Universidade de Évora - Instituto de Investigação e Formação Avançada
Universidade de Trás-os-Montes e Alto Douro

Programa de Doutoramento em Agronegócios e Sustentabilidade

Tese de Doutoramento

Family Farming in Huambo: An Economic and Social Sustainability Approach to Overcoming Poverty

Antonino Abel Chivala Kamutali

Orientador(es) | Maria Raquel Lucas
Pedro Damião Henriques
Ana Alexandra Vilela Marta Rio Costa

Évora 2025

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Évora 2025

DEDICATION

To my parents,

To my wife,

To my children,

To my brothers.

Acknowledgements

To God, who gave me life, from whom came the strength, health and courage to start and finish this thesis.

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Abstract

Family farming plays a fundamental role in the livelihoods of households in Huambo, Angola. This study aimed to analyze the nature and characteristics of family farming in Huambo Province and to propose sustainable production systems that enable families to achieve a level of well-being above the poverty line. Given the high levels of poverty in Angola, particularly in rural areas where farming is often a way of life, Ethnographic Linear Programming (ELP) models were employed. These models enabled a comprehensive analysis of the economic and social sustainability of farming households, incorporating aspects of social organization, history context, culture and daily practices. This approach also provided a solid foundation for recommending technologies and policy interventions to promote the long-term sustainability of these households.

The results reveal that family farmers operate farms of varying sizes: very small (area <= 1ha; 44,4%), small (1 < area ≤ 3 ha; 18,2 %); medium (3 < area ≤ 5 ha; 20,3%); and large (area > 5 ha; 17,1%). Under current conditions, agricultural yields are low, and the models indicate that very small and small-scale farmers remain to live below the poverty line (they are poor). In contrast, medium and large-scale farmers surpass the poverty threshold. The introduction of high-yield certified seed varieties in crop production and, in livestock farming, the adoption of goats capable of producing two births annually, has proven to be effective in increasing productivity and improving household outcomes.

To strengthen family farming systems in Huambo, it is important to develop and implement public policies. Priority measures include improving access to land, expanding rural credit schemes, enhancing rural extension services, empowering rural women, and promoting agricultural cooperatives. These interventions are necessary for fostering sustainable agricultural development and lifting more families out of poverty.

Keywords: Family Farming, Angola, Poverty, Ethnographic Linear Programming, Sustainability.

Resumo

A agricultura familiar desempenha um papel fundamental na vida dos agregados familiares do Huambo em Angola. Este trabalho teve como objetivo analisar a natureza e as caraterísticas da agricultura familiar na província do Huambo e propor sistemas de produção alternativos que sejam sustentáveis e permitam às famílias atingir níveis de bem-estar acima do limiar de pobreza. Desta forma, considerando os elevados níveis de pobreza em Angola, especialmente nas zonas rurais, onde em muitos casos a agricultura é considerada um modo de vida, foram desenvolvidos modelos de Programação Linear Etnográfica (PLE). Estes modelos permitiram a análise da sustentabilidade económica e social dos agregados familiares agrícolas de forma abrangente, incorporando aspetos da organização social, contexto histórico, cultura e práticas quotidianas. Esta abordagem também forneceu uma base sólida para sugerir tecnologias e intervenções políticas para promover a Sustentabilidade a longo prazo destes agregados familiares.

Os resultados obtidos mostram que os agricultores familiares têm explorações de diferentes dimensões: muito pequenas (área <= 1ha; 44,4%); pequenas (1 < área ≤ 3 ha; 18,2 %); médias (3 < área ≤ 5 ha; 20,3 %); e grandes (área > 5 ha; 17,1 %). Nas condições atuais, as produtividades são baixas e os modelos indicam que os agricultores muito pequenos e de pequena escala continuam a viver abaixo do limiar de pobreza (são pobres). Em contrapartida, os médios e grandes agricultores ultrapassam o limiar da pobreza. A introdução na produção vegetal de novas variedades de sementes certificadas com índice produtivo elevado e, no caso da pecuária, a adoção de cabras com duas parições por ano, mostrou-se eficaz para aumentar a produtividade e melhorar os resultados das famílias.

Para reforçar os sistemas de agricultura familiar no Huambo é importante desenvolver e implementar políticas públicas. As medidas prioritárias incluem a melhoria do acesso à terra, a expansão de programas de crédito rural, o reforço dos serviços de extensão rural, a capacitação das mulheres rurais e a promoção de cooperativas agrícolas. Estas intervenções são necessárias para promover o desenvolvimento agrícola sustentável e tirar mais famílias da pobreza.

Palavra-chave: Agricultura familiar, Angola, Pobreza, Programação Linear Etnográfica, Sustentabilidade**.**

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List of Abbreviations and Acronyms

ADRA.......*Ação Para o Desenvolvimento Rural e Ambiente* [Action for Rural Development and the Environment]

CPLP.........*Comunidade dos Países de Língua Portuguesa* [Community of Portuguese-speaking Countries]

ECA...........Escola de Campo de Agricultores [Farmers' Field School]

ELP ....Ethnographic Linear Programming

ESAN........Food and Nutrition Security Strategy

FAO ....Food and Agriculture Organization of the United Nations

HDI ....Human Development Index

IBEP..........*Inquérito sobre o Bem-Estar da População* [Population Well-being Survey]

IDA ....Institute of Agrarian Development

IFAD ....International Fund for Agricultural Development

INE............*Instituto Nacional de Estatística* [National Institute of Statistics]

LP..............Linear Programming

MAF..........*Ministério da Agricultura e Florestas* [Ministry of Agriculture and Forestry]

MOSAP ....*Projeto de Transformação da Agro-pecuária Familiar* [Family Farming Transformation Project]

OPSA.........*Observatório Político e Social de Angola* [Angola Political and Social Observatory]

UNICEF....United Nations Children's Fund

WFP ....World Food Programme

WHO.........World Health Organization

CHAPTER 1 - INTRODUCTION

In sub-Saharan Africa, hunger and extreme poverty have persisted for decades, with efforts to address these challenges progressing at a frustratingly slow pace. This chapter aims to contextualize the study and highlight the key challenges faced by family farming in the Huambo region. Through a comprehensive literature review and a deep understanding of the study area, the central research question was identified, guiding the formulation of specific objectives to address it. To pursue these objectives, the ELP methodology was adopted. The development of ELP models, capable of providing a thorough analysis of the economic and social sustainability of farming households, represents a pioneering and innovative approach. Finally, this chapter presents the structure of the thesis, aligning it with the defined objectives.

1.1. Context and Background

In sub-Saharan Africa, hunger and extreme poverty have persisted for decades, with solutions to these challenges advancing at a frustratingly slow pace. Subsistence agriculture, dominated by small-scale family farms, remains the foundation of rural livelihoods across the region.

A key challenge lies in narrowing the gap between actual and potential income levels. Bridging this gap would not only allow family farmers to meet their household food needs but also to generate surpluses for sale, creating income opportunities and offering a pathway out of poverty (Gassner *et al.*, 2019).

This objective is closely aligned with the United Nations Sustainable Development Goals (SDGs), adopted in 2015, which emphasize the eradication of poverty and hunger alongside the promotion of sustainable agricultural practices. As noted by Ortiz *et al.* (2018), family farming possesses significant potential to contribute to the various dimensions of sustainability, offering a viable route toward achieving these global targets.

Angola continues to face high levels of poverty, particularly in rural areas, where the poverty rate reaches 57.2% (INE, 2019). Family farmers, who represent the primary source of food production, face numerous challenges in maintaining agricultural productivity and ensuring household feeding and well-being.

Access to credit remains severely limited, with only 6% of rural households benefiting from modern financial services. The use of agricultural inputs is similarly low: just 48% of farmers purchase seeds, plants, or cuttings; only 5% use fertilizers; and a mere 1% apply pesticides. Traditional tools still dominate the production process, with 98% of farmers using hoes, 89% using machetes, 70% relying on axes, and only 13% using shovels (IBEP, 2015).

Despite these limitations, Angola's agricultural sector holds significant potential to improve rural livelihoods and contribute to national development. Realizing this potential, however, depends on the implementation of effective policies and the strengthening of institutional frameworks (Pacheco, 2003). Policy governance must be centred on people and address the urgent needs of family farmers.

The 2019 United Nations Human Development Report highlights Angola’s struggles, with a Human Development Index (HDI) of 0.574, dropping from 147th to 149th place - making it the Lusophone country with the steepest decline in the assessment. As stated before, family farmers in Angola continue to produce under challenging conditions, hindered by limited access to modern agricultural inputs such as credit, fertilizers, and pesticides.

According to the work of FAO, IFAD, UNICEF, WFP, and WHO (2019), sub-Saharan Africa is home to over 230 million undernourished people, making it the most food-insecure region in the world. Within the framework of the Food and Nutrition Security Strategy (ESAN) of the Community of Portuguese Speaking Countries (CPLP, 2012), Angola emerges as the most problematic country in the community in terms of food and nutrition security and is followed by Mozambique, Guinea-Bissau, East Timor, and Cape Verde.

Family farming plays a fundamental role in eradicating hunger and poverty while serving as an excellent alternative for promoting sustainable agriculture (Díaz & Morejón, 2018). Although many authors acknowledge the potential of family farming in addressing these global challenges, most studies narrowly focus on the farm itself, neglecting other critical dimensions of agricultural livelihoods.

Deus et al. (2018) identify two types of models for analysing agricultural households across multiple dimensions: those based on the neoclassical microeconomic theory of production and mathematical programming, with particular emphasis on ethnographic linear programming (ELP). According to Creswell (2009), ethnography involves the detailed description and interpretation of a group's social or cultural system.

Deus et al. (2018) utilized ELP as a tool to study family farming systems in East Timor, providing insights into several key dimensions of agricultural livelihoods. These include agricultural production, the integration of product and factor markets, the consumption of agricultural and non-agricultural goods, and household participation in family, festive, and community activities.

In Huambo Province, where there are cyclical climatic irregularities and the scarcity of fertile soils, most of the territory is suffering demographic pressure, over-exploitation of the land, improper cultivation techniques, and erosion. These factors contribute to low agricultural productivity across much of the region. According to Pacheco (2003), the sustainability of agricultural systems in this part of Angola has been severely compromised, which accounts for many of the challenges faced by family farmers and their persistently high levels of poverty.

In Huambo, many family farmers whose agricultural production fails to meet their food needs seek alternative sources of income outside farming. However, low levels of education, the number of children in households, and the limited availability of job opportunities in rural areas make it difficult for farmers to find viable alternatives. These challenges have been contributing to a rural exodus. Despite this trend, pluriactivity - the pursuit of multiple income-generating activities - plays an important role in the social reproduction of these households.

Given this context, the aim of the study was to determine whether the agricultural systems in Huambo are sustainable and capable of reducing the observed levels of poverty.

The central research question guiding the study was: Are agricultural systems in Huambo capable of reducing the levels of poverty experienced by households in a sustainable manner?

Based on this research question, the objectives of the study were formulated and are presented in the following section.

1.2. Objectives

In light of the above and in order to address the central research question, the following objectives were established.

The general objective of this study is to analyse and find sustainable family farming systems that enable rural households to achieve a level of well-being above the poverty line.

To achieve this overarching aim, the following specific objectives were defined:

1. Identify and characterise the family farming systems practiced in Huambo Province;
2. Select the study area and identify representative agricultural systems and households;

3. Develop and validate ELP models for the selected households, analysing their economic and social sustainability;
4. Identify and test alternative sustainability scenarios, focusing on both economic and social dimensions, that address existing challenges and potentials, with the goal of improving household well-being beyond the poverty threshold;
5. Provide policy recommendations to enhance household living conditions and promote sustainable rural development.

1.3. Methodological note

To achieve the established objectives, the ELP methodology was selected. Given the high levels of poverty in Angola, particularly in rural areas where agriculture is often considered a way of life for many households, developing ELP models that allow for a comprehensive analysis of the economic and social sustainability of family farming households is both pioneering and innovative. These models incorporate aspects such as social organization, history, culture, education, health, and daily life, factors that are fundamental to the maintenance and survival of these households.

This approach is pioneering because there are no known studies on family farming systems in Angola that have utilized ELP models. Existing studies typically take a sectoral or crop-based approach (Pacheco, 2003; Vitongue, 2004; Chaves, 2009; Bernardo, 2012; de Celestino, 2013; Muondo, 2013; Marcelino, 2014; Adriano, 2015; Sapalo, 2015; Katiavala, 2015; Jerónimo, 2015; Camavana, 2016; Nzinga & Suris, 2016). Notable studies in Africa that have used ELP models include those by Gill (2010) for Kenya, and by Thangata, Hildebrand, and Gladwin (2002) and Thangata, Hildebrand, and Kwesiga (2007) for Malawi.

This study is innovative for two key reasons. First, it contributes to scientific advancements by expanding knowledge about the economic and social dimensions of subsistence family farming, while also creating a tool to support agricultural planning and decision-making that can be replicated in other contexts. Second, it offers a practical contribution by applying ELP models to identify solutions and alternatives that can enhance the well-being of farmers and their households in Huambo.

To achieve the proposed objectives, ELP was used as the methodological approach, as these models enable the integration of various dimensions of the social organization of subsistence farming households (Deus *et al.*, 2018). According to Hildebrand *et al.* (2003), ELP is favoured by many researchers because it allows for the analysis of two key dimensions: the production of agricultural goods and the household's reproduction activities. Bernard (1995) highlights the importance of ELP by combining linear programming, a quantitative method, with ethnography, a qualitative research approach. This combination provides a deeper understanding of the socio-cultural and economic aspects of a household.

The methodology involved bibliographic research, primary data collection, ELP model development and validation, model results for a baseline scenario, and the identification of alternative scenarios. The first stage involved bibliographic research to gain a deeper understanding of the subject. During this phase, the Scopus and Web of Science databases were explored, supplemented by research into technical and scientific documents, reports, and statistical data. The research focused on the following topics: family farming, poverty, ELP, economic incomes of family farming, agricultural production systems, social organization of households, and poverty (objectives 1 and 2). Special attention was given to research studies and institutional reports related to the Province of Huambo and its agricultural context.

At the end of the first stage, a set of data was gathered, providing deeper insights into the study topic and contributing to the identification of key elements related to the types of family farming systems in Huambo.

The second stage involved primary data collection, model development and validation, model results for a baseline scenario, and the identification of alternative scenarios. Data was gathered through focus groups, interviews, questionnaire survey, and field notebooks.

The focus groups aimed to collect general information about each village included in the study. Two meetings were held in each village, with farmers participating in both. The first meeting focused on gathering information about the village's historical profile, key social and economic institutions, primary activities, agricultural calendar, main crops cultivated, food availability, and other relevant details. The second meeting was conducted to validate and supplement the data collected during the first meeting.

Although no fixed number of participants per village was established, efforts were made to ensure diverse community representation. On average, 21 farmers per village took part.

The interviews were scheduled in advance, in coordination with the traditional village authority (*Soba*), and were held at the *Soba*'s residence. To maximize farmer participation while minimizing disruptions to their daily routines, the meetings took place in the late afternoon and early evening. The interviews were directed at village leaders and representatives of social organizations, with the objective of collecting information to cross-validate and complement the data obtained from the focus groups. Respondents included *Sobas* (traditional authorities), their secretaries, elders (advisors to the *Sobas*), church representatives, leaders of cooperatives and associations, representatives of ECAs, youth leaders, and, in some instances, representatives of political parties. The interviews with community leaders covered general information about the village, its structure and functioning, types of activities carried out, local festivities, external support received, main challenges faced by farmers, and prospects for the development of agriculture and the community more broadly. Both the interviews and focus groups placed particular emphasis on identifying potential pathways for the future of the communities studied. Initially planned to March and December 2020, the interview was postponed due to the Covid-19 pandemic and ultimately took place between December 2020 and December 2021, adhering to Covid-19 prevention measures.

The selection of villages for inclusion in the questionnaire sample, was primarily informed by the type of agricultural system employed. Villages were chosen based on their geographic positioning and the scale of agricultural production within their respective municipalities. Farmers were selected with the assistance of the *Soba* and Agricultural Development Station technicians, based on the following criteria: age (ensuring the participation of young people); gender (encouraging the inclusion of women); participation in the farmer's field school (involving members of Farmers' Field School (ECA)); and religion (representing different church groups within the community). Meanwhile, the questionnaires were administered to households representing family farming systems in Huambo. The households were selected from each village, and the questionnaire design was structured to directly address the central research question. For the sample selection, the farmers were chosen randomly within the villages for their willingness to participate in the study. In this study, the non-probabilistic sampling technique was used because it was not possible to specify the probability of a subject belonging to the population. Within this, the non-probabilistic criterion sampling technique was applied because the researcher selected the farming system of the household from the sample of farmers surveyed by the questionnaire. A total of 158 participants were gathered. It was structured in four main sections which incorporate the following aspects (1) the farmer and his family, (2) farm, (3) crop and animal crops and technology, (4) sources of income and monthly household expense. The survey questions were designed to collect data on both the production systems employed and the socio-economic conditions of the households, thereby enabling the classification of different family farming typologies according to farm size. Specifically, variables such as the main characteristics of the farming systems, irrigation practices, weed and pest control strategies, fertilization methods, labour organization, food consumption patterns, and the relative importance of different food groups were included. This procedure is also consistent with Andrade (1986), who defines representative farmers as those whose resource indicators correspond to the most frequent combinations, therefore, being closest to the general trend while encompassing the widest range of available resources.

Additionally, other relevant aspects related to objectives 1, 3, 4, and 5 of the study were examined (see Annex I).

This phase ultimately aimed to characterize the daily routines of the households, with particular emphasis on their involvement in productive, reproductive, and community-related activities.

The findings from phase 2 provided the foundation for phase 3 of the study, particularly in estimating labour requirements for agricultural, livestock, community, festive, and domestic tasks. These estimates served as key inputs for the ELP modelling conducted in phase 3, among other elements that enabled the development of the model.

The third stage focused on the development of the ELP model, which enabled the analysis and formulation of proposals for sustainable family farming systems in the Huambo region. Given the high levels of poverty in Angola, particularly in rural areas where agriculture often constitutes a way of life for many households, this stage aimed to assess whether the ELP model allows for a comprehensive analysis of the economic and social sustainability of family farming units.

In this context, the study explored the integration of elements such as social organization, historical context, cultural practices, education, health, and everyday life as essential to ensuring the continuity and resilience of these households.

This process also involved evaluating both the challenges and the potential of local agricultural systems, offering valuable insights into how farming families can improve their livelihoods and overall well-being.

1.4. Organization of the Thesis

The thesis is organized into five chapters (Figure 1). It begins with an introductory chapter that outlines the context, objectives, and structure of the research. This is followed by three core chapters, each corresponding to articles that have been either published or submitted to peer-reviewed journals or edited volumes. The final chapter presents the concluding remarks, offering a synthesis of the main findings and the overall contributions of the study.

To ensure coherence and uniformity throughout the document, all bibliographic references are consolidated at the end of the thesis and formatted according to APA style guidelines. Additionally, all tables and figures have been renumbered to support a continuous and consistent reading experience.

A brief overview of each chapter is presented below.

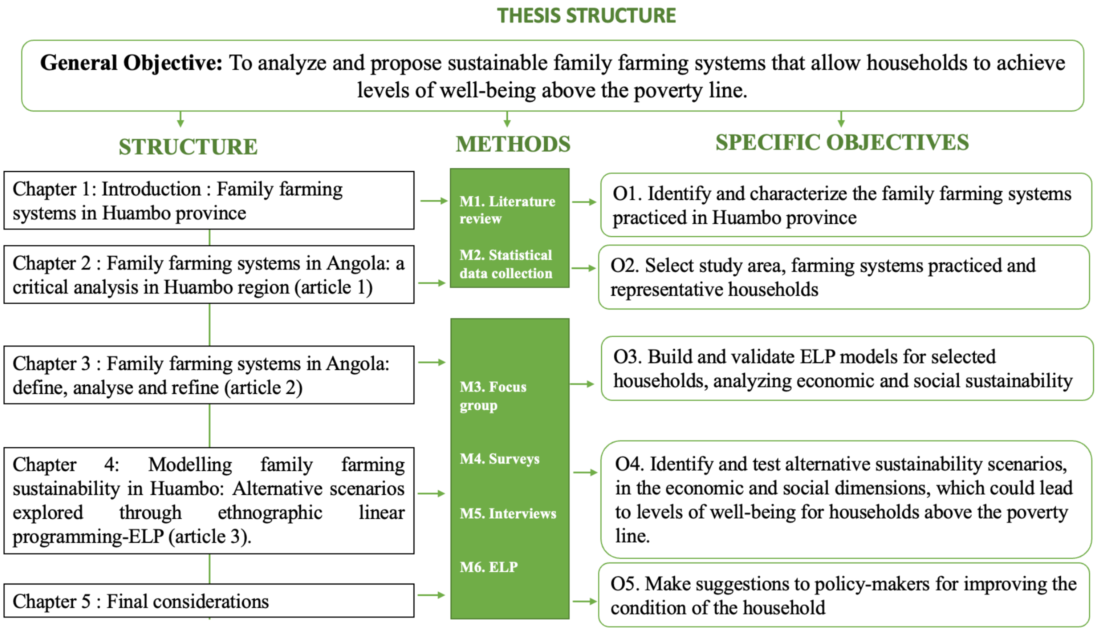

Figure 1. Thesis structure

Source: Own elaboration.

Chapter 1. Introduction

Chapter 1 introduces the topic of family farming in Huambo and presents the central research question. Based on this question, the study's objectives are outlined, along with the general methodology employed to achieve them.

Chapter 2. Family farming systems in Angola: a critical analysis in the Huambo region

This chapter aims to understand the nature and characteristics of family farming in the province of Huambo and reflect on the intersections between well-being, poverty, multifunctionality and sustainability.

The first level of analysis involved identifying, characterizing, and examining the farming systems practiced in Huambo, using official secondary data sources.

The second level comprised a critical appreciation of these farming systems, facilitated through discussions at the first Huambo Peasant Forum, a more focused and restricted environment. By mapping out the distinct dimensions of family farming within the Huambo context, this chapter underlines the need for deeper and more innovative analysis, particularly in assessing the sustainability of family farming systems from both economic and social perspectives. The goal is to understand how these systems can contribute to reducing household poverty levels.

Chapter 3. Family farming systems in Angola: define, analyse, and refine

This chapter aims to define and analyse the family farming systems in the region to understand their technological potential and to redefine their core objectives, including feeding the family, improving well-being, and reducing poverty.

Primary data was collected through a questionnaire survey, designed to gather information on the adopted production system as well as the socio-economic conditions of the households. This approach allowed for the characterization of different family farming typologies based on farm size.

Chapter 4. Modelling family farming sustainability in Huambo: alternative scenarios explored through ethnographic linear programming (ELP)

The aim of this chapter was to identify and test alternative sustainability scenarios, considering both economic and social dimensions, while accounting for the potential and challenges of family farming. The goal was to determine whether the welfare levels of households are above the poverty line.

Based on the ELP models built and validated in the previous chapter for households in Huambo, the economic and social performance of farmers was measured. This approach allowed for the identification of alternative pathways that households could follow to surpass the poverty line and potentially break the cycle of poverty.

Chapter 5. Final considerations

The fith and final chapter presents the main conclusions, policy proposals, key contributions of the thesis, limitations and prospects for future research.

All the references used across the various chapters are listed in the final section. Furthermore, it was decided to number the sections, figures, and tables consecutively to standardize the thesis.

CHAPTER 2 - FAMILY FARMING SYSTEMS IN ANGOLA: A CRITICAL ANALYSIS IN HUAMBO REGION [1]

Family farming plays a key role in the economy of several countries, including Angola. This paper aims to understand the nature and characteristics of family farming in the province of Huambo and to reflect on intersections between wellbeing, poverty, multifunctionality and sustainability. Through a literature review, secondary data, restricted discussions with experts, complemented with participant observation, allow to identify different forms of family farming organization and recognize its fundamental role in the management of agricultural operations and production processes in Huambo. The critical analysis of the sector suggests the need to generate more and new information on family farming in Huambo that allows the assessment of critical issues on family well-being, poverty line, sustainability of systems, territories and the ethnographic dimensions of family farming.

[1] The original work of this chapter was published in: Kamutali, A.; Henriques, P.D.; Lucas, M.R.; & Marta-Costa, A. (2022). Family farming systems in Angola: a critical analysis in Huambo region. International *Journal of Sociology of the Family*, 48 (1-2), 43-70.

