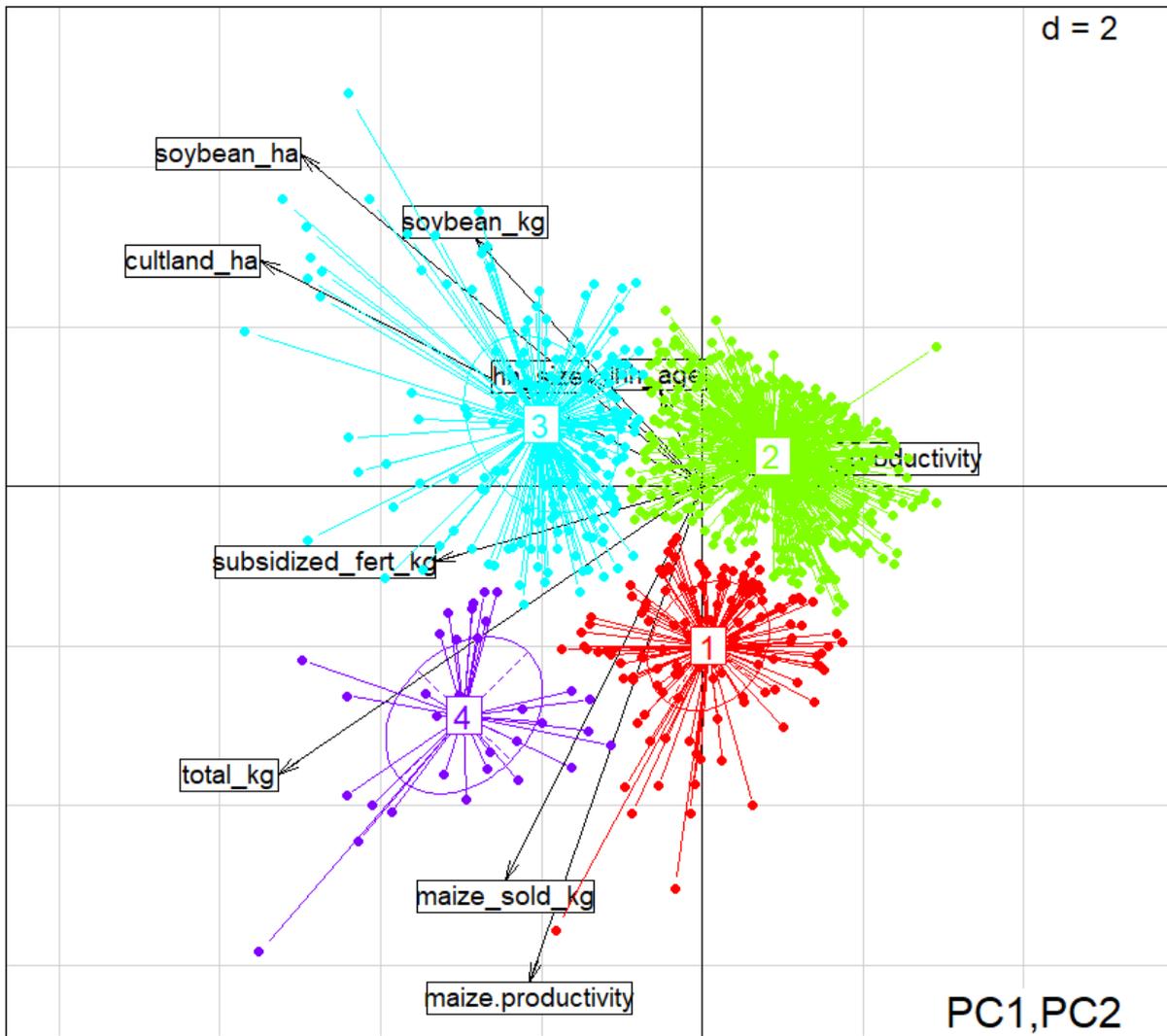
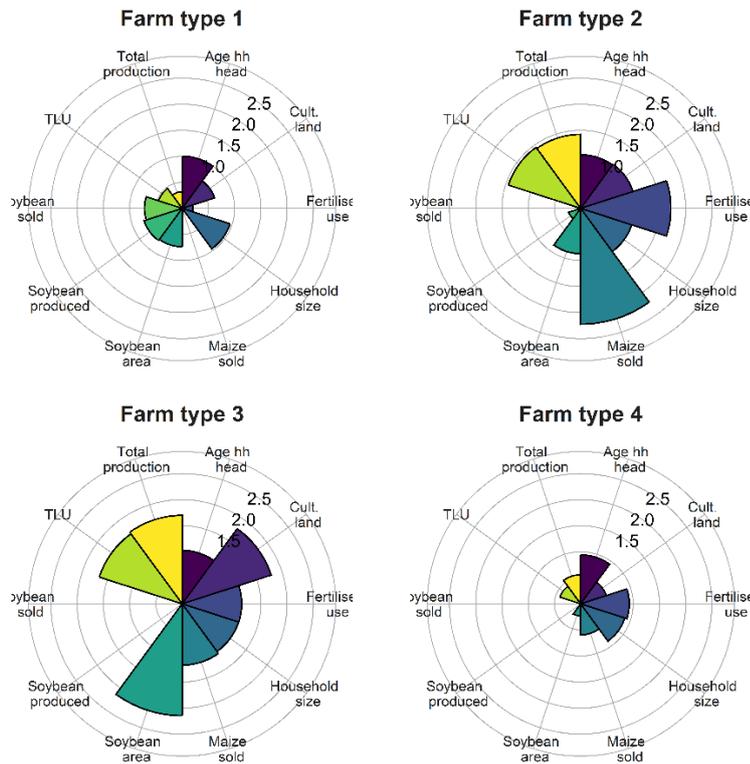Figure 2 Output of hierarchical clustering, showing four farm types

Figure 3: Radar charts illustrate the studied quantitative variables on separate axes, all emanating from a central point for each farm type. These variables were first analyzed using principal component analysis and then subjected to hierarchical clustering to identify farm typologies within the pooled data. The values are scaled to the average of each variable across all farm types.

Recommendations

This work is the first step in understanding farm diversity in the Chinyanja Triangle and provides a basis for the next step in this research. Additional research is recommended to:

(i)　　　characterize the different technology adoption pathways and farm transformation trajectories among farmers in relation to soybean intensification, considering their diverse needs and potential benefits. This includes improving subsistence livelihood outcomes through nutritional integration, utilizing soybean for livestock feed, and adopting soybean as a cash crop. Additionally, explore the potential for developing a regional soybean-led productivity business hubs.

(ii)　　　Identify different input packages for different trajectories (explore scenarios) to make economic sense while preserving the ecological integrity.

(iii)　　　Propose different policy recommendations for promoting the performance of the different farm typologies

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