2.1. Introduction

Discussions on the concept of family farming and organizational forms, gained international relevance in the 1990s (Schmitz and Mota, 2007). The deepening of knowledge on agricultural family production and its destination, forms of development and adaptation to the market or business systems, and concerns over the possibility of its eventual disappearance in response to the intensification of business production relations (Finatto and Salamoni, 2008), are still themes under current debate.

The multifunctionality of family farming systems is being increasingly recognized as an element for promoting sustainable development in rural areas (Galdeano-Gomez et al., 2017). Family farming is not a homogeneous farmer's category and its definition is complex, depending on the territorial context, the combination of social and economic factors in each different region and country, the number of variables considered due to their quantitative dimension, and, also, the perspectives of the authors. It may vary from the rural population that manages a subsistence agricultural area (Schmitz and Mota, 2007) or a production and social reproduction unit, which main characteristics are family management and predominantly family labour use in farming activities (Denardi, 2001; Miranda et al., 2006), or even economic-production units of reduced size managed by the head of the household (Galdeano-Gomez *et al.*, 2017). Several common factors are predominance of family labour on the farm, the management assigned by the head of the family and the small size.

Despite the different conceptualizations and constraints, family farming represents an important role in agricultural commodity and non-commodity products, food production, insurance of family nutritional needs, generation of income, food quality improvement, sustainable use of natural resources, and occupation and valorisation of rural territories (Miranda *et al.,* 2016). Also, family farming is important to long-term maintenance of the economy in many rural agricultural areas, due to their expertise on local production and ability to adapt, as well as the know-how which was handed down to them over the generations (Galdeano-Gomez et al., 2017). Additionally, the family farmer's motivation encompasses, very often and primarily, social and environmental aspects that benefit the community instead of maximizing personal profit (Ikerd, 2013; Roberts et al., 2013). The constraints are mainly caused by the low levels of income and investments in family farming, which affect the family' quality of life (Schmitz and Mota, 2007; Porro and

Porro, 2015), the pressure of the distribution sector of agricultural products, the lack of support infrastructure and assistance from public institutions, and the difficulties in accessing new technologies and markets (Dantas and Ikeda, 2017).

Family farming reproduces itself in such diverse ways that it requires a specific analysis for each space, context, and time (Finatto and Salamoni, 2008). In Africa, most of the food originates from family farming, which is typically produced by women who face numerous difficulties (Ali *et al.*, 2015). Despite the methods being used to alleviate poverty, namely the empowerment (Debrah, 2013), these constraints on livelihoods and the lack of economic development in rural areas, are responsible for the migration of young adults into cities, seeking jobs and other opportunities (Yeboah, 2010). In this context, Adekeye (2014) provided an interesting idea to achieve sustainable development, supported on the recognition of African's structural and institutional specificities and the attendance to their socioeconomic problems, mentalities, and attitudes.

In Angola, the situation is not so distinct from other African countries

in terms of poverty and social problems in the rural communities (Moya, 2016). Angola's global poverty incidence is 41% (below of 12.181 kwanzas per month), being greater in rural areas (56%), particularly in the provinces of Kwanza Sul, Lunda Sul, Huila, Huambo, Uige, Bié, Cunene and Moxico.

The reduction of income-earning opportunities out of agriculture and the fall of the international oil price, repositioned the family farming – as a sole occupation or combined with casual off-farm jobs – as a way out of hunger and poverty (Temudo and Talhinhas, 2017). In Angola's current context, family farming accounts for about 81% of cereal production, 92% of root and tuber production, 89% of pulse and oilseed production, 85% of meat production, and 30% of fish catch (MAF, 2020). The activity involves most of the country's working rural population, which faces enormous challenges, most notably, equitable access to land, water, technical assistance, credit, and generally the lack of input (MAF, 2020). Greater knowledge of the common and differentiating elements of family farming, and their critical aspects, is needed and useful to understand and recognize family farming facets and organizational customs, and to support strategies and policies in developing countries such as Angola, where information is scarce. These strategies can contribute to the sustainability of the practiced systems, their territories, and the agents that depend on them.

With the adequate support, family farming can become a sustainable source of good quality food supply and a promoter of local and rural development (Miranda *et al.,* 2016).

This paper aims to understand the nature and characteristics of family farming among the Huambo province, one of the most important agricultural regions in Angola. Its purpose is to analyse the existing data and generate new information on this group, necessary for a better understanding of this phenomenon, and for exploring the intersections between wellbeing, poverty, multifunctionality, sustainability and vulnerabilities. Little research and attention have targeted family farming in Huambo, and no specific policies have been implemented in Angola to help reduce their poverty and improve the wellbeing of rural families and communities. The paper also reflects the approaches that are available within literature, which fit a deeper analysis of family farming whilst considering the maintenance of its multifunctionality and the increase in economic and social sustainability.

2.2. Family Farming Concept and Dimensions

According to Upton (1996), farm households have two main functions that fall into two distinct areas of neoclassical microeconomic analysis - the consumer function in consumer theory and the producer function in production theory.

Quitari (2015) considers that several contemporary researchers have engaged in conceptual and methodological studies around the definition of family and/or peasant agriculture in the early twentieth century. According to that author the approaches of researchers in one way or another, fall on the specificity, interdependence or economic integration of peasant agriculture in relation to the capitalist economy. In this regard, the arrival of the market in rural areas makes households open to the outside and the nature of production, consumption and income changes profoundly.

Some models have been developed for understanding those changes and the objectives and functions of rural households, from peasant or subsistence to small or family farming. These models incorporated the production and consumption decisions and their interdependency as well as the market of resources and products (Deus, 2018). For instance, Chayanov's (1974) household model considers the inexistence of a market for family labor, and unlike the capitalist enterprise, which is based on the extraction of salaried labor and which priority is the maximization of profit, family production is oriented towards the satisfaction of the family's needs and reproduction. Notwithstanding, Chayanov (1974) does not deny the interest of the family farmer to obtain profit from his productive activity, but this interest is necessarily subordinated to the satisfaction of the family.

On the other hand, the Barnum-Squire's household model fully incorporates the market both in terms of production, consumption, off-farm family labour contracting, and revenue sources. A family farmer integrated into the market, who uses advanced technological means in the production process, should never be characterized as a peasant (Abramovay, 1992).

The debate on family farming is not new, but in recent times it has gained wide discussion in academia, government policies, and social movements. The conceptual delimitation of family farming suggests several strands, among which Altafin (2007) highlights two. One considers that modern family farming is a new category, resulting from the transformations experienced by developed capitalist societies. The other defends family farming as an evolving concept, with significant historical roots in the peasantry.

The importance of family labour, land ownership or management, kinship relations and the transfer of ownership to the next generation are the main criteria for defining family farming (van Vliet *et al.,* 2015).

In FAO's (2014) study on the concept of family farming, the 36 definitions of family farming used by academics, government, and civil society organizations, which describe the characteristics that make family farming unique, were reviewed. It ~~was~~ concluded that the definition of family farming varies across countries and contexts. However, most definitions recognize the role of family labour and the role of the family in managing the operations of the production process (Table 1). *Family farming (also family agriculture) is a means of organizing agricultural, forestry, fisheries, pastoral and aquaculture production which is managed and operated by a family and predominantly reliant on family labour, including both women's and men's. The family and the farm are linked, coevolve and combine economic, environmental, reproductive, social and cultural functions* (FAO, 2014: III).

Table 1. Dimensions for defining family farming

Dimension	Description
Manpower	Family farming relies mainly on family members to provide labour, though exceptionally some family farms rely on hired labour.
Management	The family is responsible for managing the agricultural production.
Size	The size of the farm, in terms of land area and/or in terms of agricultural production.
Provision of a sufficient source of livelihood	Mining is seen as a source of family sustenance, either for subsistence or to generate enough income to guarantee a sustainable life.
Residence	The farm is the family's place of residence. Some definitions stipulate a minimum distance between the farm and the family residence.
Family ties and generational aspects of family farming	Some definitions refer to generational or family ties. They understand the farm as a unit of succession or as a source of inheritance within the family; and/or stipulating the requirement of marriage or blood between owners/managers of the farm.
Community and social networks	Family farming as a link to the community or the social implications of agriculture.
Subsistenceoriented	The main objective of production is to obtain food for family consumption.
Heritage	Family farming as a family asset (heritage) by land, capital or skills/ knowledge.
Land ownership	The premises that require the family to own the land on which they farm.
The family as the main investor	The family as the main source of investment for the farm
Efficiency and Capacity	References to the difficulties of family farming in adopting new agricultural technologies, efficiency issues, as well as the ability of farming families to operate the farm.
Ecological sustainability	Family farming is seen as a source of ecological or sustainable agriculture
Transition	Transitioning family farming beyond the capacity of family labour and management.

Source: Adapted from FAO (2014).

Family farming plays a key role in eradicating hunger and poverty, reducing inequality, promoting employment, increasing income for family reproduction and presents itself as an excellent alternative for the sustainable development of countries (Ivchenko, 2016; Díaz and Morejón, 2018). Thus, it is essential to ponder sustainable development and, primarily, sustainable land use, whilst bearing in mind the dynamic interactions of human and natural systems (Sies, 2014).

2.3. Researching Procedures

The research uses both quantitative and qualitative data, on two different and complementary levels, to examine the nature and characteristics of family farming among the Huambo province. The first level consisted in the identification, characterization and analysis of the farming systems practiced in the province of Huambo, from official secondary data sources. Data collection during this phase was also directed at technical and scientific documents, though special attention given to research studies and institutional reports on the province and agriculture of Huambo.

The second level comprised a critical appreciation of the farming systems of Huambo, through discussions within a restricted environment, the first Huambo Peasant Forum, a public Webinar dedicated to the business of agriculture in Angola. The first event took place on 29th December 2020 and included 150 participants, namely, farmers' representatives from the eleven municipalities of the province of Huambo, private officials of the provincial agricultural sector, provincial government officials, academics, and representatives of non-governmental organizations. The Webinar held on 17th February 2021 had a broad participation, no enrolment restrictions and quite a heterogeneous audience.

These discussion groups were further complemented with field notes and observations, which were performed in the last semester of the year 2020 and the first trimester of 2021.

According to the state of the art and the research objectives, the collection and analysis of the information was driven to typologies of agrarian systems. These included production indicators, agricultural labour use, tools and instruments used in production, crops growth information on technological crop itinerary and other socioeconomic and cultural issues.

The critical appreciation of the farming systems of Huambo, was supported on a matrix analysis, which was oriented towards the dimensions defined by the FAO document (2014). This document reflected the reality of the different typologies of family farming in Huambo.

2.4. Huambo Family Farming Overview

2.4.1. Importance of the Huambo province and family farming in Angola

Agriculture plays an extremely important role in the socio-economic structure of families in Huambo, being the main economic activity of the region's rural households. The statistical data available for the national context (Table 2) shows the existence of about 2.900 thousand family farms, with an average area of less than two hectares. These farms are responsible for the cultivation of 91,5% of the utilized agricultural area (UAA) available in Angola and producing about 80% of cereals and horticulture and 90% of leguminous, roots, and tubers. On the other hand, business agriculture corresponds only to 0,3% of the total number of farms, representing 8,5% of the utilized agricultural area, while farm size reaches, on average area, over 54 hectares.

Table 2. UAA (In Ha) and production volume (Ton) per farm type, in Angola, in 2017/2019

Type of farming	Family farming				Business agriculture			
Agricultural year	2017/2018	%	2018/2019	%	2017/2018	%	2018/2019	%
Number of Farms	2.866.811	99,7	2.923.605	99,7	8.826	0,3	8.826	0,3
Utilized Agricultural Area (Ha)	5.192.012	91,5	5.195.333	91,5	481.247	8,5	483.229	8,5
Production of cereals (Ton)	2.363.644	82	2.356.678	81	521.584	18	545.965	19
Production of leguminous (Ton)	512.306	90	513.702	89	58.697	10	61.252	11
Production of roots and tubers (Ton)	9.948.167	91	10.193.075	92	928.688	9	942.752	8
Production of horticulture (Ton)	1.516.968	80	1.515.494	78	383.038	20	523.297	22

Source: Adapted from MAF (2018 and 2019)

Regarding the production of cereals, leguminous, oilseeds, and horticulture, the Huambo province ranks first position in the totality of the Angolan production (Table 3). Huambo accounts for 27,3% of cereals, 20,2 % of leguminous and oilseeds, and 28,2 % of horticulture. The provinces of Bié and Cuanza Sul rank in the first five positions for the three types of production considered, while Benguela and Huila are important for cereal and horticulture, and Malange for leguminous and oilseeds.

Between 2017 and 2019, the increases in certain productions, were attributed to the surge in technical assistance and the delivery of technological packages to more rural families. These packages were distributed by the Institute of Agrarian Development (IDA), through a project which supported family farming and commercialization (MOZAP 2).

Table 3. The Main Crop Productions in the Angola`s Provinces in 2017/2019

Angola's Provinces	2017/2018	2018/2019	% in total (average 2017-2019)
Cereals production (Ton)			
Huambo	763 700	816 835	27.3
Cuanza Sul	618 726	646 911	21.9
Bié	436 079	471 952	15.7
Benguela	307 586	326 549	11.0
Huíla	311 228	249 205	9.7
Other 13 provinces	447 908	391 191	14.5
Angola	2 885 227	2 902 643	100.0
Leguminous and oilseeds production (Ton)			
Huambo	114 531	116 756	20.2
Bié	98 669	101 253	17.4
Cuanza Sul	84 109	89 363	15.1
Uige	61 535	63 420	10.9
Malange	40 241	40 540	7.0
Other 13 provinces	171 917	163 622	29.3
Angola	571 002	574 954	100.0
Horticultural production (Ton)			
Huambo	538 270	544 804	28.2
Benguela	510 016	532 398	27.2
Cuanza Sul	161 209	163 617	8.5
Bié	138 534	144 425	7.4
Huíla	123 487	120 738	6.4
Other 13 provinces	428 397	432 809	22.4
Angola	1 899 913	1 938 791	100.0

Source: Adapted from MAF (2018 and 2019).

2.4.2. Diversity of family farming in Huambo

In the colonial period, the agrarian production structure was based on a dual model, represented by a traditional and a more entrepreneurial sector. The former was characterized by subsistence farming practices, little market orientation, family labour and an agricultural area between 2 and 3 hectares. The entrepreneurial production system used modern agricultural practices, its production was market oriented, the labour force was of salaried nature, with strong mechanization and the dimensions of the farms were above 10 hectares (Pacheco, 2003).

In the post-independence period, according to Katiavala (2007), agri-food production continues to be ensured by family farming, with insignificant business sector contribution. Camuti (2016) states that family farming in Angola, particularly in the Central Highlands region, began to play a prominent role in the supply of different products for local markets, going beyond the subsistence function and assuming a commercial feature.

In Huambo, there is no single type of family agriculture. According to different authors inside family farming, there is a diversity of farm and household typologies.

Based on production purposes, a study by Pacheco et al. (1997) in the Ekunha municipality of the Huambo province, identified four typologies of family farming. The first is constituted by women who live alone, generally widows or of absent husbands. They produce to guarantee their livelihood and often seek to work as wage earners on someone else's farm. The second typology is represented by elderly men, who produce for their own and the family's subsistence, though when agricultural income is not enough to guarantee their livelihood, there is a need to look for paid work outside their farms. The third typology, called common peasants, is characterized for having one or more animal traction units, and employs the family labour from the previous typologies. To ensure the livelihood of the household, agricultural production is sold to the market. The last typology is made up of the richest farmers, which have at least 10 cattle heads, houses covered with tiles, zinc sheets, *lusalite* and own motorcycles, tractors, vans, and trucks. Agricultural activities employ outside workers and corn harvests are between 2 to 3 tons.

Also using the production objectives criterion, IDA (2004) identified four typologies of family farms in Angola. In the first typology, production is aimed mainly for household consumption and when insufficient to guarantee the household livelihood, it is complemented with the harvest of wild-grown produce. The second typology refers to farmers who produce to ensure the livelihood of the household and sell production surplus at the market. The farms with livestock as a main activity, representing the third typology, have most of their production directed to the market, while the family livelihood is guaranteed by the monetary income that comes from the commercialization of animals. The fourth typology concerns family farms which production is mainly sold to the market. During peak seasons, labour is hired, self-subsistence is reduced, and some consumer goods are purchased in the market

More recently, the FAO (2013) classified the agrarian production systems of Huambo into five typologies, based on the ten criteria described in Table 4. The differentiating factors are based on the resources used, namely the production area and the nature of the used labour; These were the following: the objective of the production which in turn dictates which main crops are produced; the production technology which also conditions the productivity; the complementarity with animal production activities; the social organisation of the farm and the support it provides to the family household; the existence of pluriactivity related to the need to support the family household; and, finally, the relationship with the market, according to the volume of production attained. In this study, Katiavala (2015) pointed out both, the dominance of family labour in Huambo family farming and the fact that more than 50 percent of household income is resultant from outside sources, through wages and minor trade activities.

Table 4. Main Characteristics of FAO Agricultural Farm Typologies in Huambo

Agricultural Dimensions/Farm typologies	Subsistence family farms	Stable family farms	Family farms with employees	Commercial family farms	Large enterprises farms
Production area	Up to 2 ha	Up to 2 ha	5 to 15 ha	10 to 50 ha	Up to 1000 ha
Labour type	Unpaid family	Unpaid family	Unpaid family and hired	Hired	Hired permanent and temporary
Production aim	Partial annual household food needs	Total annual household food needs	Household food needs and sale	Sale	Sale
Major crops	Intercropping of corn with beans	Intercropping of corn with beans and vegetables	Several crops (irrigated horticultural crops)	Several crops and vegetables throughout the year	Wide range of crops
Animal husbandry	Mostly without animals	Small animals (chickens and goats)	Small animals (chickens, goats and pigs)	Mainly cattle	Several livestock species
Production technology	Hoes, axes and machetes	Animal traction (own or rented); gravity irrigation systems	Own animal traction	Motor pumps for irrigation; Animal traction (in some cases tractors)	Mechanization with tractors
Productivity	Very low	Low	Medium	High	High
Social organization	Households headed by men; women engaged in production and domestic activities; Children engaged in production activities	Households headed by men; women engaged in production and domestic activities; Children engaged in production activities	Farmers are village leaders belonging to respected village families	Farmers are local leaders belonging to respected local families	Farmers belong to financially wealthy families
Farmer and family activities	Off-farm work (payments in cash or kind)	Pluriactivity of household members	Pluriactivity of household Members	Agricultural and commercial activity	Agricultural and commercial activity
Market linkages	Very reduced (no product to sell)	Reduced (none or few products to sell)	Regular (local markets for surplus products)	High (local and provincial markets)	Very high (local, provincial and capital markets)

Source: Adapted from FAO (2013).

2.4.3. Land tenure

Huambo still has abundant and productive land in need of exploring. Access to land tenure is a key component in strategies for family farming livelihoods so to enhance and sustain food security.

Angola's Constitution of the Republic enshrines land as the original property of the State, and its access is governed by the Land Law No. 9/04 of November 9, 2004.

Despite the *Land Law* prohibiting the possibility of community land concessions, purchases, and sales, practice has shown otherwise. The results of Katiavala (2015), reveal that farmers have access to land by inheritance, purchase, lease, and other forms (assignment or occupation).

The situation of land tenure and use, as well as the conditions necessary for such rights to be legally recognized at a community and individual level, are directly linked to the guarantee of community land tenure and local community rights of access, which constitutes a fundamental condition for incorporating these actors in sustainable land management (Land Law No. 9/04 of November 9, 2004).

Field observation confirmed the findings in Lote's (2015) study, in which the most frequent mean to acquire land rights is the assignment by inheritance, after the purchase or both. The current context is different from the one before the end of the war conflict in 2002. After 2002 the Angolan legislators had demonstrated a consistent tendency to protect the land rights of the country's rural and poor peri-urban populations and also to direct some land resources to support the development of commercial farming and mineral extraction (Clover, 2005).

Land is an important political matter which is debated in the parliament, influencing the platforms of political parties. Also, Angolan civil society advocates for the promotion of land tenure rights for women and the protection of the urban and rural poor against arbitrary and forced removals (Cain, 2019).

Rural communities have collective rights to own, manage and usufruct of the community's means of production, namely the community rural land occupied and utilized in a useful and effective way, according to the principles of self-administration and self-management, either for housing, for agricultural activity or for the achievement of other purposes recognized by the customary and by the Angolan land law.

The land law recognizes, to the families from rural communities, the occupation, the possession, and the rights to usufruct of the community rural lands, which they occupy and use in a beneficial and effective way according to the custom.

Article 9 of the Land Law provides in point 1, that the State respects and protects the land rights held by rural communities, including those that are based on uses or custom. However, point 2 of the aforementioned article, establishes that rural communities' land can be expropriated for public benefit or subject to requisition, upon fair compensation.

On land that is integrated into the State's private domain, the State can transmit or constitute land rights, free of charge, for the benefit of people who demonstrate evidence of insufficient economic means, who wish to integrate settlement projects in less developed regions of the country or for institutions of recognized public utility, that pursue the purposes of social, cultural, religious or sporting solidarity.

Access to land by farmers is usually done through inheritance, which is passed on from generation to generation. During parents' life, there is also a transfer of land to their sons. In both cases, preference is given to male sons and rarely to daughters. It is advocated that daughters will be able to benefit from the land of future husbands. Within the communities, renting or buying land is not common, since current families inherited their land from their ancestors. However, people from outside the communities can be observed buying land in the rural villages. In these cases, the buying and selling process, is always accompanied by the traditional local authorities, elders and relatives of the seller who serve as witnesses.

According to the Law, the transfer of land rights by act, in life, is made by means of a declaration by the parties in the concession title, with personal recognition of the transferor's signature which is subject to registration in general terms.

The transfer due to death is subject to registration in the concession title, and the signature of the successor must be recognized in person, after notary presentation, so that he may achieve a document proving the right of succession.

The Law provides that the land on which surface rights have been constituted or have been granted and which was object of useful and effective use during the legally established terms, may be sold, with exemption from public auction, to the holders of those limited land rights.

The purchase and sale contracts can be ended by the State or by the local authorities, if the rates of useful and effective use of the land are not observed for three consecutive years or six interpolated years, whatever the reason.

2.4.4. Crops and land use

The main agricultural crops of Huambo are maize and beans, grown as intercrop followed by potatoes, cassava, fruit trees, cabbages, tomatoes, onions, garlic and carrots (Camuti, 2016; Kamutali et al., 2020; Tchikola, 2016). The first two are mainly grown and intended for family self-subsistence food, while the others are also grown as cash crops (Table 5).

Table 5. Area (HA), Production (Ton) and Productivity (Ton/Ha) of the main crops in Huambo, between 2013/2014 and 2018/2019

Crops	Agricultural years	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019
Maize	Area (Ha)	311 519.72	329 033.46	233 091.20	321 831.25	172 632.67	181 022.31
	Production (Ton)	228 512.29	235 004.65	131 638.42	454 740.21	147 952.01	160 890.24
	Productivity (Ton/Ha)	0.7	0.7	0.5	1,4	0.8	0.8
Bean	Area (Ha)	353 302.2	388 862.1	881 199	645 546	616 924.4	460 489.05
	Production (Ton)	117 507.16	126 593.16	308 012	304 053.7	254 994.9	159 774.78
	Productivity (Ton/Ha)	0.3	0.3	0.34	0.47	0.4	0.3
Potato	Area (Ha)	41 958	44 473	80 177	81 259	74 326.7	42 273.4
	Production (Ton)	314 005	459 768	539 058	631 280.03	654 880.95	414 746.33
	Productivity (Ton/Ha)	7.4	10.3	6.7	7.7	8.8	9.8
Horti-cultural products	Area (Ha)	37 412	40 079.7	40 079.7	42 964.7	47 076.2	47 106.9
	Production (Ton)	323 596.09	363 824.26	328 265.74	386 570.77	400 906.72	435 099.49
	Productivity (Ton/Ha)	8.6	9	8	8,9	8,5	9.2

Source: Adapted from IDA (2014-2019)

Maize is the most widely grown cereal in Huambo. It is the main source of carbohydrates in the region and it is consumed fresh (*massaroca*), dried and transformed into flour (*pirão* and *quissangua*), semi-processed (*canjica, rolão*) and the its bran is used for animal provision (chickens and pigs).

Beans are also highly appreciated by families in Huambo, as they usually accompany most of the main meals of the day. Their cultivation has been driven by the domestic market and reached values over of 600 thousand hectares in the agricultural year 2017/2018, corresponding to more than 200 thousand tons.

The area dedicated to potatoes has oscillated throughout the years, having minimum values close to 45.000 hectares in 2014/2015. It is a cash crop, as it has been grown mainly with the aim of being sold at the local and provincial markets.

The area dedicated to vegetables, has been stable between 2013/2014 and 2018/2019, especially for carrots, cabbage, tomatoes, onions, garlic and kale. The purpose of this production is twofold, for sustenance and for sale.

Most of the crops, have a relatively low productivity per acre, revealing little variation throughout the years, except for 2015/2016 and 2016/2017, for which productivity levels were low due to climatic changes.

According to Katiavala (2015), farms in Huambo are characterised by a high degree of fragmentation and spatial dispersion of plots along the *catena* line. Figure 2 presents the ecological *catena* of cultivation which varies according to the positions on the hillside and human interaction. It is divided into three main units with local designations - *Onaka* in plains and depressions; *Ongongo* or plateau; and *Ombanda* situated in an intermediate position (Morais, 1976).

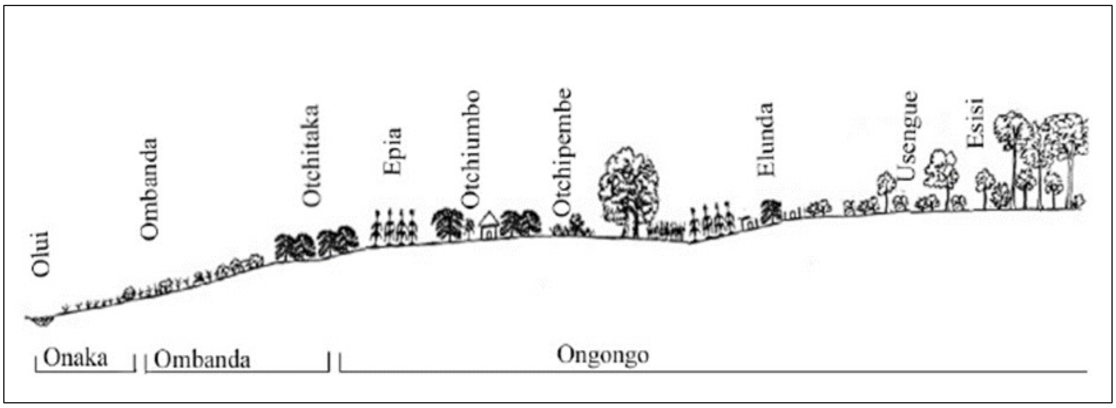

Figure 2. *Ovimbundu* Farming Catena

Source: Delgado-Matas (2014).

The cropping system in the *catena* determines the existence of different types of ploughs in Huambo, which have the following characteristics:

− *Onaka* (lowland plough) - part of the marginal zone of rivers and streams, with hydromorphic soils. During certain times of the year, they become flooded and lack drainage. The plots are prepared at the end of the cold period (July) and sowing takes place in August.

− *Ombanda* (edge and slope ploughing) - transitional plot between the lowlands and the slope, outside the flooding area but with a rise in the water table. The plots are used by farmers soon after the first rains or in August if the farmer is able to irrigate.

− Épia *ongongo* (ploughing from above) - plots on the slopes and in the high areas of the *catena*, on which crop rotations are traditionally carried out. They are used after the first rains, from October for the first season of maize and beans; in February for the second season of beans, peas and reindeer potatoes; and in March for sweet potatoes.

− *Elunda* (ploughing in the old villages) - cultivation plot in the areas of the old villages, where the fertility fund is increased by human and animal presence.

− *Otchumbo* (ploughing close to the dwellings) - plot located in the space of the dwellings, benefiting from fertilisation by human and animal presence (Morais, 2000).

− *Ovipembe* (fallow) - plot left fallow after the exhaustion of the land by the ploughing of the highlands (Vitongue, 2004).

According to Delgado-Matas (2014), the agricultural *catena* system of the *Umbundu* people has evolved from a subsistence system to an agricultural management system that provides food, timber and energy while preserving their identity, social and environmental sustainability. New technologies and crop varieties that increase yields in *Ombanda* and *Onaka* ensure food security for most rural households.

2.4.5. Agricultural resources and technologies

The main tools used in the agricultural production process in Angola are the hoe (98%), machetes (89%), axes (70%), and shovels (13%) (IBEP, 2015). In Huambo, files and ploughshares are also used (Camuti, 2016; Kamutali et al., 2020; Tchikola, 2016). MAF (2019) highlights that 72% of the cultivated area in Angola is worked manually, 25% is aided by animal traction and 3% is done mechanically.

Farmers at the household level face many challenges in producing and ensuring the well-being of their households. Access to credit reaches only 6% of households and the use of agricultural inputs is limited, with only 48% purchasing seeds, plants, or cuttings, 5% using fertilizers, and 1% using pesticides (IBEP, 2015).

Regarding labor use, in old days, Vitongue (2004) mentions that in the family production units of the Ovimbundu (people who mostly inhabit the central plateau of Angola), agricultural work was a woman's task, who in this way met the food needs of the family, in addition to their domestic duties (to prepare the meals (flour) and to collect and transport firewood and water). On the other hand, men were employed in the commercial organizations of the caravans, worked in hunting and gathering products. They started in the agricultural activity with the expansion of *otchumbo* (plowing near the houses) and with the cultivation of products that began to be commercially accepted, only after the failure of the previous mercantile activities. The heavier work such as felling and digging, the *nakas* (plowing the lowlands), was reserved for them so that they could collaborate, in this way, with the women's plowing activities. Nowadays, there is no separation between men's and women's agricultural duties, the agricultural works are little differentiated, except for the heavier tasks (Kamutali et al., 2020).

2.4.6. Social organization and festive activities

What is primarily observed, in terms of social organization in the rural communities of Huambo, is the existence of nuclear family households consisting of husband, wife, and children. However, one also finds marriages between of one man and two or more women. Katiavala (2015) states that nuclear households are inserted in the framework of kinship relations which strongly influence the life of the couple, in various aspects of daily life, such as conflict resolution, management of land assets, marriage alliances, transmission of inheritance, among others.

It is also observed that after the family, the social organization is marked by the existence of traditional and religious leaders, representatives of political parties and in some cases the leaders of associations, cooperatives, and farmer field schools (field observation). According to Katiavala (2015), the traditional leadership of a village comprises the chief, who is assisted by a group of advisors, consisting of elders. The traditional leaders are a kind of village government that articulates the connection with the government authorities of the commune, municipality, and province to which they belong.

The religious leaders are mostly from the Catholic and Protestant churches. These leaders have a strong influence on the individual and collective conduct of the rural households, which varies according to the doctrinal orientation of each church. In rural Huambo, the local and collective conduct is also influenced by the most important political party representations, the MPLA (Popular Movement for the Liberation of Angola) and UNITA (National Union for Total Independence of Angola). Local Party leaders try to control the population to gain more members for their side. In some cases, ancestral kinship ties are affected and relationships are disintegrated due to partisan motivations (field observation).

Agricultural cooperatives can have a relevant effect on sustainable developmental, through the engagement of families with the objective of generating revenues and creating employment, (Kanyane and Ilorah, 2015). The existing model of rural cooperatives is very dependent on external support and their upsurge seems to be motivated by the need for assistencialism. Members join in the hope that they will be able to access NGO and government donations to invest in their individual farms. The role of the government does not stimulate creativity, much less help the cooperatives to be financially and administratively autonomous so that they are seen as authentic agricultural enterprises.

The government could intervene more, creating and strengthening infrastructures and policies which support rural development, rather than limiting its action to distributing, in many cases outside of the agricultural season, fertilizers and hoes in agricultural campaigns (Kamutali et al., 2020).

The festivities, amusements, and rituals play a great role in the life of the *Ovimbundu* populations. The main festivities in the rural areas of Huambo are *alembamento* (traditional marriage), religious marriages, male initiation (*Evamba*) and others relating to the satisfaction of some superstition, determined by the *tchimbanda* (a kind of fortune-teller and healer) to appease the *osande* (spirit of the family, causing abnormality in the case of a sick person), whether related to plagues, drought, or excessive rain (Vitongue, 2004).

During the festivities, the consumption of fermented corn-based beverages (*ochimbombo*) or unfermented (*ochissangua*) are common, as well as the consumption of the distilled beverage made of sugar cane, sweet potato, or germinated corn (*ossonge*), the *walende*, or *catchipembe* (*brandy*). These are brightened by traditional dances that accompanied by the music of the *ongoma* (batuque) (Field observation). According to Vitongue (2004), many dances have the proper names of the ceremonies to which they are related with, such as *essaka*, *olundondo*, *unhanga*, *ombuio* and *evamba*.

2.4.7. Market linkages

Huambo farming families faced several difficulties in accessing markets and getting fair selling prices on their agricultural products. The marketing of agricultural products is done, preferably, on an individual basis by each rural household; it is dominated by informality and exercised mainly by women (Kamutali et al., 2020).

Field observation revealed that the marketing circuit integrates a network of intermediaries. There are those who buy the products in the hands of farmers, and those who buy in the hands of the latter and then sell them at urban markets. Therefore, the economic importance that agricultural commercialization has for producers, intermediaries, and consumers is incontestable. Marcelino (2014) identified the limitations in the marketing chain of agricultural products in Huambo by degree of importance, by physical access, by structure of the agricultural market and by its knowledge, information, and organization. These factors are important determinants to the autonomous and sustainable integration of producers in the market, for which an integrated action of all dimensions is required.

The lack of transportation and the quality of road access, the absence of a processing industry which transforms agricultural production, and the difficulty in accessing other agricultural services. explain the current difficulties in agricultural commercialization in the province of Huambo (Kamutali et al., 2020). Meaning, the current level of organization for family farming in Huambo it is not yet sufficient to face the existing challenges in the markets of agricultural products.

Although most family farms are multi-functional production and consumption units, largely devoted to a high degree of production for self-consumption, they can still sell a limited but significant amount of staple food crops and cash crops in formal or informal markets. Only a few are market oriented, and the transactions are mostly done by traders in local markets. Only a few do so it in vertically integrated agribusiness markets. In the poorest family farms, they survive with labour allocation strategies that combine farming and non-farm activities such as petty trading, craft-making and artisanal mining selling in the market.

2.4.8. Family farming economy and management

According to the field observation, the households can be divided into three groups by gender division of labour and leadership. One group comprises the full male-headed households (including the households constituted by single, divorced or widowed men) in which the man spends the same or more working days in the field when compared to the women. Nonetheless, some couples helped each other in the performance of given tasks, for instance, women aided with sowing and men helped in the harvesting of cassava. The other group includes the households composed of single, divorced or widowed women who are both the head of the household and the farm manager. Lastly, the households which have the highest proportion of dependent members, in which the families are often are composed of old women and their young children and/or grandchildren and, usually, the husband has a job outside agriculture. In those cases, boys used to help their mothers in all agricultural and domestic work and even learned how to cook. However, after marriage, they will only cook if the wife is ill or absent. Concerning family economy, generally, men and women did not get their incomes from selling their products, although men were responsible for buying clothing for their wives and children, and for providing the household with salt, meat and fish. Those who went to work on a plantation for six months used to return in time to perform the clearing of fields and, when remunerated, they would buy clothes, salt and sugar to back bring home.

The general management decisions and all the decision-making processes on what to produce, in what quantity as well as the destination of the products obtained, are dependent on the typology of the households. Thus, decisions can be made in a shared manner (by the couple and/or family), just by the man, the responsible person (man or woman) or by the direction of the cooperative and their members. In the latter case, the planning of the collective production and the destination of the products (consumption by members or the sale in local markets) is done mainly by the management of the cooperatives and in some cases, with prior discussion in a member meeting (Kamutali, 2019). Members who do not participate in collective production, do not receive their benefits or have obligations to the cooperative. The obligation is to work in the field at least once a week. Most cooperative members do not directly receive income from the collective production. The profits that proceed from the sale of products are channelled to the cooperative's fund, which are not autonomous and always needed external state support and donations from non-governmental organizations (NGO). Indirectly, producers benefit from this fund by applying for a community credit bank and/or other cooperative social support, such as supply of credit inputs, equipment and training. The field observation showed that there was some inaccuracy regarding the amount of funds obtained, raising the need of improving the accounting records and financial management of the cooperatives. According Kamutali (2019), globally, farmers are not satisfied with the services provided by the cooperatives, whose leaders are mostly full-time male farmers with no formal studies and their own fields.

2.5. Critical Analysis

Family farms are pervasive in the economy of Huambo and they shape the social organisation of this largely rural population. In addition to their significance in food production, self-sufficiency and income source, they also play a key role in social protection and sustainable development through their multifunctionality. Moreover, these communities figure a political organisation. Consequently, the state of human development in Huambo (poverty level, food security and gender relations) largely reflects the socio-economic (mis)fortunes of family farms, even if their socio-political importance is not reflected in Angola's public policy priorities.

Huambo family farming comprises a diverse set of relatively small-sized socio-economic typologies, which mainly use family labour and limited landholdings to pursue diverse agricultural, pastoral, and natural resource management activities. The land rights are mostly obtained by purchase to the state or inheritance. Family farming evolution has been influenced by customary and cultural traditions, the colonial past, years of conflict and forced migrations, massive urbanization, and the recent socioeconomic development.

Taking into account the criteria related to the type of family labour and cultivated area, three main groups of family farming systems practiced in Huambo were considered (Table 6).

Table 6. Analysis of the Positive (+) And Negative (-) Aspects of the Three Family Farming Systems from Huambo

Description	Group I	Group II	Group III
Production	-	-	-
Productivity	-	-	-
Crop diversity	-	+	+
Labour force	-	+	+
Production technology	-	+	+
Chemicals use	+	+	-
Hydrographic network use	-	-	-
Financial capacity	-	+	+
Market relations	-	-	+
Management and independence	-	-	-
Cooperative practices	-	-	-
Family living conditions	-	+	+
Gender inequality	-	-	-
Hunger and poverty	-	+	+

Legend: Group I – Farms with family labour; Group II – Farms with salaried labour and size less than 15 ha; Group III: Farmsteads.
Source: Own elaboration.

Table 6 reveals the weakest transversal aspects of the three family farming groups (volume of production, productivity, use of the hydrographic network, non-professional management practices, financial capacity, excessive dependence on external support, cooperation network and gender inequality). However, groups II and III also present strong points of economic and social scope, associated with the used production technology, supported on a more robust financial capacity, which allows for better living conditions for its practitioners. Group I stands out by the reduced quantities of chemical products used, which translates into greater environmental benefits.

The location of the farms in the centre of the country and the existence of research and agricultural education institutions constitute opportunities for the development of the farming systems practiced by the three groups under study. However, the limited access to scientific information, the lack of industry to transform and preserve the products, and the existence of a reduced number of suppliers that allow access to the necessary factors of production are the main threats observed across all three farming groups. These limitations need to be addressed to leverage the practice of agricultural activity in Huambo, in its multiple dimensions and in its various scales of production.

Family farming in Huambo produces mainly food from self-subsistence crops such as maize and beans (often intercropped) and cash crops such as potatoes and vegetables. Family labor denotes a gendered distribution of tasks, in which households at some point stop working on their plots to work off-farm for a given market wage or in exchange for a given product. Women are quite under burdened with tasks, besides working on the farm. They take care of domestic chores (preparing flour, transporting firewood and water, preparing food, taking care of the children). Land tenure is traditional, fixed, and dispersed through different places based on ecological catena, that assume the following local designations: *Onaka* (lowland ploughing), Épia *ongongo* (highland ploughing), *Elunda* (ploughing in the old villages), and *Otchchongo* (ploughing near the dwellings). The agricultural work is essentially manual and sometimes resorts to animal traction, using working tools such as hoes, machetes, axes and ploughs.

The access to tenure land is a key component in Huambo family farming livelihood strategies for enhancing and sustaining food security. Land tenure is not only a development matter but a rights-based issue. It means that rights to land are not only a support to economic production, but also, a basis of social relationships and cultural values, and a source of prestige and often power (Clover, 2005). Particularly, use rights are an integral part of social capital, giving people the foundation on which to assert self-determination within their society, culture, agro-ecosystem and economic context (Ramírez, 2002). It is only by giving people real rights that they can engage fully in development (Clover, 2005). However, such circumstance must be accompanied by public policies so to control a spatial planning that benefits the entire territory.

Several factors contribute to the Huambo agricultural potentialities and can be structured in four axes as exposed in Figure 3. The role of family agriculture in the regional economy may be reinforced with better market linkages through cooperatives and enhancing the value of quality production. The contribution to feeding the population should be emphasised, and the productive systems need greater knowledge and research to enable a more efficient use of resources, such as soil and water. The rainfall annual distribution – which allows to produce annual plants twice a year – and the multitude of water courses, favour irrigation crops.

The failure to achieve globally comparable agricultural productivity levels can be attributed to the relative insecurity of land tenure, their narrow subsistence orientation, and intra-family farm and systemic obstacles to economies of scale in production and marketing.

The government should recognize the potential of smallholder agriculture for the diversification of the country's economy, poverty reduction, and (re) building a more equitable and reconciled society. For such to happen, they need to recognize and take steps towards improving rural roads and transportation networks, family farming's access to mechanization, to credit and to the market, and guaranteeing their land tenure security. Special attention should be given to female-headed households, which need a particular and more sustained approach to guarantee the family's well-being.

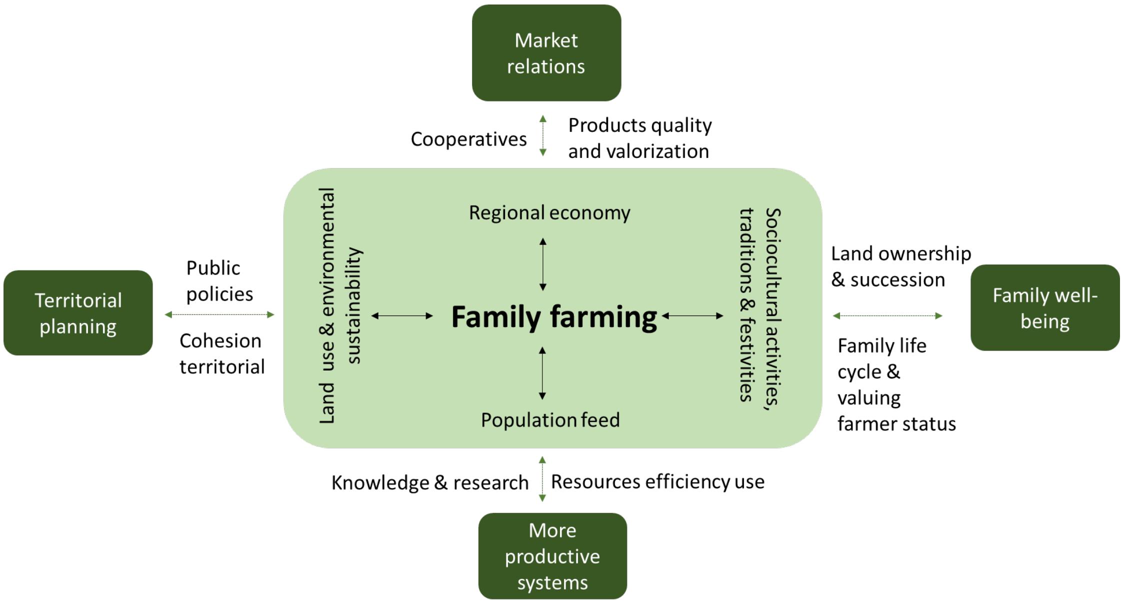

Figure 3. Factors that Contribute to Family Farming Agricultural Potentialities in Huambo

Source: Own elaboration.

2.6. Final considerations

Angola's agricultural development strategy which seeks to increase domestic food supplies, should be built with the contributions of both the family smallholder farmers from Huambo and other provinces, and the national and international corporate farmers. Nonetheless, a more effective, specific, and adequate family farming support should be considered. One that attends to their multifunctionality and provides a sustainable source of food, labour, rural and local development as well as representativeness in the agricultural sector structure. The purpose should be to improve the functioning of food markets, through the promotion of an enabling environment for domestic private investment, focusing on the binding constraints for productivity growth, targeting hunger by increasing per capita production through innovation and technological changes, expanding the irrigated cropped areas, and reducing food imports.

National agricultural and rural development strategies ought to integrate the home market and enhance food sovereignty at a regional level, based on qualitatively higher levels of consumption and social reproduction (including higher-value foods). The unique advantages of family farming, including their labour absorption, versatility in production, low energy requirements and regard for ecological balance, could be enhanced through public support that enables small-scale family farms to realize their employment potential.

Further research is called to generate more and new information regarding Huambo's family farming, seeking to address critical issues of family wellbeing, poverty line, and sustainability of the systems, their territories and family's farming ethnographic dimensions. Additionally, there is bureaucracy associated with access to official data and lack of statistic and scientific information about Angola and the province of Huambo. This paper, by mapping out the distinct dimensions of family farming within the Huambo context, underlines the need to go further in these analyses, in a deeper and innovative way, analysing the sustainability of family farming systems, in their economic and social dimensions so to understand how they can reduce the households' poverty levels.

To better represent the functioning of Huambo households considering their systems' diversity and cultural and ethnographic characteristics, an ethnographic linear programming model can be used to not only analyse productive activities but also reproductive and community activities, which are central to the organization and functioning of Huambo rural communities. This methodology will allow for the testing of policies, technologies, reproductive changes, and modifications in the community's social norms, as well as explore their results and predict the consequences for the future of family farming unities and communities.

CHAPTER 3 - FAMILY FARMING SYSTEMS IN ANGOLA: DEFINE, ANALYSE AND REFINE [2]

In Huambo-Angola, different farming structures can be observed. These are responsible for the region's agricultural production which remains insufficient to cover family needs, due to low productivity, irregular supply, and reduced capacity to compete with imports. This work aims to define and analyse this region's family farming systems so to understand their technological potential and redefine their fundamental objectives, namely, feeding the family, improving wellbeing, and reducing poverty. Based on surveys of family farmers, the findings show that these farming systems are structured by distinct area sizes, land access, productive activities, used technologies, market integration levels, and farmer characteristics, which reflect in market orientation. To refine agribusiness perspectives for the future, small farmers have a social and territorial role which is balanced by other farms who are more market and industrial orientated.

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[2] The original work of this chapter was published in: Kamutali, A.; Henriques, P.D; Lucas, M.R.; & Marta-Costa, A. (2024). Family farming systems in angola: define, analyse and refine. In A. Galati, M. Fiore, A. Thrassou, D. Vrontis (Eds.), *Agribusiness Innovation and Contextual Evolution: Strategic, Managerial and Marketing Advancements*, Volume I (pp. 23-48). Palgrave Macmillan, Cham. DOI: 10.1007/978-3-031-45738-8_2. ISBN 978-3-031-45737-1; 978-3-031-45738-8 (EBook)

3.1. Introduction

Family farming plays a key role in the social development and balanced growth of countries (Damasceno et al., 2011), being identified as an alternative to the promotion of environmentally friendly development (Santos et al., 2012). Family farming stands out in the eradication of hunger and the fight against poverty, presenting itself as an excellent alternative to sustainable agriculture (Díaz & Morejón, 2018), since it guarantees food and nutritional security, handles natural resources better, protects the environment, and seeks to improve leadership levels. Due to its importance, the year 2014 was declared, by the United Nations General Assembly, as the year of family farming (FAO, 2014a).

Despite its importance, Alves (2019) considers that family farming faces problems which solutions are difficult. Among its impasses, the author highlights the reduced production, the lack of value addition in products, the low negotiation capacity, the limited and unskilled labour force, management difficulties, little training and information, the scarcity of land, the absence of associative practices, and the absence of an agricultural policy directed to this type of agriculture and farmers.

This means that, despite the economic, social and environmental contribution of family farming uncovered by the literature (e.g. FAO, 2014a, 2014b; FAO & IFAD, 2019), the challenges faced by this type of agriculture require urgent knowledge and a better and more complete understanding of family production systems, in order to allow guiding policy efforts that lead to sustainable systems, as argued by Lowder et al. (2019). This is the main objective of this study, to individualise the socio-economic characteristics and productive technological conditions of family farms, according to their size, and to identify their differences and similarities. This knowledge on the differences between family farms, namely in terms of dimension and their patterns, allows for a proper engagement with sustainable policy and decision making, which is in line with the emergent literature (e.g. Lowder et al., 2019).

This understanding is necessary to discern if the survival of family farms will depend on their transformation rather than their preservation, and if long-term viability should be the focus of the policies aimed at rural areas (van Vliet et al., 2015). The strategy should be to empower family farming while focusing on promoting sustainable and innovative practices to increase agricultural productivity, create rural employment opportunities for income diversification, and strengthen organizations and institutions operating in rural areas to facilitate family farmers' access to rural services and markets (Impiglia & Lewis, 2019). But for this, the typology and characteristics of the systems must be understood, and the choices made by the family farmers must be known. Family farmers may opt for several crops on their farms (ploughs) with the aim of improving income and minimizing both market and climatic risks, or, contrastingly, their decision on agricultural diversity may be influenced by off-farm income (Ochoa et al., 2019).

In the specific case of the African continent, small farms are predominant, whose agrarian systems play a key role in providing food and reducing poverty levels. The challenge for this type of farm is to close the gap between current and potential incomes so to ensure that family farmers can provide food to their families and earn a surplus that they can sell, which profit will contribute to lifting them out of poverty (Gassner et al., 2019). According to Ali et al. (2015), in this geographical context, most of the food comes from family farming and mostly produced by women who face various difficulties. Family farming in Angola, which is located on the South Atlantic coast of West Africa, constitutes an economic activity which occupies a large part of the population, being currently responsible for the production of about 81% of cereals, 92% of roots and tubers, 89% of legumes and oilseeds, and 85% of meat (MINAGRIF, 2020).

Furthermore, Mosca (2014) explains that over the decades family production systems have undergone different levels of transformation because of the intensity of capital penetration in rural areas, especially agrarian and commercial capital, and the extraction of natural resources. Despite the worst human development indices, the author notes that most African governments have not opted for policies that favour family farming and, as a result, poverty levels have remained high for decades.

In this context, this work aims to define and analyse family farming systems in Huambo, one of Angola's most important agricultural regions, with the purpose of improving knowledge on their technological potential and redefining their production systems to better orient them towards feeding the family, improving well-being, and reducing poverty. Additionally, this chapter considers the need to improve agricultural censuses to deepen the understanding of farms, for that purpose, additional and extremely useful surveys on family farming systems were conducted.

The deepening of knowledge on family farm production and its fate, the forms of development and adaptation of this segment to market and business systems, as well as the possibility of its eventual disappearance in response to the intensification of business production relations (Finatto & Salamoni, 2008) are still topics of current discussion, which reveal the importance of the present work. Knowledge of the common and differentiating elements of family farming and the critical aspects associated with it, is useful to understand the several forms of organisation of the activity and supporting strategies and policies for the sector in developing countries. In these countries, information is scarce, and these may enable the sustainability of the systems practiced, their territories and the agents that depend on them.

The chapter is structured into five sections. After this brief Introduction, the Literature review exposes the theoretical contextualisation of the topic. Then, the Methodology section is presented, which details the process followed to obtain and process the data, followed by the Presentation of the results. The last section presents the Discussion and Conclusions, in the light of the theory on the topic and with the exposition of the main contributions of the work, namely at the level of the definition of public policies and their potential impacts on family farming in Huambo.

3.2. Literature review

The diversity of concepts of family farming derives from the combination of social and economic factors in different regions and countries, as well as from the motivations of the authors who try to define it. Nonetheless, despite the inexistence of a consensual definition (Chaves et al., 2023), all models of family-based production are used to define family farming (FAO & IFAD, 2019). According to Denardi (2001) and Miranda et al. (2006), and more recently Morais et al. (2023), family farms can be understood as a production and social reproduction unit, which main features are family management and predominant family labour in agricultural activities, being the owner also a worker on the farm.

The conceptual delimitation of family farming suggests several aspects, among which Altafin (2007) highlights family farming as a new category resulting from the transformations experienced by developed capitalist societies, and as an evolving concept with significant historical roots in peasantry.

This system is characterized mainly by the predominance of family labour and particular forms of succession in relation to land ownership that is generally transmitted from generation to generation (Taveira et al., 2019). In family farming, local knowledge, adaptive skills, and know-how that is passed down between generations also prevail. For all these reasons, family farming is fundamental to maintaining the economy in rural areas (Galdeano-Gomez et al., 2017). Following Lowder et al. (2019), it is estimated that there are around 570 million family farms worldwide, which occupy 70 to 80% of agricultural land and produce 80% of food worldwide.

A family farm is a production and consumption unit as well as a production and social reproduction unit (Santos et al., 2012). On these farms, management and labour are generally family-based, and this occurs because there is no separation between management and labour, both being under the responsibility of the producer and his family. Even when there is a need to hire labour, it occurs to complement the family labour force.

In the perspective of van Vliet et al. (2015), the family labour, the transfer of ownership to the next generation and land management, are the main criteria of family farming. In this type of agriculture, management is essentially carried out from the family's perspective, so any policy measure to support this type of farmers should consider the perception of the managers of the family production units. Therefore, the manager's ability to interpret the decisive variables to obtain better economic, social, and environmental results for the family farm is fundamental (Viol et al., 2017). In this regard, Finatto and Salamoni (2008) refer that family farming, in its great majority, presents productive structures of smaller territorial size, which makes it easy to convert them into a purely agroecological farming system. Also, Gornitzky (2015) considers that family farming activities are diversified, that they produce most of the food and ensure the conservation of biodiversity and preservation of the environment. Additionally, they can play an important role in the transition to sustainable food Systems, concerning the reduction of climate change, alongside poverty and hunger (FAO & IFAD, 2019), having economic, environmental, social, and cultural functions (Chaves et al., 2023).

Naturally, family farming is a production system geared toward family self-consumption (Morais et al., 2023) but, in some cases, market motivations are also present. In this context, the main problems exposed by Chaves et al. (2023) regarding family farming arise from the lack of investment and inefficient logistics. Investments in the agricultural sector are important and necessary, but they must be based on local knowledge and promote linkages between the agricultural sector and other sectors, as well as between rural areas and urban areas in cities.

In agreement with FAO statistics (2014b), over 70% of the global population have food insecurity and they come from rural areas of developing countries. Many of them are subsistence farmers or agricultural workers who are poorly paid (Chaves et al., 2023).

In Sub-Saharan African countries, the agrarian systems play two main roles, firstly they provide food and secondly, they reduce the existing levels of poverty (Gassner et al., 2019). Unfortunately, for these mostly low-income countries, agricultural interventions to increase agricultural productivity and eradicate poverty for family farmers have been limited (Gassner et al., 2019), and multisectoral programs involving actors from agriculture, nutrition, and health are needed (Cole et al., 2016).

The majority of the agricultural labour force in this geographic area is made up of women. Ali et al. (2015) indicates that they represent 50% of the agricultural labour force, while Palacios-Lopez et al. (2015) point out that women's contribution to agricultural labour in Africa is in the range of 60 to 80%. In general, women's agricultural activities include weeding, sowing, harvesting, and threshing. Men are usually limited to clearing and preparing fields that include felling trees (Moseley & Watson, 2016). However, even though in family farming the feminization of the agricultural workforce is real and global, women have difficulty in obtaining loans or gaining title to the land on which they work, as well as accessing mechanization, services, land, and internal and external markets (Moseley & Watson, 2016).

In the case of Angola, agri-food production continues to be provided by family farming, with the contribution of the business sector being insignificant (Katiavala, 2007). In this country, the traditional production system is characterized by the use of subsistence farming practices and little market orientation, family labour and an agricultural area between 2 and 3 acres. The business production system uses more modern agricultural practices, is market-oriented, uses wage labour with a strong mechanization component, and the farm sizes are above 10 acres (Pacheco, 2003). Nevertheless, more recently, Camuti (2016) states that family farming in Angola, particularly in the Central Highlands region, has started to play a prominent role in the supply of different products for local markets, going beyond the subsistence character and assuming a commercial feature.

Therefore, identifying the differences and similarities of the different family farming systems, constitutes the research question of this study, which answers may support the better definition of the objectives of these systems, as well as lead to the implementation of policies that are further adjusted to its context.

Some studies have been developed so to identify the different typologies of family farming systems. Based on production objectives, in a study carried out in the municipality of Ekunha, Huambo province, Pacheco (1997) identified four typologies of family farming. The first, consisted of women living alone, who were widows or had absent husbands, produced to ensure their livelihood. The second typology was represented by elderly men who produced to ensure their subsistence and that of their families. The third had one or more animal-drawn joints and employed farmers from the first and second typology. In addition to ensuring the livelihood of the household, they were market oriented. The fourth typology was made up of the wealthiest farmers, who had at least 10 head of cattle and produced for market transactions.

Later, in 2004, the Institute for Agrarian Development (IDA), using the production objectives criterion, also identified four typologies of family farm enterprises in Angola. In the first typology, the productions were mainly for household consumption. The second referred to farmers who produced to ensure the livelihood of the household and destined the surplus production for markets. The third typology was represented by family businesses of agro-pastoral economy, which had livestock as their main activity and as a complement to agricultural production. The fourth typology was of family agricultural enterprises strongly influenced by market production. In this case, subsistence production was reduced, consumer goods were bought in the market, and during peak periods salaried labour was hired.

Regardless the farm typology, in Angola, family farmers face many challenges to produce and ensure the well-being of their households. Access to credit reaches only 6% of households, the use of agricultural inputs is limited, where 48% purchase seeds, plants or cuttings, 5% use fertilizers and only 1% use pesticides. The main tools used in the production process are hoe (98 %), machetes (89 %), axes (70 %) and 13 % shovels (IBEP, 2015).

In this paper, the typology of family farms under study is defined according to farm size.

3.3. Methodology

3.3.1. Study area

Huambo is a province in Angola, with an area of 35 771 km^2 and, administratively, it is divided into eleven municipalities: Huambo, Bailundo, Ekunha, Caála, Cachiungo, Londuimbale, Longonjo, Mungo, Chicala-Choloanga, Tchindjenje and Ucuma (Figure 4).

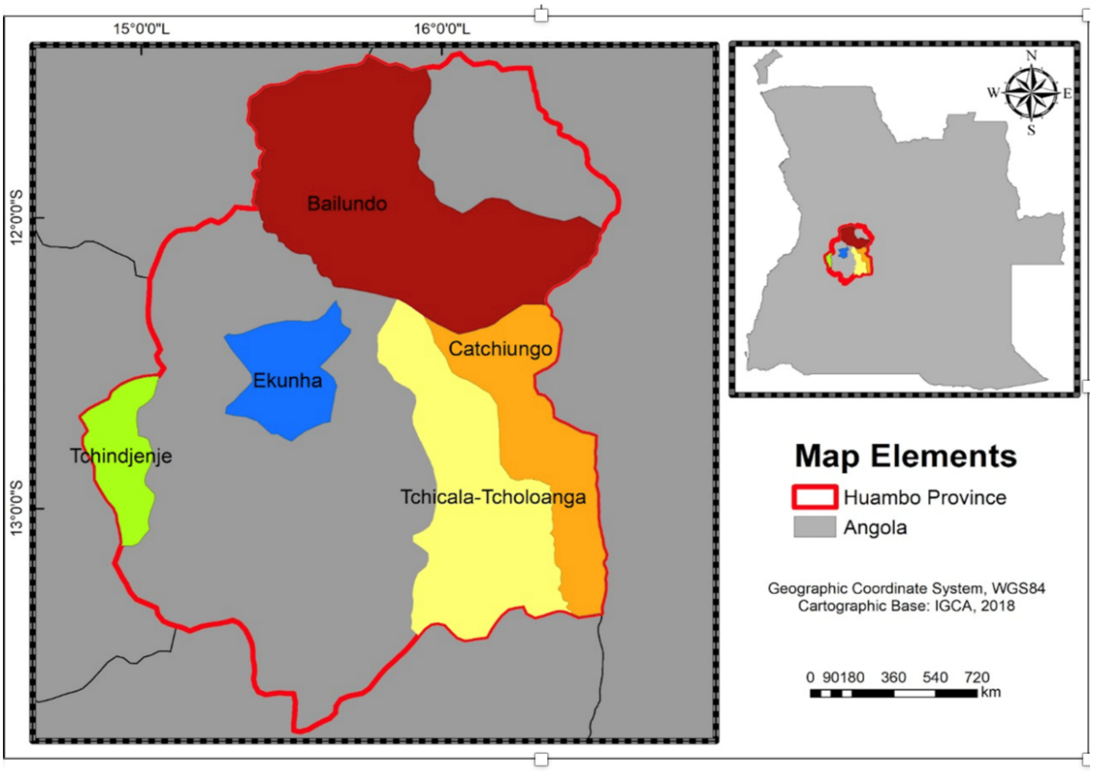

Figure 4. Study area, in Huambo (Angola)

Source: Own elaboration.

The 2014 Census (INE, 2014) indicated that 1 896 147 people resided in the province of Huambo, of which 899 690 were males and 996 457 were females. The municipality of Huambo is the most populous, concentrating 35% of the population of the province. It is followed by the municipalities of Bailundo 15%, Caála 14%, Londuimbale 7% and

Catchiungo 6%. The municipality of Tchinjenje recorded the lowest number of residents with 2% of the population in the province.

The Huambo province lies in the alternating wet and dry climates of the intertropical alicyclic regions, due to the altitude at which most of the territory is located. The climate is generally temperate, with an average annual temperature below 20° C. The rainy season coincides with the hot season and lasts for almost seven months. Precipitation values range from 1100 mm to 1400 mm, with December being the wettest month and March the driest.

With support from Institute of Agrarian Development (IDA), the selection of the municipalities for the study was carried out using as criteria (1) population levels, (2) volume of production, and (3) presence in the field schools of farmers. The application of these criteria resulted in the selection of the municipalities of Bailundo, Ekunha, Catchiungo, Chicala Cholohanga, and Tchinjenje.

3.3.2. Sample Selection

Angola has 2 900 thousand family farms, with an average area of less than two acres per farm, which occupy 91.5% of the utilized agricultural area available. Only 0.3% of the total number of farms in the country corresponds to business agriculture, which represents 8.5% of the utilized agricultural area, but with an average area over 54 hectares (MAF, 2018, 2019).

In the Huambo province, agriculture is the main economic activity of the region's rural households, playing an extremely important role in the socio-economic structure of families (Kamutali et al., 2022). The Huambo province ranks first position in the totality of the Angolan production of cereals, leguminous, oilseeds, and horticulture. Huambo accounts for 27.3% of cereals, 20.2% of leguminous and oilseeds, and 28.2% of horticulture (MAF, 2018, 2019).

For the sample selection, the farmers were chosen randomly within the villages for their willingness to participate in the study. A total of 158 participants were gathered from the municipalities of Bailundo (50), Ekunha (45), Cacthiungo (42), Tchicala Tcholohanga (11), and Chinjenje (10).

3.3.3. Data Collection

Primary information was collected through the application of a questionnaire survey. The use of questionnaire surveys for data collection is a very useful tool. Not only does it make it possible to obtain and collect data easily, effectively, and quickly, but it is also a good tool to assess the respondents' opinions and ways of thinking, allowing for a geographically more comprehensive sample (Gil, 2008).

The questionnaire follows the suggestions of Gil (2008) by including the research questions, the objectives of the study and the potential information that would answer them. It was structured in four main sections which incorporate aspects about (1) the farmer and his family, (2) farm, (3) crop and animal crops and technology, (4) sources of income and monthly household expense.

The questions incorporated were aimed at collecting data on the production system adopted as well as the socio-economic conditions of the family, enabling the different typologies of family farming to be characterised, according to the size of the farm. Namely, the main characteristics of farming systems; irrigation system, weed and pest control methods; fertilization methods and labour use; meals and the importance of different foods were used as survey variables.

The respondent characterization in the first section follows the Hill and Hill (2009) recommendations. The remaining sections were dedicated to more specific aspects at a more advanced stage of the questionnaire, supported by the suggestions of Thayer-Hart et al. (2010) and Maciel et al. (2014).

The surveys were applied with the support of the IDA technicians, who were previously trained on survey application by the authors. The period of information collection was between March 14 and July 16, 2022. The survey application had an average duration of 1 hour.

3.3.4. Data treatment

After obtaining the information from the questionnaires applied, the data were processed using the statistical software SPSS, version 27.0, from which a database was created. Descriptive statistics, primarily, were used to summarize all information, and then applied statistical inference, χ^2, F-test and P-value, for the study of the frequencies of the phenomena and the relationships between the variables.

3.4. Results

A total of 158 farmers from five municipalities in the Huambo province were interviewed. The collect data were organized according to area size of farms into three categories: small farmers (S; area ≤ 3 ha; 62.7 %); medium farmers (M; 3 < area ≤ 5 ha; 20.3 %); and large farmers (L; area > 5 ha; 17.1 %).

Men dominate as the head of the holding in totals farms (70.3%) and by size classes (S=64.6%; M=71.9%; and L=88.9%) while the presence of women in this position is less accentuated as the area size increases (S=35.4; M=28.1; and L=11.1%). These differences in gender distribution by size classes are significant (p-value=0.049).

Regarding age of farmers, the average age is 44.2 years, but smaller farmers are younger (43.0) than medium (43.5) and larger farmers (49.5 years), and these differences among size classes are significant (p-value of 0.052).

Although not significant (p-value=0.215), smaller farmers have a higher percentage of "married" (S=54.5% and total sample=50.6%) while larger farmers have a higher percentage of "single" (L=59.0% and total sample=42.4%). Widowed and divorced farmers account only for 6.3 and 1% of the sample, respectively.

Regarding education, 7.6% of the interviewed farmers did not go to school, 32.9% have primary school, and 48.7 and 10.8%, have preparatory and secondary school, respectively. These levels of education are distributed in very similar proportions among the three farm sizes and their differences are not significant (p-value=0.487).

The average household members are 7.6, and when farm size increases there is an increase in the number of household members (S=6.8; M=8.3; and L=9.7) being these differences significant (p-value=0.000). Also, the overall annual income of the household (606 771 AKW) increases with farm size (S=510 060 AKW; M=641 065 AKW; and L=929 167 AKW), not being significant (p-value=0.335).

Table 71 shows the main characteristics of farming systems by farm size. With respect to land acquisition, land is mostly inherited, but decreases slightly with farm size increase;

purchased land is more important for medium and large firms; and land originating from traditional authorities is more relevant for small firms; and no significant differences were found among farm sizes.

Overall, the average experience in farming is 24.3 years, though large farmers have more experience in agriculture than small and medium farmers. Regarding the farming system, agriculture predominates (71.5%) and only 28.5% practice agriculture and livestock, while this farming system has a greater weight in medium farms.

Regarding the technology used, 85.4% practice agriculture manually, 13.3% use animal traction and only 1.3% use a tractor. In small farms manual cultivation predominates and both animal traction and mechanical traction increase from small to large farms, with the differences among farm size being significant. The intercropping system is dominant (59.5%) versus monocropping (40.5%) and the intercropping system (S=67.7%) decreases and monocropping system (L=59.3%) increases with farm size, being the differences among farm sizes significant (p-value=0.019)

There are four main vegetable crops: maize, beans, soybeans, and potatoes. Their average productivities are low and increase with farm size while, as expected, the cultivated areas increase with the size of the farms.

Regarding crop production uses, overall and by farm size, family consumption (consumption and consumption and sales) is the main destination for maize, beans and soybeans, while sales (sales and consumption and sales) is the main destination for potatoes. Farmers with market destination (sales and consumption and sales) increase with arm size, farmers who produce just for self-consumption (consumption) decrease with farm size, while farmers who just produce for the market (sales) increase for maize and beans and decrease for soybeans and potatoes with farm size.

Table 7. Main characteristics of farming systems

Variable		Farm size classes (ha)				Test	*p-value*
		Area ≤ 3	**3 < area≤ 5**	**Area> 5**	**Total**		
Ways of acquiring land							
Inherited		63.6	62.5	55.6	62.0	χ^2 =12.425	0.133
Purchased		18.2	34.4	37.0	24.7		
Traditional Authorities		16.2	3.1	3.7	11.4		
Borrowed		1.0	0.0	3.7	1.3		
Leased		1.0	0.0	0.0	0.6		
Years of agricultural practice		23.8	22.9	27.9	24.3	F=1.145	0.321
Farming system							
Agriculture		73.7	62.5	74.1	71.5	χ^2 =0.795	0.449
Agriculture and livestock		26.3	37.5	25.9	28.5		
Cultivation method used							
Manual		90.9	78.1	74.1	85.4	χ^2 =4.013	**0.020**
Animal Traction		9.1	18.8	22.2	13.3		
Tractor		0	3.1	3.7	1.3		
Cropping system used							
Monoculture		32.3	50.0	59.3	40.5	χ^2 =4.072	**0.019**
Intercropping		67.7	50.0	40.7	59.5		
Area and productivity of the different crops							
Maize	Area (Ha)	1.9	2.1	3.4	2.2	F=7.927	**0.001**
	Production (kg/Ha)	428	480	483	448	F=0.217	0.805
Beans	Area (Ha)	1.5	1.2	1.5	1.4	F=0.179	0.836
	Production (kg/Ha)	260	304	484	300	F=4.084	**0.019**
Soybeans	Area (Ha)	1.0	1.0	1.1	1.0	F=0.658	0.522
	Production (kg/Ha)	94	98	105	98	F=0.040	0.961
Potatoes	Area (Ha)	1.3	1.3	1.8	1.4	F=2.668	**0.077**
	Production (kg/Ha)	2064	1576	3117	2093	F=1.242	0.296
Destinations of the production of the main agricultural crops							
Maize	Consumption	57.3	48.4	24.0	49.7	χ^2 =17.516	**0.008**
	Sale	0.0	0.0	8.0	1.4		
	Sale & consumption	41.6	51.6	68.0	48.3		
	Other	1.1	0.0	0.0	0.7		
Beans	Consumption	36.7	29.0	16.0	31.5	χ^2 =4.478	0.345
	Sale	5.6	3.2	8.0	5.5		
	Sale & consumption	57.8	67.7	76.0	63.0		
Soybeans	Consumption	43.5	42.9	41.7	42.9	χ^2 =5.023	0.541
	Sale	13.0	7.1	0.0	8.2		
	Sale & consumption	34.8	50.0	58.3	44.9		
	Other	8.7	0.0	0.0	4.1		
Potatoes	Consumption	16.1	10.5	11.8	13.4	χ^2 =2.454	0.653
	Sale	22.6	31.6	11.8	22.4		
	Sale & consumption	61.3	57.9	76.5	64.2		

Source: Own elaboration.

For all land classes and all crops (maize, beans, soybeans and potatoes) the main water resource for irrigation is rain, being 84.8% for maize, 89.9% for beans, 92.6% for soybeans and 60.2% for potatoes (Table 8). However, the potato crop has a greater presence of small irrigation systems installed, consisting of a motor pump and plastic pipes that conduct water to the crop fields (irrigation is by flooding). It should be noted that the presence of irrigation systems is greater in larger farms.

Table 8. Irrigation system, weed and pest control methods, fertilization methods and labour use

Variable		**Farm size classes (ha)**				**Test**	***p-value***
		Area ≤3	**3<area ≤5**	**Area >5**	**Total**		
Irrigation system of the different crops							
Maize	Rain Expectancy	83.8	90.6	81.5	84.8	χ^2=1.867	0.932
	Irrigation system	3.0	3.1	3.7	3.2		
	Both 1 & 2	12.1	6.3	14.8	11.4		
Beans	Rain Expectancy	91.9	90.6	81.5	89.9	χ^2=3.225	0.521
	Irrigation system	3.0	3.1	3.7	3.2		
	Both 1 & 2	5.1	6.3	14.8	7.0		
Soybeans	Rain Expectancy	96.7	95.0	88.3	92.6	**χ^2=9.399**	**0.052**
	Irrigation system	3.3	5.0	0.0	2.9		
	Both 1 & 2	0.0	0.0	16.7	4.4		
Potatoes	Rain Expectancy	62.2	59.1	57.1	60.2	χ^2=1.650	0.800
	Irrigation system	11.1	13.6	4.8	10.2		
	Both 1 & 2	26.7	27.3	38.1	29.5		
Weed and pest control methods and fertilization methods							
Weed Control	Manual	80.8	84.4	100.0	80.8	χ^2=6.074	0.194
	Herbicides and manual	4.0	3.1	0.0	3.2		
	None	15.2	12.5	0.0	12.0		
Pest Control	Pesticides (chemical)	12.1	18.8	44.4	19.0	**χ^2=16.669**	**0.002**
	Organic control	21.2	31.3	18.5	22.8		
	None	66.7	50.0	37.0	58.2		
Fertilizers	Manure	19.2	18.8	7.4	17.1	**χ^2=18.184**	**0.004**
	Chemical	21.2	21.9	37.0	24.1		
	Both	26.3	37.5	55.6	33.5		
	None	33.3	21.9	0.0	25.3		
Labour use (days per acre)							
Maize		21.5	17.8	19.0	20.2	F=0.511	0.601
Beans		14.5	21.7	14.9	16.1	F=2.189	0.117
Soybeans		8.6	13.0	17.3	12.0	F=1.629	0.212
Potatoes		13.3	14.9	16.6	14.5	F=0.303	0.740

Source: Own elaboration.

With respect to weed control, in all size classes, the main method used is manual weeding, with an average of 80.8%. Regarding pest and disease control, there are significant differences, large farmers (44.4%) use chemical pesticides, small farmers (66.7%) do not use any method of control of pests and for medium farmers, organic control accounts for 31.3% and no methods for 50%. In fertilization, there are significant differences among farm size classes (p-value=0.004), chemical fertilizers and composted manure increase with farm size and the absence of fertilizer use is relevant for small (33.3%) and medium (21.9%) enterprises.

Labour use per acre for maize and beans does not exhibit any pattern, while for soybeans and potatoes, labour use per hectare increases with farm size. All agricultural activities are implemented almost exclusively with the farmers' savings.

In family farming, self-consumption plays an important role in family nutrition, so agricultural activities provide a substantial percentage of the food consumed by family farmers. Table 9 summarizes the main foods consumed by families at the main daily meals and the degree of importance for the Huambo households of each food.

At breakfast, the main foods consumed are bread (59.9%), sweet potatoes (22.9%) and potatoes (9.6%). For lunch, the main food of the households has been fungi with beans and cabbage (89.0%) and fungi with meat (6.5%). For dinner, the main food is fungi with beans and cabbage (34.8%), rice with beans (25.2%) and pasta with beans (23.9%). Only the lunch meal shows some differences by farm size (p-value=0.023), fungi with beans and cabbage decreases by farm size, fungi with meat (15.6%) increases with medium farmers and fungi with meat (7.7%) and potatoes with meat (7.7%) increases for large farmers.

The families perceived the following foods as the most important: fish, cabbage, sweet potato, kiwi, pumpkin, meat, beans and fungi. Although the other foods are equally important, these are the ones that stand out the most, which are of daily consumption in the main meals of the families, as is the case of fungi (in Huambo made primarily from maize flour), beans and cabbage. These three crops form the basis of family food in the region and are the most cultivated. According to Kamutali et al. (2020), in Huambo, farmers cultivate several crops: 20.5% have two agricultural crops, 32.2% have three, 24% have four, 20.4% have more than four agricultural crops and 2.3% have only one agricultural crop. In the main agricultural crops, which farmers have on their ploughs, the self-subsistence food crops, maize (94.2%) and beans (73.7%), stand out, followed by reindeer potato (42.1%), cabbage (25.7%), tomato (23.4%), onion (22.8%), garlic (9.4%) and carrot (6.4%).

Table 9. Food meals and the importance of different foods

Variable	Farm size classes (ha)				Test	*p-value*
	Area ≤ 3	3 < area ≤ 5	Area > 5	Total		
Morning meal – Breakfast						
Bread	61.6	50.0	65.4	59.9	χ^2=6.132	0.804
Sweet Potatoes	21.2	34.4	15.4	22.9		
Potatoes	9.1	9.4	11.5	9.6		
Boiled cassava	4.0	3.1	7.7	4.5		
Pumpkin	2.0	3.1	0.0	1.9		
Boiled corn	2.0	0.0	0.0	1.3		
Afternoon meal – Lunch						
Fungi with beans and cabbage	92.7	84.4	80.8	89.0	χ^2=17.808	**0.023**
Fungi with meat	3.1	15.6	7.7	6.5		
Pasta with beans	3.1	0.0	3.8	2.6		
Potato with meat	0.0	0.0	7.7	1.3		
Rice with beans	1.0	0.0	0.0	0.6		
Evening meal – Dinner						
Fungi with beans and cabbage	30.9	40.6	42.3	34.8	χ^2=11.307	0.334
Rice with beans	30.9	9.4	23.1	25.2		
Pasta with beans	22.7	25.0	26.9	23.9		
Fungi with meat	8.2	12.5	3.8	8.4		
Rice with meat	6.2	6.3	3.8	5.8		
Potatoes with meat	1.0	6.3	0.0	1.9		
Importance of different foods*						
Fish	4.38	4.38	4.17	4.34	F=0.600	0.550
Cabbage	3.89	4.13	3.75	3.92	F=1.199	0.304
Sweet Potato	3.84	4.25	3.67	3.90	F=2.503	**0.085**
Quisaca	3.91	4.27	3.38	3.89	F=2.446	**0.096**
Pumpkin	3.45	4.13	3.29	3.56	F=5.855	**0.004**
Meat	3.46	3.50	2.78	3.36	F=3.039	**0.051**
Bean	3.21	3.84	3.33	3.36	F=2.829	**0.062**
Fungi	3.37	3.26	3.29	3.34	F=0.135	0.874
Potato	2.96	3.25	3.21	3.06	F=0.701	0.498
Pasta	3.12	3.16	2.67	3.05	F=1.268	0.285
Rice	3.08	3.10	2.83	3.05	F=0.524	0.593
Bread	2.41	2.34	2.79	2.45	F=0.773	0.463

Source: Own elaboration.

Legend: 1= less important; until 5=very important.

3.5. Discussion and conclusions

The family farming systems in Huambo are diversified and are structured on small (up to 3 ha), medium (3 to 5 ha), and large (5 to 20 ha) farms, with small units being the most representative, which is in accordance with Lowder et al. (2019)'s data. Within these farm size classes, it was possible to highlight specific characteristics and tendencies that should be considered in the public policy development context.

On the one hand, the age of the farmers, secondary school attendance, and income and number of household members increases as the farm size increases. On the other hand, the representativity of women as farmers is greater in small farms than in the others, and marriage is more important when the size of the farm is small. These findings reveal that different family characteristics dominate according to the size of the farm, and they give rise to different family farming decisions, with implications on the production system adopted. That is, in small-scale farms, the tendency may be to produce food that is consumed closer to the source of production, as suggested by Lowder et al. (2019) and, therefore, the representativity of women is greater, as they are dedicated to the family, and marriage is also more important. In contrast, on large farms qualification levels are higher and may be more conducive to market interactions. In other words, in small farms the social sustainability issues seem to dominate, and since they are exclusively dedicated to feeding the family and potentially epitomize incomes below the poverty line, the development of social policies also becomes more pressing. In larger farms, economic sustainability may be gaining space, thus, it is important to define policies that allow their monitoring with environmental protection criteria so to avoid unbalanced farming practices in future.

This conclusion is in line with Morais et al. (2023) who argue that the farmers' decisions are based on an understanding of the whole system to which they belong to, and, consequently, the rural community reflects the conditions of the family farms (Kamutali et al., 2022). Therefore, it is necessary to know and understand the socio-economic and environmental background and the productive technology that make up the farm to shape public policies to this context and achieve the goals. This paper contributes to this end goal.

Regarding the origin of the land used by the farmers, it is mostly inherited, with some land being purchased by large farms and some small farms being distributed by traditional authorities. Experience in agriculture increases with farm size and the predominant production system is agriculture (vegetable crops only). These situations naturally reveal the greater competitive capacity of larger farms, in terms of financial resources and education levels, as is observed in all contexts of farming production and not only in the familiar one (e.g. Sellers & Alampi-Sottini, 2016).

Manual cultivation of the land predominates with animal and mechanical traction increasing with farm size. The cropping system is mostly intercropping, but monocropping grows with farm size. The productivity of the main crops, maize, beans, soybeans, and potatoes is low, but also increases with farm size. The predominant source of water is from rain, but in potatoes cultivation irrigation systems are gaining increasing importance with farm size. These results confirm the lower availability of productive resources by small farms and the need of scale for their adoption. In this context, the development of a more organised sector, as referred by Chaves et al. (2023), possibly through the adoption of associative and cooperative structures, according to Morais et al. (2023), may constitute responses to the challenges of low productive scale.

Regarding the control of pests and diseases and fertilizers, as farm size increases, the use of chemicals increases, and small farmers have modest use of them. This observation highlights the environmental character of the small property, which tends to be lost with the increase in scale, and therefore the dissemination and transfer of knowledge that influences the use of cultural practices in balance with nature is inevitable. As exposed by Morais et al. (2023), it is necessary for the farmer to be aware of the consequences of his actions.

The main destination of production is domestic consumption, but market sales are also very important, especially for potatoes, and they weight increases as farm size increases. Generally, the Angolan farming has a weak performance, despite the improvements that are evident with the increase in the size of the property, due to the use of inappropriate agronomic practices, including the scarce use of improved technologies, with potential effects on the entire value chain. Nonetheless, it has the potential to grow, in terms of size, quantity and quality, which is needed to feed the family and generate income above the poverty line. For that, strategies to promote investment and the organizations of family farmers should be a feasible solution to improve the agricultural production and yields, which is in line with Chaves et al. (2023).

In conclusion, family farming exhibits common and differentiating elements which are useful for understanding the various forms of organization of the agricultural activities and supporting the creation of strategies and policies for the sector, namely in developing countries, where information is sometimes scarce and for which different policies will certainly be needed, as disclosed by Lowder et al. (2019).

This diversity in farming systems, from small family farms, poor in resources and scarcity of land, to larger ones, with greater availability of production factors and better socio-economic conditions, allow us to refine agribusiness perspectives for future, giving small famers a social and territorial role balanced by other farms which are more market and industrial orientated.

However, the constant need for data on their characteristics and conditions is essential to monitor their evolution, which is necessary to better adjust policies that lead to their sustainable development.

CHAPTER 4 - MODELLING FAMILY FARMING SUSTAINABILITY IN HUAMBO: ALTERNATIVE SCENARIOS EXPLORED THROUGH ETHNOGRAPHIC LINEAR PROGRAMMING (ELP)[3]

The aim of this study was to develop an ethnographic linear programming model for family farmers in Huambo to estimate their current incomes and explore alternative sustainability scenarios, focusing on the economic and social dimensions while considering the potential and challenges of family farming. The model was developed in four stages: (i) designing the questionnaire to gather relevant data; (ii) pre-testing the questionnaire for validation and subsequent refinement; (iii) selecting a household whose information would be used to validate and adjust the model; and (iv) constructing the PLE model. The results reveal that the models for very small and small farmers do not allow them to exceed the poverty line, indicating that they are economically disadvantaged, while medium and large farmers are above the poverty threshold. The introduction of new certified seed varieties with higher production potential, alongside the adoption of livestock practices such as introducing goats with two births per year, proved effective. In terms of economic sustainability, the annual net income of farms adopting these new technologies, along with the net income per capita, is positive for all identified types of farmers.

[3] The original work of this chapter was submitted for publication: Kamutali, A.; Lucas, M.R.; Marta Costa, A.; Carvalho, M.L.S. & Henriques, P.D (2025). Modelling family farming sustainability in Huambo: alternative scenarios explored through ethnographic linear programming (ELP).

4.1. Introduction

Family farming is a production system primarily aimed at family self-sufficiency, with varying levels of market integration, contributing significantly to the rural economy (Galdeano-Gomez et al., 2017). This system is mainly characterized by the predominance of family labour and specific patterns of land succession, typically passed down from generation to generation (Taveira et al., 2019). Family farming preserves and relies on local knowledge, adaptability, and traditional know-how, which are transmitted across generations.

In many countries, family-based agriculture represents a vital sector, both socially and in terms of agricultural output. Despite its undeniable importance, it faces numerous challenges, including undercapitalization, limited access to credit, weak market integration, insecure land tenure, restricted land use, and insufficient access to technical assistance and support services. Also, family farmers often struggle with low land capitalization and organizational weaknesses.

Family farmers navigate a complex landscape of crises and pressures that affect both their livelihoods and agricultural productivity. These challenges span multiple dimensions, including agricultural production, market access, pricing, and broader socio-economic factors such as aging populations, poverty, labour shortages, and restricted access to essential agricultural technologies and information (Touch et al., 2024). The cumulative effect of these constraints significantly impacts their well-being, economic stability, and long-term sustainability in agriculture.

In response to rising agricultural input costs, many family farmers seek to reduce their reliance on modern inputs but fear potential yield declines. Some have considered adopting organic fertilizers and composting as adaptive strategies but are often discouraged by limited access to raw materials and labour constraints (Milkias & Degefu, 2024).

Given the complex interplay of social, economic, and biophysical factors in smallholder farming systems, it is essential that farmers actively participate in the development of transdisciplinary innovations. This process must fully account for the diverse challenges shaping farming systems, recognizing that farmers are not a homogeneous group and will have varying expectations and priorities in research and innovation efforts (Musvoto et al., 2015).

In this context, the sustainability of family farms depends on their transformation rather than mere preservation, with long-term economic viability as a key focus of rural policies (van Vliet et al., 2015). To enhance income and reduce market and climate-related risks, family farmers may diversify their crop production, while agricultural diversity and income levels can also be influenced by off-farm employment (Ochoa et al., 2019).

Ensuring access to technology for family farmers is an important strategy for promoting both economic and social sustainability. However, evaluating alternative innovation pathways must prioritize the fair distribution of benefits and address inequalities in access to resources and services. This evaluation should be an ongoing process, integrated from the earliest stages of innovation development, to guarantee a broad and equitable distribution of services, benefits, and impacts across farming communities.

The impact of future technological advancements on crop yields remains uncertain, yet the assumptions surrounding these changes are fundamental to the evolution of agricultural areas. Technology enhances access to information and markets while boosting productivity. However, several challenges hinder its widespread adoption (Choruma, 2024). As noted by Souza Filho et al. (2021), technological trajectories — shaped both upstream and downstream of agriculture — create varying opportunities for farmers depending on their position in the production chain, geographical location, scale of operation, and organizational structure.

Across the African continent, small farms dominate the agricultural landscape, playing a decisive role in food production and poverty reduction. However, yields and productivity levels remain low, primarily due to limited access to production technology. The key challenge for these farms is bridging the gap between current and potential yields and incomes (Gassner et al., 2019). African farmers face significant demands, including food insecurity, climate change adaptation, inadequate access to locally suitable technologies, and persistent poverty. Low agricultural productivity and vulnerability to natural disasters, such as droughts, floods, and cyclones, directly impact food security and the well-being of rural families (Marassiro et al., 2021).

Angolan agriculture is marked by diversity and heterogeneity in technology use, with notable regional differences and disparities between family and corporate farming. Despite these challenges, family farming remains the dominant economic activity, currently accounting for approximately 81% of cereal production, 92% of roots and tubers, 89% of legumes and oilseeds, 85% of meat, and 30% of fish production (MINAGRIP, 2020). The average family farm size in Angola is 1.85 hectares, while in Huambo, it is 2.6 hectares. Huambo province has the largest cultivated area in the country, representing about 19% of Angola's total cultivated land (INE, 2022).

In Huambo, family farming systems are diverse and classified into four categories based on farm size: very small (area ≤ 1 ha), small (1 < area ≤3 ha), medium (3 < area ≤ 5 ha), and large (5 < area ≤ 20 ha). Small farms are the most prevalent. Manual cultivation dominates among smaller farms, while the use of animal and mechanical traction, modern inputs, and off-farm labour increases with farm size (Kamutali et al., 2024).

As a result, poverty, hunger, and food insecurity tend to be more severe among smaller farm households. Under current conditions, these systems are not capable of significantly reducing poverty levels. Angola faces high levels of poverty, particularly in rural areas, where the poverty rate stands at 57.2%. Family farmers - the country's primary food producers - struggle with numerous challenges in sustaining agricultural production and ensuring the well-being of their households (INE, 2022).

This article aims to identify solutions to the constraints and poverty affecting family farming systems in Huambo through the application of ethnographic linear programming (ELP). Following this introduction, a literature review examines modelling techniques for family farming systems, with a particular focus on ELP. The methodology section outlines the structure of the ELP model, the alternative technologies assessed, and the key results obtained. Finally, the article concludes with findings and policy recommendations aimed at improving the livelihoods and living conditions of rural families in Huambo province.

4.2. Technological Pathways for Family Farming: A Modelling Perspective

In developing countries, small farmers predominantly operate mixed crop-livestock systems, integrating various agricultural enterprises within their farms. Crops serve both as food for household consumption and as a source of income through cash sales. Likewise, livestock contribute to food and income while also providing draft power for land cultivation and manure for soil fertilization (Herrero et al., 2010). In many tropical regions, particularly in sub-Saharan Africa, small-scale farmers are important in ensuring food security for low-income populations.

A key concern is whether these farming systems can sustainably increase household incomes and improve food availability and access for rapidly expanding urban populations in the years ahead. According to Herrero et al. (2014), the future role of smallholder farmers in global food production and food security remains highly uncertain.

The adoption of new agricultural technologies is a critical factor in enhancing productivity, strengthening food security, reducing poverty, and driving agricultural development. However, integrating and effectively utilizing these technologies has long been a complex challenge due to various constraints in the adoption process (Bizimana & Richardson, 2019). For instance, smallholder farm productivity in developing countries is often hindered by policy and structural barriers, leading to slow improvements in crop yields and agricultural stagnation (Norton, 2014).

To accurately capture the idea that small farmers may face vastly different futures, several authors have proposed and developed the use of scenarios. Scenarios are sets of alternative narratives, expressed through words and/or numbers, that describe plausible future outcomes (van Notten et al., 2006; Kok et al., 2007). These scenarios help improve understanding of how systems function, behave, and evolve, while also aiding in the evaluation of future developments under different policy orientations (Kok et al., 2011).

The definition of a multiple or alternative scenarios approach involves blending available technological options with the perspectives of relevant stakeholders, such as policymakers, farmers, experts, and technicians (Biggs et al., 2007; Kinzig, 2006).

Scenarios are then tested within agricultural farm models by comparing a baseline scenario with the defined alternative scenarios.

The modelling of rural households initially focused on production aspects and later expanded to include consumption, as well as the presence of a labor market, whether through hired labor or the possibility of family off-farm work. Over time, the social and ethnographic dimensions of rural households were also considered and integrated into farm models.

Chayanov's initial model of self-sufficiency, which assumed no market for family labour, was progressively modified and enhanced by the introduction of markets for resources and products (Ellis, 1988; Hammel, 2005). This led to the development of the Barnum-Squire model, which incorporates the hiring of family labour off the farm and provides a framework for forecasting household responses to changes in household variables (Barnum-Squire, 1979).

The Low model (Low, 1986) diverges from the previous models by focusing on agricultural production within the specific context of African countries bordering South Africa. It incorporates a salaried labour market and wage variation across different categories of work. Additionally, the social and ethnographic dimensions of rural households, explored through rural sociology, were addressed in the work developed by Hildebrand (2003).

The evaluation of these conceptual models under various scenarios can be conducted using two fundamental tools, econometrics or mathematical programming. From a forward-looking perspective, mathematical programming models, particularly linear programming (LP), have been applied to agriculture since the 1950s. These normative models are widely used in agricultural planning to assist farmers in making decisions about resource organization and utilization, thereby improving economic outcomes (Heady, 1958). LP models are also fundamental tools for analysing both small and large agricultural systems, as well as more complex systems like peasant and subsistence farming. These models can incorporate a temporal dimension through multiperiod models or a spatial one, with aggregate models applied at regional or national levels.

ELP emerged in the 1990s, with Hildebrand as its main proponent (Hildebrand, 2003). ELP integrates not only the productive aspect of households but also the reproductive and socio-cultural dimensions. It combines LP, a quantitative method, with ethnography, a qualitative research approach, to deepen the socio-cultural understanding of households. This integration allows for a comprehensive analysis of the various dimensions of social organization within farming families, particularly those engaged in subsistence agriculture. Hildebrand et al. (2003) highlight the advantages of ELP in simultaneously analysing production activities and the reproduction of agricultural assets. The ethnographic dimension enables a detailed understanding of what is done, who does it, when, how, and why, considering the multidimensional nature of production, reproduction, and community components of households. The ultimate goal is to maximize household well-being (Wilsey, Gill & Rios, 2012; Deus et al., 2021).

Using ELP to model households and their agricultural systems requires meticulous data collection, storage, management, and processing. This approach allows for the testing of various policies, technologies, reproductive changes, and shifts in social and community norms. It facilitates the exploration of their potential outcomes and the prediction of their consequences for rural households and communities (Deus et al., 2021).

ELP has been applied in several studies across the American continent, including those by Neto (2014), Mello and Hildebrand (2012), and Araújo (2010) in Brazil; Wilsey and Hildebrand (2011) in Mexico; Harper, Granda, Hildebrand, and Messina (2006) in Cuba; Cabrera, Hildebrand, and Jones (2005) and Rios (2010) in Peru; Breuer (2002) in Paraguay; Breuer, Hildebrand, and Cabrera (2004) in Ecuador; Bellow (2004) in Guatemala; Smith (2014) in Costa Rica; and Slaughter (2012) in Haiti. In Africa, notable studies include those by Kamutali (2022) for Angola; Gill (2010) for Kenya; and Thangata, Hildebrand, and Gladwin (2002) and Thangata, Hildebrand, and Kwesiga (2007) for Malawi. In Southeast Asia and the Pacific, the recent application of ELP by Deus et al. (2021) in modelling household farming systems in four districts of East Timor stands out. In this work, the authors identified and analysed the variables that differentiate households and their farming systems.

The application of ELP in agricultural systems has been contributed to valuable insights into household modelling and the socio-economic sustainability of family farming in different contexts. Kamutali (2022) assessed the suitability of ELP for planning and managing family farming by developing and validating a household model to analyse economic and social sustainability in Huambo, Angola. This study focused on a representative farming household in a region where farming is essential for livelihoods, yet poverty remains high. The objective was to create a replicable management tool, incorporating multiple dimensions of daily life, such as economic, environmental, social, historical, cultural, educational, health, and organizational factors, all of which reflect the complex relationships between farming households, rural communities, and the market. The results highlighted the effectiveness of ELP as a management tool, demonstrating its potential for broader application despite various constraints.

In a similar vein, Herrero et al. (2014) applied an agricultural simulation model, “FARMSIM” to evaluate alternative technologies in farming systems. Their approach combined the IMPACT tool linked to a LP model, allowing them to generate optimal solutions for farm household management while considering constraints. The model’s objective was to maximize gross margin by integrating sales from agricultural and animal products, income from other sources, and expenses related to agricultural inputs, animal inputs, labour, and other costs. This modelling approach demonstrates the relevance of LP in optimizing farm household operations, similar to Kamutali's use of ELP to integrate various dimensions of farm management.

The work of Gill (2010) examined the intersection of health and food security in rural households in Kenya, focusing on the impact of HIV/AIDS on food insecurity. Gill’s findings showed that the contraction of HIV by an adult male leads to greater food insecurity compared to when a female adult is infected. This study highlighted the importance of considering health-related issues and their socio-economic impacts on rural households, an aspect that can be integrated into household models like ELP to improve the understanding of family farming systems’ vulnerabilities.

Similarly, Thangata, Hildebrand, and Kwesiga (2007) modelled the impact of HIV/AIDS on agricultural adoption and food security in Malawi. Using a dynamic 8-year PLE model, they found that the illness of an adult, regardless of gender, reduces the area available for cultivation, thus exacerbating food insecurity. The results also revealed that gender plays a role in how the illness impacts labour availability and food production, with men’s illnesses affecting the availability of female labour for farming.

In a previous study, Thangata, Hildebrand, and Gladwin (2002) used a 10-year dynamic PLE model to investigate agroforestry adoption in Malawi. They found that adoption decisions were influenced by land and labour availability, with gender having a neutral effect.

Together, these studies demonstrate the utility of ELP and similar models in capturing the multifaceted nature of household farming systems. By integrating various socio-economic, cultural, and health dimensions, these models provide valuable insights into the challenges faced by rural households, and can be used to inform policies and strategies aimed at improving their economic and social sustainability.

4.3. Methodology

To develop the ELP model for analysing sustainable family farming systems in Huambo Province, Angola, it is essential to design and validate household-level ELP models. These models enable the assessment of the economic and social performance of farmers, the identification and evaluation of alternative development pathways, and the integration of specific challenges and opportunities within local farming systems. Ultimately, the goal is to enhance farmers' well-being, lift them above the poverty line, and break the persistent cycle of poverty.

Prior to the development of the model, three preparatory stages were carried out: the design of a questionnaire to collect relevant data; the pre-testing of the questionnaire to validate its effectiveness and ensure replicability; and the selection of a representative household to validate and calibrate the model.

The questionnaire was structured into seven sections: (i) personal and family information; (ii) family, festive, and community activities; (iii) nutrition and food consumption; (iv) agricultural practices, including crop and livestock production and technology use; (v) marketing strategies; (vi) sources of income; and (vii) monthly household expenditures.

The initial version of the questionnaire was validated by five experts from Angola's academic, research, and development sectors, including representatives from the Faculty of Agrarian Sciences at José Eduardo dos Santos University, the Angolan Institute of Agrarian Research, and the Angolan Institute of Agrarian Development. This validation process ensured that both the content and language were appropriate and reflective of the target population's context. Based on the experts' feedback, the questionnaire was revised and supplemented with additional questions.

Households were selected for data collection based on the following criteria: (i) representation of the agricultural systems practiced in Huambo across different farm size categories; (ii) the farmer's willingness to participate in the study; and (iii) access to a mobile phone to facilitate follow-up communication.

Then, a face-to-face household questionnaire was administered through individual interviews with the head of the household responsible for farm management, following prior informed consent. The first round of data collection for model development began on November 19, 2021, and continued through follow-up interviews with household heads between November 30, 2021, and January 15, 2022.

The survey encompassed 158 households from Huambo. Based on the classification proposed by Kamutali et al. (2024), farming systems were grouped into four categories: very small farms (≤ 1 ha) – 44.4%; small farms (1 < area ≤ 3 ha) – 18.2%; medium farms (3 < area ≤ 5 ha) – 20.3%; and large farms (> 5 ha) – 17.1%. Table 10 presents the key characteristics of the family farming systems considered in the analysis.

Table 10. Key Characteristics of the Selected Farming Systems

Item	Very small	Small	Medium	Large
Size classes ha	≤ 1 ha	1 < and ≤ 3	3 < and ≤ 5	> 5
Number of farms	70	29	32	27
Average area ha	1.00	2.25	4.25	32.00
Vegetable crops	Corn, beans, potatoes, onions	Corn, beans, potatoes, onions	Corn, beans, potatoes, onions	Corn, beans, potatoes, onions
Livestock	Chickens	Chickens	Chickens, goats and cattle	Chickens, goats and cattle
Community Activities	Church, commemorative dates of the country, province and municipality and enthronement of the soba			
Festive activities	Wedding, anniversary, baptism, evamba, harvest and funeral.			

Source: Own elaboration.

From the total of 158 surveyed households, classified into four previously defined farm size categories, one representative household was initially selected from each category for model development. A case-based approach was adopted instead of using class averages, given the heterogeneous nature of the dataset. Aggregated averages often obscure critical variations and outliers, elements that are essential for understanding the constraints and opportunities within each farming system. By selecting representative cases, the model is better equipped to reflect the structural diversity and complexity of family farming in Huambo, enabling a more realistic simulation of household-level decision-making and resource allocation (Tittonell et al., 2005; Giller et al., 2011).

This procedure is also consistent with Andrade (1986), who defines representative farmers as those whose resource indicators correspond to the most frequent combinations, therefore, being closest to the general trend while encompassing the widest range of available resources.

The data collected from the 158 households made it possible to identify key variables that distinguish farming households in terms of activities, resources, technologies, and objectives, allowing the ELP model to incorporate the specific characteristics of each farming system.

Subsequently, four representative households were selected within each of the four farm size categories, based on the most frequent (modal) combination of characteristics, following an ordered set of criteria: farming system, total farm area, gender of the household head, household size, education level, number of animals, and number of cultivated crops.

4.3.1. Description of the EPL model used

The ELP model was developed based on several key assumptions: it is static and deterministic, designed to capture the most relevant aspects of family farming systems across the productive, reproductive, and community dimensions. Its primary objective is to maximize household well-being by guiding decisions on the composition of activities, considering the available resources and household needs. The model's objective function aims to maximize the household's margin by subtracting the costs of both productive and non-productive activities, including labour, from the household's total earnings. Constraints are imposed to regulate the use of the farm's and family's resources, based on their availability and capacity.

The developed model, along with its variables and considered parameters, is presented in the matrix model (1) and detailed in Annexes II and III.

Function Objective:
(1)
Max $E(Z) = - C_vX_{(v)} - C_pX_p + R_{(v)}Q_{(v)} + R_pQ_{(p)} - W_bN_{(b)} - W_fQ_f - W_mQ_{(m)} - W_xV_{(x)}$

Subject to restrictions:

Land use restrictions:
$A_{av}X_v \leq T_{(a)}$

Restrictions on the use of male labour:
$B_{bv}X_v + B_{bp}X_p + B_{(bf)}Q_f + B_{bm}Q_m + B_{bh}X_h - N_b \leq T_{(b)}$

Restrictions on plant production:
$-S_{qv}X_v + S_{qf}Q_f + S_{qm}Q_m + Q_v \leq 0$

Restrictions on animal production:
$S_{tp}X_p + S_{tf}Q_f + S_{tm}Q_m + Q_p \leq 0$

Restriction on festive activities:
$Q_f = 1$

Restriction on community activities:
$Q_m = 1$

Restriction on fixed costs:
$V_x = 1$

where the variables are:
$\mathbf{N_b}$ - column vector (b × 1) of hired labour;
$\mathbf{Q_v}$ - column vector (x × 1) of demand for plant foods for sale;
$\mathbf{Q_p}$ - column vector (z × 1) of demand for animal feed for sale;
$\mathbf{Q_f}$ - column vector (f × 1) of the festivities;
$\mathbf{Q_m}$ - column vector (m × 1) of the communities;
$\mathbf{X_v}$ - column vector (v × 1) of plant production activities, in terms of area occupied;
$\mathbf{X_p}$ - column vector (p × 1) of animal production activities, in terms of heads;
$\mathbf{X_h}$ - column vector (h × 1) of family activities;
$\mathbf{V_x}$ - vector (1 × 1) for fixed costs.
×
and the parameters are:
$\mathbf{A_{av}}$ - matrix (a × v) of land requirements for plant activities;
$\mathbf{B_{bv}}$ - matrix (b × v) of labour input coefficients for the plant sector;
$\mathbf{B_{bp}}$ - matrix (b × p) of labour input coefficients for the animal sector;
$\mathbf{B_{bf}}$ - matrix (b × f) of labour input coefficients for the festivities;
$\mathbf{B_{bh}}$ - matrix (b × h) of labour input coefficients for family activities;
$\mathbf{B_{bm}}$ - matrix (b × m) of labour input coefficients for community activities;
$\mathbf{S_{qv}}$ - matrix (q × v) of coefficients relating production to plant activities;
$\mathbf{S_{tp}}$ - matrix (t × p) of coefficients relating production to animal activities;

$\mathbf{T_a}$ - column vector (a × 1) of land factor availabilities;
$\mathbf{T_b}$ - column vector (b × 1) of labour factor availabilities;
$\mathbf{C_v}$ - line vector (1 × v) of plant activity costs;
$\mathbf{C_p}$ - line vector (1 × p) of livestock activity costs;
$\mathbf{R_v}$ - line vector (1 × v) of plant product prices;
$\mathbf{R_p}$ - line vector (1 × p) of livestock product prices;
$\mathbf{W_b}$ - line vector (1 × b) of labour purchase prices;
$\mathbf{W_x}$ - scalar for fixed costs;
$\mathbf{W_f}$ **-** scalar referring to the costs of the festivities;
$\mathbf{W_m}$ **-** scalar for community costs.

Household production systems are organized around five distinct land types known locally as *Épia* (ploughing from above: plots located on the slopes and higher areas of the catena, traditionally used for crop rotation); *Onaka* (lowland plough: areas along the marginal zones of rivers and streams, characterized by hydromorphic soils); *Octhumbo* (ploughing near the dwellings: plots situated close to the homestead, benefiting from natural fertilization due to the presence of humans and animals); *Ombanda* (edge and slope ploughing: transitional plots between lowlands and slopes, located outside flood zones but influenced by rising water tables); and *Elunda* (ploughing in former villages: cultivated areas in abandoned or former village sites, where soil fertility is enhanced by historical human and animal occupation). Among these, *Épia* and *Onaka* are the most significant, contributing substantially to household livelihoods and forming the backbone of the local agricultural economy.

The information gathered from these diverse production systems was essential for model construction, leading to ELP models of relatively high complexity, both in terms of constraints and variables, thereby capturing the multidimensional nature of household-level decision-making.

The household workforce consists of both male and female members, including adults and young individuals. In addition to family labour, the workforce also includes hired labour. The demand for labour encompasses various activities, such as crop production, livestock management, domestic chores, as well as festive and community-related tasks. For crop activities, labour is required for the cultivation of maize, beans, reindeer potatoes, and onions across different types of land. This includes essential tasks such as land preparation, sowing/planting, weeding, fertilizing, pest control, harvesting, and threshing. In livestock management, labour demand is divided among the care and feeding of cattle, goats, and chickens. Certain tasks, such as animal feeding and domestic chores, tend to be dominated by one gender.

The household also owns a set of agricultural tools and equipment, including a machete, axe, hoe, plough, and cart, which result in fixed costs for the household.

The main crops cultivated by the household include reindeer potatoes, maize, beans, and onions, while the animals raised are cattle, goats, and chickens. Productivity per hectare for these crops is relatively low. Maize yields are highest in *Épia*, beans in *Onaka*, and potatoes in *Ombanda*. The fertility and prolificacy rates for cattle and goats are both 0,75. Cattle give birth every two years, goats once a year, and chickens twice a year. Each laying of chickens typically results in an average of 8 chicks.

The variable costs associated with crop activities include the purchase of modern inputs such as seeds, fertilizers, phytopharmaceuticals, and the rental of animal traction, particularly for larger farms. Animals are fed in the field year-round on communal land, with no associated costs for goats, sheep, and chickens.

Crops are both sold and consumed for household needs, with reindeer potatoes serving as the primary cash crop. Cattle are not typically slaughtered for family consumption but are generally sold, contributing to increased family income. Goats are primarily used to generate income for emergency needs and are often slaughtered during festive seasons for family consumption. Chickens are utilized for both sale and household consumption, particularly during special occasions such as festivities.

The household's main domestic activities are primarily carried out by the woman and her children and occur daily throughout the year. Key festive activities include alambamento, weddings, birthdays, baptisms, evamba, harvest celebrations, and funerals. Community activities encompass participation in national, provincial, and municipal commemorative events, involvement in church activities, and the enthronement of local chiefs (*sobas*).

4.3.2. Tested scenarios

The productivity of the main crops cultivated by family farmers in Huambo - maize, beans, onions, and potatoes - is generally low (Kamutali et al., 2022). According to

Suvedi et al. (2017), many smallholder farmers in developing countries have yet to adopt improved agricultural technologies, such as high-yield seed varieties and enhanced farming practices, which could significantly increase productivity and contribute to the sustainability of their livelihoods.

Technology plays an important role in determining the economic and financial performance of agricultural operations. It not only enhances labour and total factor productivity but also strengthens key linkages within the agricultural value chain. These impacts can be both positive and negative, influencing the long-term sustainability of family farming systems (Marassiro et al., 2021).

In the case of Huambo, no prior studies or official records were found concerning crop budgets or alternative production scenarios. Therefore, in collaboration with technicians from the *Instituto de Investigação Agronómica de Angola* (based in Huambo), the *Direcção Provincial da Agricultura do Huambo*, the *Instituto de Desenvolvimento Agrário (IDA)*, professors from the *Faculdade de Ciências Agrárias da Universidade José Eduardo dos Santos*, and based on the authors' field experience, a series of development scenarios were formulated.

These scenarios include the introduction of technologies aimed at increasing productivity, such as the use of certified seed varieties with higher yield potential, the incorporation of new crops like soybeans, and improvements in livestock systems - for example, the introduction of goats capable of birthing twice a year and the expansion of egg-laying hen flocks. The implementation of these technologies should be adapted to the specific characteristics of each farm type, with a gradual and differentiated approach for very small, small, medium, and large-scale farmers.

The scenarios analysed in this study are summarized as follows:

1. Baseline Scenario: This scenario is characterized by minimal input use. Seeds are of low quality, either saved from previous harvests or sourced locally. Fertilization consists of a single application of 100 kg of 12-24-12 as base fertilizer. No insecticide or fungicide treatments are applied.
2. Alternative Technology: This scenario utilizes purchased seeds of a medium-quality population variety. Fertilization includes 400 kg of 12-24-12 and 400 kg of dolomitic limestone, applied in planting trenches to serve both as fertilizer and for base liming. This results in the application of approximately 90 kg of nitrogen (N),

96 kg of phosphorus (P), and 48 kg of potassium (K). One insecticide treatment and two fungicide treatments are applied. In addition, this scenario focuses on the use of goats with high reproductive potential, capable of giving birth twice per year. This practice increases herd productivity and contributes to both income generation and household food security.

4.4. Results and discussion

This section presents the results generated by the ELP models, encompassing both the baseline ((see Annex IV) and alternative scenarios (see Annex V). It also provides a comparative analysis of household well-being using key indicators such as poverty status, minimum income thresholds, and average household income.

4.4.1. Baseline scenario

The results of the ELP model on land use and crop distribution across the four farmer categories indicate that *Épia* is the most extensively utilized land type. The average area allocated to *Épia* increases with farm size: 0.5 hectares for very small farmers, 1.0 hectare for small farmers, 2.0 hectares for medium-sized farmers, and 20.0 hectares for large-scale farmers. Table 11 presents the distribution of land types and their respective crop allocations.

Table 11. Different types of land and their occupation by crops (unit: Ha)

	Total Surface	Surface used	Maize* beans	Potato	Onions
Very small					
Elunda	0.125	0.125	0.125	0.000	0.000
Épia	0.500	0.500	0.500	0.000	0.000
Onaka	0.125	0.125	0.125	0.000	0.000
Octhumbo	0.125	0.125	0.125	0.000	0.000
Ombanda	0.125	0.125	0.125	0.125	0.000
Small					
Elunda	0.250	0.250	0.250	0.000	0.000
Épia	1.000	1.000	1.000	0.000	0.000
Onaka	0.500	0.500	0.500	0.500	0.000
Octhumbo	0.250	0.250	0.250	0.000	0.000
Ombanda	0.250	0.250	0.250	0.250	0.000
Medium					
Elunda	0.250	0.000	0.000	0.000	0.000
Épia	2.000	2.000	2.000	0.000	0.000
Onaka	1.000	1.000	1.000	0.000	0.000
Octhumbo	0.500	0.101	0.101	0.000	0.000
Ombanda	0.500	0.500	0.500	0.009	0.491
Large					
Elunda	2.000	2.000	2.000	0.000	0.000
Épia	20.000	20.000	20.000	0.000	0.000
Onaka	5.000	5.000	5.000	5.000	0.000
Octhumbo	2.000	2.000	2.000	0.000	0.000
Ombanda	3.000	3.000	3.000	3.000	0.000

Source: Own elaboration

Across all categories, the maize-bean consortium emerges as the predominant cropping system, reflecting its central role in household food security and income generation within family farming systems in Huambo.

The main economic results for the four types of farmers in their current situation are presented in Table 12. For very small farmers, the primary costs are related to festivities (35.0%), fixed costs (33.3%), and agriculture (31.7%). For small farmers, agriculture constitutes the largest expense (51.1%), followed by festivities (25.1%) and fixed costs (23.8%). For medium and large farmers, the main costs are related to festivities and agriculture. Large farmers allocate a higher percentage of their expenses to agriculture

(49.9%) and festivities (32.8%), while contract labour (13.9%) emerges as the second most significant cost item for large-scale farmers.

In terms of revenue, crops account for more than 80.0% of the income across all four types of farms. Within crop revenues, the sale of maize, beans, and potatoes are the primary sources of income. Livestock plays a more significant role for small (14.3%) and medium (19.7%) farms.

Table 12. Main household costs and revenues for the baseline scenario (unit: AKZ)

Item	Very small	Small	Medium	Large
Costs				
Crop	14 501	32 625	1 167 854	28 192 000
Livestock	0	0	230 000	288 000
Off-farm labour	0	0	89 808	4 962 000
Fixed	15 225	15 225	15 905	77 902
Festivities	16 000	16 000	769 000	2 061 500
Community	0	0	70 000	40 000
Total costs	*45 726*	*63 850*	*2 342 567*	*35 621 402*
Revenues				
Crop	270 240	648 000	3 611 338	65 232 000
Livestock	45 000	45 000	886 400	1 748 000
Total revenues	*315 240*	*693 000*	*4 497 738*	*66 980 000*
Net Margin	**269 514**	**629 150**	**2 155 171**	**31 358 598**
Net Margin per ha	**269 514**	**279 622**	**507 099**	**979 956**

Source: Own elaboration

As shown in Table 12, both the net margin and net margin per hectare are positive for all farming systems. According to Siqueira et al. (2020), when the net margin is positive, the producer can cover all fixed and variable costs, while also receiving compensation, thereby ensuring the sustainability of their productive activity in the medium to long term. However, if the net margin is negative, the fixed costs will not be fully covered, which could lead the producer into a process of decapitalization.

To assess the well-being of rural households within the Angolan economy, it is important to compare per capita income with the poverty line, the minimum wage, and the average wage (Table 13). The net income generated is insufficient for very small and small farmers to surpass the poverty line for all household members. For these farms, the situation is particularly dire, as net income only covers 17.0% and 39.8% of the per capita poverty line, respectively. Medium-sized farms also fail to meet the average per capita wage, covering only 93.0% of it.

Considering that approximately 31.1% of Angola's population lives below the poverty line, this figure highlights a substantial segment facing serious economic and social challenges (OPSA, ADRA, and CINVESTEC, 2024). These findings are consistent with those reported by Deus et al. (2019), who concluded that households with limited land areas struggle to escape the persistent cycle of poverty under current conditions. As indicated by the minimum land thresholds identified in the models, there is a pressing need to expand the size of family farms to improve household resilience and livelihoods.

Table 13. Income and per capita income in baseline scenario (unit: AKZ)

Item	Very small	Small	Medium	Large
Number of household members	5	5	6	8
Net revenue	269 513	629 150	2 155 171	31 358 600
Net revenue per ha	269 513	279 622	507 099	979 956
Monthly income per capita	4492	10 486	29 933	326 652
Monthly poverty line per capita	26 353			
National average salary	32 181			

Source: Own elaboration.

Very small and small-scale farmers face a wide range of complex challenges, crises, and pressures that affect both their agricultural production and livelihoods. These challenges span multiple areas, including agricultural production, the sale of agricultural products, pricing, and socio-economic factors such as aging, poverty, labour shortages, and limited access to essential agricultural technologies and information (Touch et al., 2024).

According to Queiroz and Batalha (2003), modelling the cost structure in agriculture must consider the specific characteristics of managing these environments. For instance, seasonality is a key feature of agricultural production, as are activities such as spraying, fertilizing, and other operations, which depend on variables like pest infestations, disease outbreaks, and rainfall patterns.

Increasing potential yields has been achieved through genetic improvements, such as enhancing light capture or the efficiency of converting light into biomass. Reducing the yield gap can be accomplished through improved crop management practices or further genetic enhancements (Ewert et al., 2005).

To improve the effectiveness and efficiency of farms, it is crucial to consider increasing investment and implementing training and technical support programs. These initiatives will ensure that beneficiaries have the necessary resources and knowledge to develop sustainable and impactful income-generating activities (OPSA, ADRA, and CINVESTEC, 2024).

4.4.2 Alternative scenario

The alternative scenario proposed in this study is the introduction of new certified seed varieties with a high production index, along with improvements in livestock production, such as goats that can give birth twice a year. Table 14 presents the results of the models incorporating these new technologies. As shown, the net margin for the different types of family farms using the new technologies is higher compared to their baseline scenarios, indicating a significant improvement in the economic sustainability of the various farm sizes.

Table 14. Main household costs and revenues with alternative scenario (unit: AKZ)

Item	Very small	Small	Medium	Large
Costs				
Crops	777 440	1 749 000	8 604 732	68 287 360
Livestock	0	0	230 000	288 000
Contract labor	0	0	377 850	4 962 000
Fixed	15225	15 225	15 905	77 902
Festivities	16 000	16 000	769 000	2 061 500
Community	0	0	40 000	40 000
Total	*883 665*	*1 780 225*	*10 037 487*	*75 716 762*
Revenues				
Crop	3 234 900	7 318 000	23 234 500	207 339 008
Livestock	75 000	75 000	946 400	1 868 000
Total	*3 309 900*	*7 393 000*	*24 180 900*	*209 207 008*
Net Margin	**2 426 235**	**5 612 775**	**14 143 413**	**133 490 246**
Net Margin per ha	**2 426 235**	**2 494 567**	**3 327 862**	**4 171 570**

Source: Own elaboration.

Considering the results, where very small, small, and medium-sized farmers exhibit low levels of well-being, the introduction of new technologies has enabled these family farmers in Huambo to surpass both the poverty line and the average wage (Table 15). This improvement assumes that farmers adopt new technologies, a process that is not immediate for all farmers or technologies. It often requires a gradual approach, tailored to different farm sizes, and may involve the development of technologies specifically adapted for very small and small-scale farmers. While the average wage in Angola does not allow for definitive conclusions about per capita income, it highlights that urban families with this average wage, considering their family size, are in an even more vulnerable situation than rural families.

Table 15. Income and per capita income in the alternative scenario (unit: AKZ)

Item	Very small	Small	Medium	Large
Household members	5	5	6	8
Net revenue	2 501 235	5 612 775	14 113 410	133 490 200
Monthly income per capita	41 687	93 546	196 020	1 390 523
Monthly poverty line per capita	26 353			
National average salary	32 181			

Source: Own elaboration

Agricultural extension programs contribute significantly to the transfer of knowledge, technologies, and best practices to farmers. These programs are increasingly essential for improving agricultural productivity, ensuring food security, and enhancing rural livelihoods (Bhat et al., 2024). In addition, it is important to support the development of service-oriented enterprises that provide mechanization and technical assistance, promoting good agricultural practices to strengthen the capacity and resilience of family farmers in Huambo.

Technological innovations in the agricultural sector are not limited to machinery alone, they also include technologies that enhance crop productivity through improved cultivation patterns, irrigation systems, pest and disease control, and other advancements (Santoso et al., 2023). Furthermore, ensuring the availability of certified seeds, fertilizers, and agrochemicals is critical for achieving the desired production levels. These factors are vital for the development of agriculture in Huambo, as the success of agricultural activities is directly linked to the availability of these production inputs. The poor state of access roads to major consumption centres, which creates significant delays, presents a major challenge to the flow of production.

The drive to increase productivity has been the cornerstone for developing and incorporating various technologies aimed at boosting production (Asunción, 2024). However, environmental and natural resource concerns have, to some extent, been overlooked over time. Today, agriculture is recognized as one of the primary sources of negative environmental impacts, making it decisive to pay special attention to these aspects (Souto Maior et al., 2012).

4.4.3 Environmental and social sustainability of Huambo farming types

Intensive agricultural activities and monoculture, from an ecosystem perspective, contribute to the homogenization of the landscape, fragmentation and loss of habitats, microclimatic changes, and the decline of important species and populations of both fauna and flora (Liu et al., 2018). However, as shown by the results in Table 16, the agricultural production systems in Huambo are diverse, with many farmers practicing crop consortia involving grasses and legumes. This approach offers an advantage over monoculture systems.

To assess the environmental impact of the agricultural production systems of family farmers in Huambo, it is essential to examine various factors, including the cultivation techniques employed and the quantity of inputs applied during production. Key inputs encompass diesel, nitrogen, phosphorus, potassium, insecticides, herbicides, and plastic bags (Table 16).

Table 16. Environmental sustainability of the baseline scenario

	Very small	Small	Medium	Large
Livestock production system	Extensive field animals	Extensive field animals	Extensive field animals	Extensive field animals
Crop production system	Intercropping	Intercropping	Intercropping and monoculture	Intercropping and monoculture
Crop and animal residues	Incorporation into the soil	Incorporation into the soil	Incorporation into the soil	Incorporation into the soil
Fertilization used	Organic	Organic	Mineral	Mineral
Diesel	Without	Without	98 L	
Mineral nitrogen	Without	Without	24 Kg	
Mineral Phosphorus	Without	Without	48 Kg	
Mineral potassium	Without	Without	24 Kg	
Herbicides	Without	Without	Without	
Insecticides	Without	Without	2 L	

Source: Own elaboration.

According to the results, a positive aspect of the situation of family farmers in Huambo is the relatively low quantity of inputs used in the production process. The quantities of diesel, nitrogen, phosphorus, potassium, insecticides, herbicides, and plastic bags are either non-existent or minimal compared to intensive or super-intensive agricultural systems.

The introduction of new technologies leads to changes in the environmental factors observed, with the use of modern production inputs doubling in the new technology scenarios when compared to the baseline, as shown in Table 17.

Table 17. Use of modern inputs per ha for Huambo farming types

Name	Baseline scenario			Alternative scenario			
	Maize* beans	Potato	Onions	Maize* beans	Potato	Onions	Soy
Nitrogen	24	24	24	48	48	36	48
Phosphorus	48	48	48	96	96	72	96
Potassium	24	24	24	48	48	36	48
Herbicide	0	0	0	2	1	1	1
Insecticide	1	2	1	3	5	3	4
Bags	53	20	20	110	30	30	55
Diesel	60	98	60	162	130	153	141

Source: Own elaboration

In Huambo, agricultural activities are central for sustaining the livelihoods of rural households. The household workforce consists of both men and women, with significant contributions from both adults and young members of the household. Most family farms rely heavily on family labour, where household members engage in the activities of the farm. However, in order to meet some of the household's basic needs, such as food during certain times of the year, children's education costs, and health expenses, household members often take on paid work outside the family farm. According to INE (2022), 40.4% of family farms in Huambo have members engaged in paid labour outside of their farms.

Labour on the farm is primarily used for tasks related to the cultivation of maize, beans, reindeer potatoes, soybeans, and onions. These tasks include land preparation, sowing/planting, weeding, fertilizing, pest control, harvesting, and threshing. The labour requirements for these activities are the same across the different types of land (*onaca*, *épia*, *ombanda*, *elunda*, and *otchumbo*). For very small and small-scale farmers, the workforce is predominantly made up of family members - the father, mother, and children. Medium and large-scale farmers, however, tend to employ hired labour in addition to relying on their own family members.

As small producers face economic and social vulnerabilities, rural areas offer various alternatives and a diversity of agricultural and non-agricultural activities that can supplement their livelihoods (Ellis, 2000).

Table 18 presents the results regarding the farmers' labour needs and availability. Very small and small farms, have a surplus of adult labour (both female and male), totalling 458 days, and 196,9 days, respectively. This surplus could be used for off-farm work and the revenues could help improve farm and family incomes. For medium and large farmers, however, there is no surplus labour. In these cases, these farmers usually hire additional labour to compensate for the lack of workers.

Table 18. Needs and availability of family labour

Labour	**Adult males**	**Young Men**	**Total Male**	**Female Adults**	**Young Women**	**Total Female**
Very small						
Total needs	*84.05*	*31.4*	*115.45*	*187.9*	*111.25*	*299.15*
Family members	1	1	2	1	2	3
Total Availability	*365.0*	*182.5*	*547.5*	*365.0*	*182.5*	*730*
Labour Surplus	280.95	151.1	432.04	177.1	71.25	272.5
Small						
Total needs	*168.1*	*62.8*	*230.9*	*375.8*	*222.5*	*598.3*
Family members	1	1	2	1	2	3
Total Availability	*365.0*	*182.5*	*547.5*	*365.0*	*365.0*	*730*
Labour Surplus	196.9	119.7	316.6	-10.8	182.5	131.7
Medium						
Total needs	*762.1*	*150.4*	*912.5*	*403.5*	*218.9*	*622.4*
Family members	1	3	4	1	1	2
Availability	*365.0*	*547.5*	*912.5*	*365*	*182.5*	*547.5*
Labour Surplus	-397.1	397.1	0	-38.5	-36.4	-74.9
Large						
Needs	*4 441.0*	*118.6*	*4 559.6*	*1 949.1*	*278.3*	*2 227.4*
Family members	1	2	3	1	4	5
Availability	*365*	*365*	*730*	*365*	*730*	*1095*
Labour Surplus	-4076	246.4	-3829.6	-1584.1	451.7	-1132.4

Source: Own elaboration.

As can be seen in Table 19, that incorporates off farm labour revenues, for both very small and small farms, total net revenue improves, but the monthly net revenue per capita is still below, almost half of the poverty line, therefore insufficient to break minimum poverty levels.

Table 19. Income and per capita income with off-farm labour

Item	Very small	Small
Number of household members	5	5
Net revenue from baseline scenario	269 513	629 150
Net revenue from off-farm labour	458 000	196 900
Total net revenue	727 513	826 050
Monthly total net revenue per capita	12125	13768
Monthly poverty line per capita	26353	
National average salary	32181	

Source: Own elaboration.

In order to achieve the objectives of sustainable growth in food production and the reduction of rural poverty, it is necessary to help family farmers to develop more productive, profitable, resource-efficient and environmentally-friendly farms. The results obtained by Dogliotti et al. (2014) show that it is possible to improve the sustainability of family farms within the limitations imposed by their current availability of resources and the socio-economic context of each country. The main changes to the system can include increasing the crop area, introducing long crop rotations with pastures, cover crops and animal manure applications

Considering that Angola has arable land available, increasing the size of farms is a solution to increase the income and well-being of many of very small and small-scale farmers. For the baseline scenario, therefore assuming that farmers have not yet adopted the alternative scenario, a simulation in the very small and small models, estimated that the area size needed to reach poverty line would be 5,5 ha, being a valid option for breaking the vicious cycle of poverty.

Santos et al. (2024) suggest that the presence of agro-industries increases the likelihood of farmers protecting their soil, using fewer pesticides, and adopting agro-ecological practices compared to those without access to agro-industries. This greater environmental awareness and proactive behaviour are often a result of the stronger relationship between agro-industry-connected farmers and the local market, which reflects consumer demands for environmentally friendly practices and healthier food consumption.

Insufficiently planned and executed agricultural practices can have adverse effects on the environment. Soil is a critical resource for crop development, and therefore, knowledge of and the adoption of tillage systems with lower environmental impacts are essential for achieving agricultural sustainability.

Family farmers are constantly confronted with rising input costs, and many small-scale farmers have expressed a desire to reduce their dependence on agrochemicals. However, they often hesitate to do so due to concerns about potential reductions in income. Some have considered adopting organic fertilizers and composting as adaptive practices, but are deterred by limited access to raw materials and the necessary labour force (Milkias & Degefu, 2024).

4.5. Conclusions

This study has highlighted the distinct and important characteristics of family farming systems in Huambo, particularly in terms of their economic, social, and environmental performance.

Under current conditions, the productivity of farmers is low, and the findings indicate that the models for very small and small farmers do not allow them to surpass the poverty line, placing them in a state of poverty. On the other hand, medium and large farmers are above the poverty threshold.

The introduction of new certified seed varieties with higher production potential, alongside the introduction of livestock breeds (goats with two births per year), proved to be an effective strategy. In terms of economic sustainability, the annual net income of farms implementing new technologies, along with the annual net income per capita, are positive for all types of farmers. This positive income supports all expenses not included in the model and enables these family farmer models to overcome the poverty threshold.

Regarding social sustainability, agricultural activities are essential to maintaining the livelihoods of rural households. Most family farms in Huambo depend predominantly on family labour, with different household members actively engaged in various farm tasks throughout the year. This reliance on family labour reflects both the limited access to hired labour and the strong role of household cooperation in sustaining agricultural production.

In terms of environmental sustainability, the techniques employed in both agriculture and livestock farming are relatively traditional, reflecting the technological constraints of the production process. A notable positive aspect for family farmers in Huambo is the minimal quantity of inputs used in production. The amounts of diesel, nitrogen, phosphorus, potassium, insecticides, herbicides, and sacks are generally low or even non-existent, which limits environmental impact compared to more intensive agricultural systems.

In order to foster the sustainable development of family farming systems in Huambo and address the challenges faced by farmers, several public policy initiatives are necessary. These policies aim to support farmers economically, socially, and environmentally, ensuring their capacity to thrive and improve their livelihoods. The following proposals are designed to provide the necessary institutional framework and resources for family farmers:

On the subject of public policy, the first proposed initiative is a land access policy. This policy is designed to facilitate land legalization for family farmers, ensuring legal guarantees and improving access to credit, among other benefits.

The second suggestion involves the creation of a rural credit policy. To implement new technologies, family farmers must have access to various financial instruments that enable them to acquire necessary agricultural inputs.

The third proposal is the implementation of a rural extension policy. This policy should clearly define Angola's rural extension model, ensuring the provision of technical assistance to family farmers, as well as the development of a career framework for extension workers.

The fourth suggestion is a rural women's policy, which would include dedicated credit lines and financing modalities, support for land legalization, literacy programs, technical consultancy, and initiatives to encourage the inclusion of women in rural extension teams.

Lastly, the fifth recommendation is the establishment of a cooperative policy focused on training in cooperative management, production cost analysis and control, as well as the marketing and processing of agricultural products.

CHAPTER 5 – FINAL CONSIDERATIONS

Chapter 5 aims to present the main conclusions and final considerations of the thesis. It is organized into four subsections. The first subsection summarizes the key findings of the research, structured according to the five proposed objectives. The second subsection highlights the main contributions of the study, including: the development of ELP models for family farmers in Huambo; the identification of four distinct categories of family farmers; strategies to improve agricultural productivity as a means of poverty reduction; and policy recommendations to strengthen family farming in the region. The third subsection discusses the principal limitations encountered throughout the research process. Lastly, the fourth subsection offers suggestions for future research avenues.

5.1. Main conclusions

This thesis set out to address the central research question: Are agricultural systems in Huambo capable of reducing the levels of poverty experienced by rural families in a sustainable manner? To this end, the general objective was to analyze and propose sustainable family farming systems that could enable rural households to achieve a standard of living above the poverty line.

Drawing on the evidence presented across the three core chapters, each of which provided data and analysis to deepen the understanding of farming systems and everyday life in rural households, this research concludes that current family farming systems in Huambo are largely unsustainable and ineffective in alleviating rural poverty. The findings indicate that family farming in the region is characterized by a diverse array of small-scale socio-economic typologies, which rely heavily on family labour and limited land resources to engage in agricultural, pastoral, and natural resource-based activities.

The conclusions presented below are organized according to the specific research objectives outlined in Chapter 1, followed by reflections on the central objective of the study.

Objective 1. To Identify and characterise the family farming systems practiced in Huambo Province

Regarding objective one, a comprehensive review of the literature, analysis of secondary data, targeted discussions with specialists, and participant observation enabled the identification of key characteristics. Findings indicate that land ownership follows a traditional system, primarily inherited, with plots fixed yet dispersed across different ecological zones (catenas). These areas are locally categorized as follows: *Onaka* (lowland farming), *Épia ongongo* (highland farming), *Elunda* (farming in old villages), and *Otchchongo* (farming near houses). Agricultural activities are predominantly manual, though animal traction is occasionally employed. The most commonly used tools include hoes, machetes, axes, and ploughs.

The evolution of family farming in Huambo has been shaped by customary and cultural traditions, the colonial past, years of conflict and forced migration, mass urbanization, and recent socio-economic development. Family farms play an important role in Huambo's economy and significantly influence the social organization of this predominantly rural population.

Beyond their contributions to food production, self-sufficiency, and income generation, family farms are essential for social protection and sustainable development due to their multifunctionality. Consequently, key indicators of human development in Huambo, such us poverty levels, food security, and gender relations, are closely tied to the socio-economic challenges faced by family farms. However, despite their socio-political importance, these farming systems are often overlooked in the priorities of existing public policies.

Objective 2. To select the study area and identify the agricultural systems and representative households within it

Regarding objective two, surveys conducted with family farmers confirmed the diversity of Huambo’s family farming systems. Farms were categorized based on landholding size as follows: very small (area <= 1ha; 44,4%), small (1 < area ≤ 3 ha; 18,2 %); medium (3 < area ≤ 5 ha; 20,3%); and large (area > 5 ha; 17,1%). Key findings reveal that farm size is positively correlated with the farmer’s age, income, household size, and level of education. Women are more represented in small farms than in large ones, while marriage is more common among small farms.

Intercropping is the dominant farming system. though monoculture becomes more prevalent as farm size increases. Productivity for key crops, such as corn, beans, soybeans, and reindeer potatoes, is generally low but improves with larger landholdings. Rainwater remains the primary irrigation source, though irrigation systems are more commonly used for reindeer potatoes and become increasingly important on larger farms.

Pest and disease control practices, as well as fertilizer use, vary with farm size. Small farmers use minimal chemical inputs, whereas larger farms rely more on such products.

To better capture the functioning of Huambo's diverse family farming systems, considering their cultural and ethnographic characteristics, an ELP model was employed. This model enabled an in-depth analysis not only of productive activities but also of reproductive and community activities, which are central to the organization and sustainability of rural communities.

Objective 3. To develop and validate ELP models for selected households, analysing their economic and social sustainability analysis

Findings from objective three demonstrate the effectiveness of the ELP model as a management tool for the case study, showing its potential for broader application in Huambo province and similar contexts, despite natural, socio-economic, and ethnographic constraints.

The ELP model results for cultural occupation in different farming zones suggest the following crop strategies:

- *Onaka*: farmers should prioritize maize and bean production while discontinuing potato cultivation.
- *Ombanda*: the model recommends growing maize, beans, and potatoes, but advises against cultivating onions.
- *Epia*, *Elunda*, and *Otchumbo*: the model prioritizes maize and beans.

Regarding market sales, the model identifies maize, beans, and potatoes as the most profitable crops, while onions are excluded due to lower economic returns. For livestock, the model includes cows, goats, and chickens as the primary species for household farming. Among the household's monetary expenses, costs related to crop and animal activities, hired labour, and fixed costs are the most significant. The primary income source for the household derives from crop and animal production.

Objective 4. To identify and test alternative sustainability scenarios to improve household well-being above the poverty line

Findings from objective four reveal that farmers' productivity remains low. Small farmers, who represent the majority, struggle to surpass the poverty line, whereas medium and large farmers are above it. Given this disparity, introducing alternative production scenarios that enhance productivity is essential to improving small farms’ livelihoods.

In the alternative scenarios tested, two key interventions were introduced. New certified seed varieties with higher production indexes and goats farming with two births cycles per year, to improve livestock production.

Given the varying capacities of farmers, technology adoption should be gradual: low-tech solutions for small farmers, medium-tech for medium farmers, and high-tech solutions for large farmers.

In terms of economic sustainability, the results indicate that farms adopting new technologies experience higher annual net income, leading to increased per capita income across all farm sizes This additional income helps cover expenses not included in the model and enables farmers to surpass the poverty threshold.

Key social sustainability challenges include aging, gender inequality, and the well-being of small farmers. Aging farmers reported declining health and physical capacity. Women face multiple burdens, balancing subsistence farming with household responsibilities such as cooking, childcare, water collection, food processing, and firewood gathering, which is the primary source of energy. Low literacy rates among female farmers perpetuate traditional gender inequalities, limiting their access to resources and decision-making opportunities.

Access to exercise of traditional power follows a lineage-based structure, deeply rooted in kinship. Gender bias is evident in leadership roles, as men are typically preferred under the belief that they are better suited for decision-making and cultural preservation.

The central figure of traditional authority in the villages is the *Soba*, supported by the *sekulos* (elders). The cult of ancestors reinforces traditional power and serves as a mechanism to mediate generational demands. Village councils (*Ndjango*) oversee traditional justice and governance.

Catholicism and Protestantism are the dominant religions, shaping the behaviour and practices of rural households, though their influence varies depending on doctrinal orientation.

Cultural life in Huambo is also rich in rituals and celebrations, including *alembamento* (bridewealth ceremonies), religious weddings, male initiation ceremonies (*Evamba*), and superstition-based rituals, often performed by the *tchimbanda* (diviner and healer) to appease the *osande* (family spirit) in cases of illness, plagues, drought, or excessive rainfall (Vitongue, 2004; Katiavala, 2015; Kamutali, 2022).

In environmental sustainability context, agriculture and livestock techniques remain traditional, with minimal use of external inputs. Diesel, fertilizers (nitrogen, phosphorus, potassium), pesticides, herbicides, and packaging materials such as sacks are used in very limited quantities and, in many cases, are virtually non-existent.

The World Bank-funded the Institute of Agrarian Development (IDA) project, known as Angola's Family Farming Transformation Project (*Projecto de Transformação da Agro-pecuária Familiar de Angola,* MOSAP), is currently in its third phase. While it aims to transform family farming and increase food production, its impact is constrained by limited resources and incomplete coverage.

Provincial governments have also introduced local initiatives under the Integrated Development and Combating Poverty Program, but the outcomes have not yet been satisfactory and tangible.

A major challenge hindering progress is the absence of a National Public Policy on Family Farming, which significantly contributes to the underperformance of family farming systems and the slow pace of rural development in Huambo. Given these challenges, the next objective of this thesis focuses on policy recommendations to improve conditions for rural households and enhance the sustainability of family farming systems.

Objective 5. To provide policy recommendations to enhance household living conditions and promote sustainable development

In alignment with the fifth objective, five key policy proposals have been developed based on the study's findings.

The first proposal addresses land access policy, aiming to provide family farmers with legal ownership rights. Securing land tenure would provide legal guarantees and facilitate access to credit, among other benefits. Currently, most family farmers acquire land through inheritance under customary law, which does not grant legal ownership. Under the existing Angolan Land Law, all land remains state-owned, creating challenges for farmers in securing land rights.

Family farmers face numerous obstacles in legalizing their plots, including high costs, bureaucratic complexity due to multiple stakeholders, and limited access to information. To address these barriers, it is proposed that farmers be able to legalize their land within their local areas through a single entity or a network of integrated entities operating in one physical location. Furthermore, farmers should be exempt from travel fees for state-provided surveying services, and legalization fees should be subsidized to reduce financial burdens.

The second proposal focuses on a rural credit policy. To adopt new technologies and improve productivity, family farmers require access to financial instruments tailored to their needs. However, existing financial products from commercial banks in Huambo are unsuitable due to excessive documentation requirements, short grace periods, high interest rates, and rigid repayment structures. The proposed rural credit policy should institutionalize microfinance, support the establishment of microfinance institutions, and develop financial products specifically designed for small family farming. These measures would enhance farmers' ability to invest in agricultural inputs and improve production efficiency.

A clearly defined rural extension model is important for improving farmers' access to technical assistance and constitute the third proposal. The proposed policy should establish career path for extension workers and enhance public technical assistance services. It should encourage the development of private technical assistance services providers, for example through farmers' cooperative or associations, to support farmers in overcoming market challenges related to both inputs and outputs.

The fourth suggestion is a rural women's policy. Gender disparities in rural areas necessitate a dedicated policy to support women in agriculture. This policy should focus on expanding access to credit lines and tailored financial services, facilitating land legalization, implementing literacy programs, and providing specialized technical consultancy. It should also promote the inclusion of women in rural extension teams to ensure gender-sensitive agricultural support.

Finally, strengthening agricultural cooperatives is essential for improving smallholder farmers' economic resilience. The proposed policy should prioritize training in cooperative management, cost analysis and control, marketing strategies, and the processing of agricultural products. Building the capacity of cooperatives would enhance their competitiveness and sustainability.

This study aimed to assess the sustainability of agricultural systems in Huambo and their potential to reduce household poverty. The findings, explored throughout this thesis, reveal that while family farming systems in Huambo exhibit valuable economic, social, and environmental characteristics, performance, they remain unsustainable and lack the capacity to alleviate poverty effectively.

In conclusion, these results underscore the urgent need for targeted policies and interventions to address key sustainability challenges in family farming, particularly in land access, rural credit, technical assistance, and gender equity. Implementing these policies would contribute to improving farmers' livelihoods and fostering long-term rural development.

5.2. Main contributions

This study makes a significant contribution by categorizing the typologies of family farmers in Huambo, which could serve as a basis for future studies. The main contributions of the study are:

Identification of Four Categories of Family Farmers

This study identifies four distinct categories of family farmers in Huambo, highlighting the diversity within the sector. Although small-scale farmers constitute the majority, they exhibit varying levels of knowledge, skills, capital and resources. These differences translate into distinct needs, underscoring the important of targeted interventions to improve family farming systems.

The findings contribute to a more nuanced understanding of family farming in Huambo, aiding in the design of policies and programs that better address the specific challenges of each group. Future Agri-Livestock and Fisheries Censuses (RAPP) in Angola should incorporate these farmer categories, classifying them based on the physical size of their holdings to ensure more accurate reporting and policy planning for family farming.

Development of ELP Models for Family Farmers in Huambo

This study marks the first-time construction of ELP models for family farmers in Angola, offering a framework that can be replicated across the country. These models serve as a valuable policy tool for assessing household food security and planning surplus production for market integration, tailored to the specific conditions of different regions. Furthermore, the broader application of these models and the insights gained from this study can contribute to the ongoing debate on the formulation of a national family farming policy in Angola, providing empirical evidence to support more effective rural development strategies.

Enhancing Agricultural Productivity for Poverty Alleviation

This work supports the adoption of diverse technologies by offering farmers guidelines on selecting high-yield crop varieties and implementing best agricultural practices to maximize farm productivity and improve the sustainability of their production systems.

Policy Recommendations for Enhancing Family Farming in Huambo

This study proposes policy suggestions to improve family farming systems in Huambo, facilitating the development of strategies for their application and dissemination in rural communities. These policies aim to overcome different constraints and promote the sustainability of family farmers in Angola's central plateau. The proposed alternative policy paths should focus the equitable distribution of benefits while tackling inequalities in access to services and resources.

5.3. Research limitations and challenges

Throughout this thesis, several limitations were encountered, including the scarcity of bibliographical material on family farming and the lack of empirical data, which made the research process more time-consuming. One of the main challenges in designing the questionnaire, interview scripts, and focus groups was selecting the most relevant and comprehensive questions to accurately capture the reality of these households.

During the data collection phase, logistical and financial constraints related to travel and accommodations in the communities were exacerbated by difficulties in securing household participation. This reluctance stemmed, on one hand, from a distrust, partly influenced by political party representatives, and, on the other hand, from prior experiences with external actors who had made unfulfilled promises, such as improving road access, distributing fertilizers and seeds, and providing medical care. As a result, some participants with valuable knowledge about household production systems may have been excluded, potentially limiting the study's depth. Moreover, low education levels and the absence of records on production costs and income further constrained the research.

From a methodological perspective, the ELP approach also presents challenges. Selecting representative households was particularly difficult, as participants were initially surveyed via questionnaire and later contacted at home and by telephone to supplement the data used in the model. This process may have affected the generalizability of the results. Another limitation was the exclusion of human dietary patterns from the modelling process due to insufficient data, which may have impacted the comprehensiveness of the findings.

5.4. Future research directions

Although the central question of this study has been addressed, it is essential to explore comprehensive solutions to promote the economic and social sustainability of households in Huambo and, more broadly, in Angola. To this end, the following, studies are suggested as next steps:

Evaluation of Technological Innovations - Evaluate the impact of introduced technologies in terms of adaptability, productivity, profitability and accessibility for farming households. While the adoption of new technologies has played an important role in improving economic and financial performance by boosting productivity, this study should focus on evaluating farmers' adaptability to and adoption rates of these technologies. It is important to examine the barriers to technology access and explore potential solutions to overcome these challenges.

Identification of High-Impact Agricultural Practices - Investigate agricultural practices that increase productivity, such as optimized fertilization techniques and the use of improved, pest- and disease- resistant crop varieties. Many past efforts to modernize and transform family farming systems have failed due to a lack of consideration for farmers' real conditions, limited resources availability, and contextual constraints. This study aims to test different production systems and alternative, labour- and input-intensive techniques within farms, allowing family farmers to actively participate in the selection of methods best suited to their needs.

Evaluating the agroecological sustainability of family farming systems - the aim of this study will be to evaluate the different production systems using indicators which attest the agroecological sustainability of these systems. In the end, the aim is to identify possible weaknesses or potentialities that could contribute to improving the systems and the households.

Assessment of social and community sustainability - the focus of this work will first be on deepening our knowledge of the typologies of rural families according to the type of work that predominates in the production unit, which can be a useful tool for proposing intervention measures tailored to the needs of each category. The second purpose of community sustainability is to identify practices that promote the construction of a collective conscience within those communities with strong social problems and the ability to critically analyze their reality, making them more active in solving their social problems

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ANNEX I - QUESTIONNAIRE

This survey form is intended to collect data for the preparation of the doctoral thesis in Agribusiness and Sustainability, the title of which is **"Family Farming in Huambo: An Approach to Economic and Social Sustainability to Overcome Poverty".** Participation in this study is voluntary. Your privacy will be protected and confidentiality will be maintained. Your answers will be treated as confidential and it will not be necessary to provide your identity.

LOCATION

Village_______________________________*Comuna*____________________________.

Municipality______________________. Data_____/_____/________

1. **FARMER AND HIS FAMILY**

a) Data on the head of the farm/family.

Sex		Age (years)			Education				
M	H	17-29	30-50	50-70	Did not study	Primary education	First Cycle	Cycle II	Higher Education

b) Household members

Age class of members (years)					Number of members				
1-5	5-10	10-20	20-30	>30	1-3	4-6	7-8	9-10	others

c) Where do you live?

c1. Own
c2. Rent
c3. Provided

d) Your house is covered by:

d1.grass
d2. plates
d3. roof tiles
d4. gold, which one?

2. FAMILY, FESTIVE AND COMMUNITY ACTIVITIES

a) Activity of the farm manager/family on or off their property.

Own activities					Outside and paid activities				
Agricultural work	Handicrafts	Stonemason	Motorcycle cabs	Small businesses	Agricultural work	Motorcycle cabs	Professor	Carpenter	other

b) Household members' activities on or off the property

Own activities					Outside and paid activities				
Agricultural work	Handicrafts	Stonemason	Motorcycle cabs	Small businesses	Agricultural work	Motorcycle cabs	Professor	Carpenter	other

c) Participation in household activities

Activities	Responsible			Frequency		
Transporting water	Woman	Man	Daughter aged 7-15	Son aged 7-15	Children over 15	
Transporting firewood						
Turning corn into flour						
Preparing food						
Washing the dishes						
Cleaning the house						
Washing and ironing						
Washing small children						
Looking after children						
Which others?						

d) Participation in family festive activities

Wedding	Frequency	Surroundings	costs
Baptism			
Anniversary			
Evamba			
Harvesting			
Funeral			
Alambamento			
Other, which one?			

e) Community Activities

	Frequency	Woman	Man	Daughters	Children
The country's commemorative dates					
Commemorative dates of the Province					
Commemorative dates of the municipality					
Participation in church activities					
Enthronement of sobas					
Which others?					

f) Do you participate in any organization? Which organization?

	Does not participate	Participate as a member	Other, which one?
Producers' association			
cooperative			
Farmers' field school			
Group of traders			
Other, which one?			

g) Which of the following religions do you participate in?

Catholic Church		ACEI	
Methodist Church		IIA	
Baptist Church		Apostolic Faith	
Seventh-day Adventist		Which one?	

h) Who makes the family's decision about:

	Woman	Man	Men and women	Others:
What to eat				
Children's schools				
Participation in community activities				
What to produce				
Production objective				
Male initiation of sons (evamba)				
Children's marriage				
Festive activities				
Buying goods and animals				
Help from family members				
Family visits				
Health care				
Participation in a religion				
Which others?				

3. HUMAN NUTRITION

a) How many meals does the family have a day?

1. One
2. Two

3. Three
4. Four
5. How many?

b) What does the family eat?

Food	Morning	Afternoon	Night
Bread			
Potato			
Sweet potatoes			
Courgette			
Boiled cassava			
Fungi			
Rice			
Pasta			
Meat			
Beans			
Kale, cabbage			
Which others?			

c) On a scale of 1 to 5, characterize the importance of each food:

Food	1	2	3	4	5
Bread					
Potato					
Sweet potatoes					
Fungi					
Rice					
Pasta					
Meat					
Fish					
Beans					
Courgette					
Kale					
Quisaca					
Which others?					

d) Is there a difference in diet between children and adults?

Food	Morning	Afternoon	Night	Children	Adults
Bread					
Potato					
Sweet potatoes					
Fungi					
Rice					
Pasta					
Meat					
Fish					
Beans					
Courgette					
Kale					
Quisaca					
Which others?					

e) Which month has the greatest availability of food?

	Months											
	1	2	3	4	5	6	7	8	9	10	11	12

f) What are the months when food is scarce?

	Months											
	1	2	3	4	5	6	7	8	9	10	11	12

4. EXPLORATION, PLANT AND ANIMAL CROPS AND TECHNOLOGY

a) Total area of holdings

Farms by total area class			
1-2 hectares	2-4 hectares	4-10 hectares	More than 10 hectares

b) Total area cultivated in the last year

Farms by class of cultivated area			
1-2 hectares	2-4 hectares	4-10 hectares	More than 10 hectares

c) Fallow land on holdings

Farms by fallow area class			
1-2 hectares	2-4 hectares	4-10 hectares	More than 10 hectares

d) Origin of the land you farm

Inheritance	Purchase	Renting	Assignment

e) Plots and forms of exploitation

Type of plot	1-2 hectares	2-4 hectares	4-10 hectares	Over hectares
Naca				
Ombanda				
Epia				
Octhumbo				

f) How far is it from the mine?

Distance from the village to Lavra	Type of mining	Mining area	Time travelled	Means of transport used

g) On a scale of 1 to 5, characterize the importance of each type of mining:

Type of holding	1	2	3	4	5
Naca					
Ombanda					
Epia					
Octhumbo					
Other, which					

h) In which months does the Lavra do Alto plant and harvest?

Cultural activity	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Corn												
Butter beans												
Cassava												
Reindeer potatoes												
Sweet potatoes												
Courgette												
Macunde beans												
Kale												
Cabbage												
Carrot												
Onions												

i) In which months do you grow and harvest the Lavra da Baixa?

Cultural activity	Months											
	1	2	3	4	5	6	7	8	9	10	11	12
Corn												
Butter beans												
Cassava												
Reindeer potatoes												
Sweet potatoes												
Courgette												
Macunde beans												
Kale												
Cabbage												
Carrot												
Onions												

j) In which months do you realize crop operations?

Activities	**Months**											
	1	2	3	4	5	6	7	8	9	10	11	12
Choice of land												
Land preparation												
Buying the seed												
Sowing												
Bottom dressing												
Germination control												
Weeding and stacking												
Pest and disease control												
Harvesting												

k) Use of labour

Cultural operations	Husband	Woman	Children < 14 years	Children > 14 years old	Others
Felling trees					
Land clearing					
Land preparation					
Farming					
Fertilization					
Sowing/planting					
Monda					
Phytosanitary treatments					
Watering					
Harvesting					
Storage					
Selling					

l) Use of fertilizer in plowing

Use fertilizers		Type of fertilizer	Bottom dressing	Time of application	Top dressing	Time of application	Type of manure	Cost of fertilizer	Who does it?
Yes	No								

m) On a scale of 1 to 5, characterize the importance of each culture:

Cultures	1	2	3	4	5
Corn					
Beans					
Onions					
Cabbage					
Tomato					
Garlic					
Potato					
Sweet potatoes					
Cassava					

n) How much do you harvest? (area)

Cultures	Quantities in Kg
Corn	
Beans	
Onions	
Cabbage	
Tomato	
Garlic	
Potato	
Sweet potatoes	
Cassava	

o) Instruments used in the production process and which have

Name	Quantity	Price	Duration
Catana			
Machado			
Hoe			
Rake			
Scythe			
Charrua			
Other. Which ones?			

p) Technical Information

Technical operations	
Number of plants per hectare	1. Corn 2. Beans 3. Cassava 4. Reindeer potatoes 5. Courgette 6. Beans 7. Kale 8. Cabbage 9. Carrot 10. Onions
Number of seeds per hole	1. Corn 2. Beans 3. Cassava 4. Reindeer potatoes 5. Courgette 6. Beans 7. Kale 8. Cabbage 9. Carrot 10. Onions
Spacing between rows and plants	1. Corn 2. Beans 3. Cassava 4. Reindeer potatoes 5. Courgette 6. Beans 7. Kale 8. Cabbage 9. Carrot 10. Onions

q) Pests and Diseases

Pests and diseases	
What are the main pests that attack crops?	1. Corn 2. Beans 3. Cassava 4. Reindeer potatoes 5. Courgette 6. Beans 7. Kale 8. Cabbage 9. Carrot 10. Onions 11. Other
What are the main diseases that attack crops?	1. Corn 2. Beans 3. Cassava 4. Reindeer potatoes 5. Courgette 6. Beans 7. Kale 8. Cabbage 9. Carrot 10. Onions 11. Other
What pest and disease control methods do you use? Quantity and area	1. Corn 2. Beans 3. Cassava 4. Reindeer potatoes 5. Courgette 6. Beans 7. Kale 8. Cabbage 9. Carrot 10. Onions 11. Other

r) what kind of animals do you have?

1. chickens
2. ducks
3. chickens and ducks
4. pigs
5. goats
6. oxen
7. Which others?

s) the animals you breed are good for:

1. consumption
2. sale
3. sales and consumption
4. Other, which one?

5. MARKETING

5.1 Where do you sell lavra products?
   a) at the lavra door
   b) on the market
   c) in the intermediaries (at the entrance to the city)
   d) Other, which?

5.2 Who determines the selling price of products and animals?
   a) Producer
   b) Buyer
   c) Government
   d) Producer and buyer

5.3 How much do you make a month from selling animals?
   a) 2000-5000
   b) 5000-10000
   c) 10000-2000
   d) Other, which one?

5.4 How much do you earn per month from selling agricultural products?
   e) 2000-5000
   f) 5000-10000
   g) 10000-2000
   h) Other, which one?

6. SOURCES OF INCOME

1. What are the main sources of income? Crop, animal and off-farm.

Sources of income	Average value per month in Kwanzas
Corn	
Beans	
Onions	
Cabbage	
Tomato	
Garlic	
Potato	
Sweet potatoes	
Cassava	
Working as an employee in agriculture	
Working as a motorcycle taxi	
Working as a master builder	
Working as a construction assistant	
Working as someone else's maid	
Selling animals	
Sale of charcoal	
Sale of bee products	
Which others?	

2. Off-farm income (in Kwanzas)

Head of the family					Household members				
10000 20000	20000 30000	30000 40000	40000 50000	50000 100000	10000 20000	20000 30000	30000 40000	40000 50000	50000 100000

3. If you add up your income and the income of the people you live with, how much is your monthly family income?

   a) 10000 Kz
   b) 15000 Kz
   c) 20000Kz
   d) 30000Kz
   e) 40000Kz
   f) >50000Kz
   g) Other, which?

7. MONTHLY HOUSEHOLD EXPENSES

1. Family monthly expenditure

Product	Quantity (Kg)	Price in Kwanzas
Salt		
Soap		
Sugar		
Toothpaste		
Omo		
Clothes		
Medicines		
Medical consultations		
Children's school		
Which others?		
Which others?		
Which others?		
Which others?		

2. Rate the Family's objectives according to the scale indicated:

Objetives					
Meeting minimum consumption requirements (food, clothing and housing)					
Meeting families' food needs					
Maximizing monetary income for the purchase of goods					
Maximizing monetary income after meeting minimum consumption requirements					
Maximize the health status of family members					
Maximizing education for children					
Maximizing the Family's well-being					
Maximize savings					
Maximizing social status					
Maximize leisure time					
Maximizing environmental conditions					
Maximizing production					
Minimizing the use of male labour in agriculture					
Minimizing the use of female labour in agriculture					
Minimize production costs					
Other, which one?					
Other, which one?					

ANNEX II – INTERVIEW SCRIPT

What is the year the village was founded and how did it come about?

How does the succession of traditional power take place?

What are the main social and economic institutions in the village?

Are there other sources of income besides agriculture? What are these?

What are the main natural resources?

Are there any medical centers or hospitals in the village?

Are there schools in the village? What levels?

What are the links of interest with the other villages ?

What are the main crops grown in the village?

What is the agricultural calendar for these crops?

What are the farmers' main challenges and possible solutions?

What is the time of year when food is most available and most scarce in the village?

What would you like to see improved in the village? Do you have any idea how this could be done?

What are the main festivities?

What is the main external support the village receives?

ANNEX III- ELP BASE MODELS

Base Model - Very Small farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE
St
BACUAG) +5000MIFJNA+ 5000MIFJOM+ 5000MIFJEP+ 5000MIFJEL+ 5000MIFJOC
+28500BTNA+28500BTOM+ 4000CBOM -CUAG=0
BARTAG) 300MIVE + 1000FJVE + 350BTVE + 400CBVE-RTAG=0
BARTPE) +15000CAVE+1000GAVE+100OVVE-RTPE=0
BACUTC) 1000TCMA+1000TCMF-CUTC=0
BACUFX) CUFX>15225
BACUFE) CUFE>16000
TENA1) SUNA<0.2223
TENA2) MIFJNA-SUNA<0
TENA3) BTNA-SUNA<0
TEOM1) SUOM<0.1111
TEOM2) MIFJOM-SUOM<0
TEOM3) BTOM+CBOM-SUOM<0
TEEP1) SUEP < 0.4444
TEEP2) MIFJEP-SUEP<0
TEEL1) SUEL <0.1111
TEEL2) MIFJEL-SUEL <0
TEOC1) SUOC <0.1111
TEOC2) MIFJOC -SUOC <0
BAMI) -350MIFJNA-150MIFJOM-500MIFJEP-400MIFJEL-400MIFJOC+MIFE+MIVE<=0
BAFJ) -200MIFJNA-75MIFJOM-100MIFJEP-30MIFJEL-20MIFJOC+FJFE+ FJVE <= 0
BABT) -500BTNA-1000BTOM+ BTFE+BTVE <=0
BACB) -80CBOM+CBVE<=0
BAMIFE) MIFE=20
BAFJFE) FJFE=5
BABTFE) BTFE=60
NUCAAD) NUCA=2
BAPOCA) -NUCA+CACE=0
BAVECA) -CACE+CAVE=0
NUGAAD) NUGA=2
BAPOGA) -10NUGA+GACE<0
BAVEGA) -GACE+GAFE+GAVE<0
BAVEOV) -10NUGA+OVVE<0
BAGAFE) GAFE=7
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+JVMAFE+JVMAAC+JVMADM-365NUADMA-182.5NUJVMA-
TCMA<0
BAMAAG) 28MIFJNA+28MIFJOM+28MIFJEP+28MIFJEL+28MIFJOC+26BTNA+26BTOM+32CBOM-MAAG<0
BAMAPE) 22.8 NUCA-MAPE<0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM
-365NUADFM-182.5NUJVFM-TCFM <0

```
BAFMAG) 36MIFJNA+36MIFJOM+36MIFJEP+36MIFJEL+36MIFJOC +24BTNA+24BTOM+26CBOM -
FMAG<0
BAFMPE) 7.6NUGA-FMPE<0
TFADMAFE) ADMAFE>11
TFADMAAC) ADMAAC>29
TFJVMAFE) JVMAFE>11
TFJVMAAC) JVMAAC>29
TFJVMADM) JVMADM>22.8
TFADFMDM) ADFMDM>221.6
TFADFMFE) ADFMFE>11
TFADFMAC) ADFMAC>29
TFJVFMDM) JVFMDM>182.5
TFJVFMFE) JVFMFE>11
TFJVFMAC) JVFMAC>29
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=1
NUJVFM) NUJVFM=2
End
```

Base Model - Small Farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE
St
BACUAG) +5000MIFJNA+ 5000MIFJOM+ 5000MIFJEP+ 5000MIFJEL+ 5000MIFJOC
+28500BTNA+28500BTOM+ 4000CBOM -CUAG=0
BARTAG) 300MIVE + 1000FJVE + 350BTVE + 400CBVE-RTAG=0
BARTPE) +15000CAVE+1000GAVE+100OVVE-RTPE=0
BACUTC) 1000TCMA+1000TCMF-CUTC=0
BACUFX) CUFX>15225
BACUFE) CUFE>16000
TENA1) SUNA<0.5
TENA2) MIFJNA-SUNA<0
TENA3) BTNA-SUNA<0
TEOM1) SUOM<0.25
TEOM2) MIFJOM-SUOM<0
TEOM3) BTOM+CBOM-SUOM<0
TEEP1) SUEP < 1
TEEP2) MIFJEP-SUEP<0
TEEL1) SUEL <0.25
TEEL2) MIFJEL-SUEL <0
TEOC1) SUOC <0.25
TEOC2) MIFJOC -SUOC <0
BAMI) -350MIFJNA-150MIFJOM-500MIFJEP-400MIFJEL-400MIFJOC+MIFE+MIVE<=0
BAFJ) -200MIFJNA-75MIFJOM-100MIFJEP-30MIFJEL-20MIFJOC+FJFE+ FJVE <= 0
BABT) -500BTNA-1000BTOM+ BTFE+BTVE <=0
BACB) -110CBOM+CBVE<=0
BAMIFE) MIFE=20
BAFJFE) FJFE=5
BABTFE) BTFE=60
NUCAAD) NUCA=2
BAPOCA) -NUCA+CACE=0
BAVECA) -CACE+CAVE=0
NUGAAD) NUGA=2
BAPOGA) -10NUGA+GACE<0
BAVEGA) -GACE+GAFE+GAVE<0
BAVEOV) -10NUGA+OVVE<0
BAGAFE) GAFE=7
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+JVMAFE+JVMAAC+JVMADM
-365NUADMA-182.5NUJVMA-TCMA<0
BAMAAG)28MIFJNA+28MIFJOM+28MIFJEP+28MIFJEL+28MIFJOC+26BTNA+26BTOM+32CBOM-MAAG<0
BAMAPE) 22.8 NUCA-MAPE<0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM
-365NUADFM-182.5NUJVFM-TCFM <0
BAFMAG) 36MIFJNA+36MIFJOM+36MIFJEP+36MIFJEL+36MIFJOC +24BTNA+24BTOM+26CBOM -
FMAG<0
BAFMPE) 7.6NUGA-FMPE<0

TFADMAFE) ADMAFE>11
TFADMAAC) ADMAAC>29
TFJVMAFE) JVMAFE>11
TFJVMAAC) JVMAAC>29
TFJVMADM) JVMADM>22.8
TFADFMDM) ADFMDM>221.6
TFADFMFE) ADFMFE>11
TFADFMAC) ADFMAC>29
TFJVFMDM) JVFMDM>182.5
TFJVFMFE) JVFMFE>11
TFJVFMAC) JVFMAC>29
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=1
NUJVFM) NUJVFM=2
End

Base Model - Medium Farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE-CUAC
St
BACUAG) +117780MIFJNA+117780MIFJOM+117780MIFJEP+117780MIFJEL+117780MIFJOC
+1567860BTNA+1567860BTOM+80050CBOM-CUAG=0
BARTAG) 300MIVE+1000FJVE+350BTVE+250CBVE-RTAG=0
BACUPE) 115000NUVA-CUPE=0
BARTPE) +350000VAVE+15000CAVE+2500GAVE+100OVVE-RTPE=0
BACUTC) 1000TCMA+1000TCFM-CUTC=0
BACUFX) CUFX>15905
BACUFE) CUFE>769000
BACUAC) CUAC>70000
TENA1) SUNA<1
TENA2) MIFJNA-SUNA<0
TENA3) BTNA+CBNA-SUNA<0
TEOM1) SUOM<0.5
TEOM2) MIFJOM-SUOM<0
TEOM3) BTOM+CBOM-SUOM<0
TEEP1) SUEP < 2
TEEP2) MIFJEP-SUEP<0
TEOC1) SUOC <0.5
TEOC2) MIFJOC -SUOC <0
TEEL1) SUEL <0.25
TEEL2) MIFJEL-SUEL <0
BAMI) -800MIFJNA-300MIFJOM-1500MIFJEP-300MIFJEL-400MIFJOC+MIVE <=0
BAFJ) -200MIFJNA-100MIFJOM-600MIFJEP-40MIFJEL-50MIFJOC+FJAC+FJVE <=0
BABT) -4700BTNA-5500BTOM+BTFE+BTAC+ BTVE <=0
BACB) -300CBNA-800CBOM+CBVE<=0
BABTFE) BTFE=20
BABTAC) BTAC=10
BAFJAC) FJAC=5
NUVAAD) NUVA=2
BAPOVA) -NUVA+VACE<0
BAVEVA) -VACE+VAVE=0
NUCAAD) NUCA=4
BAPOCA) -NUCA+CACE=0
BAVECA) -CACE+CAVE+CAFE=0
BACAFE) CAFE=1
NUGAAD) NUGA=4
BAPOGA) -16NUGA+GACE<0
BAVEGA) -GACE+GAVE+GAFE+GAAC<0
BAVEOV) -16NUGA+OVVE<0
BAGAFE) GAFE=9
BAGAAC) GAAC=1
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+JVMAFE+JVMAAC+JVMADM
-365NUADMA-182.5NUJVMA-TCMA<=0

```
BAMAAG) 62MIFJNA+62MIFJOM+62MIFJEP+62MIFJEL+62MIFJOC +106BTNA+106BTOM+63CBOM-
MAAG=0
BAMAPE) 182.5NUVA+15NUCA-MAPE=0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM
-365NUADFM-182.5NUJVFM-TCFM<=0
BAFMAG) 37MIFJNA+37MIFJOM+37MIFJEP+37MIFJEL+37MIFJOC +84BTNA+84BTOM+28CBOM-FMAG=0
BAFMPE) 7.6NUGA-FMPE=0
TFADMAFE) ADMAFE>15
TFADMAAC) ADMAAC>67
TFJVMAFE) JVMAFE>15
TFJVMAAC) JVMAAC>67
TFJVMADM) JVMADM>68.4
TFADFMDM) ADFMDM>143.4
TFADFMFE) ADFMFE>15
TFADFMAC) ADFMAC>67
TFJVFMDM) JVFMDM>136.9
TFJVFMFE) JVFMFE>15
TFJVFMAC) JVFMAC>67
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=3
NUJVFM) NUJVFM=1
End
```

Base Model - Large Farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE-CUAC
St
BACUAG) + 513900MIFJNA+ 513900MIFJOM+ 513900MIFJEP+ 513900MIFJEL+ 513900MIFJOC +1468400BTNA+1468400BTOM+ 631500CBOM -CUAG=0
BARTAG) 370MIVE + 1000FJVE + 400BTVE + 250CBVE-RTAG=0
BACUPE) 18000NUVA-CUPE=0
BARTPE) +250000VAVE+20000CAVE+3000GAVE-RTPE=0
BACUTC) 1000TCMA+1000TCFM-CUTC=0
BACUFX) CUFX>77902
BACUFE) CUFE>2061500
BACUAC) CUAC>40000
TENA1) SUNA<5
TENA2) MIFJNA-SUNA<0
TENA3) BTNA-SUNA<0
TENA4) MIFJNA-BTNA=0
TEOM1) SUOM<3
TEOM2) MIFJOM-SUOM<0
TEOM3) BTOM+CBOM-SUOM<0
TEOM4) MIFJOM-BTOM-CBOM=0
TEEP1) SUEP < 20
TEEP2) MIFJEP-SUEP<0
TEEL1) SUEL <2
TEEL2) MIFJEL-SUEL <0
TEOC1) SUOC <2
TEOC2) MIFJOC -SUOC <0
BAMI) -1400MIFJNA-700MIFJOM-800MIFJEP-500MIFJEL-400MIFJOC+MIVE<=0
BAFJ) -700MIFJNA-400MIFJOM-1500MIFJEP-1200MIFJEL-1300MIFJOC+ FJAC+FJVE <= 0
BABT) -3000BTNA-8000BTOM+BTAC+BTFE+BTVE <=0
BACB) -5000CBOM+CBVE<=0
BABTFE) BTFE=25
BABTAC) BTAC=15
BAFJAC) FJAC=5
NUVAAD) NUVA=16
BAPOVA) -0.375NUVA+VACE<0
BAVEVA) -VACE+VAVE=0
NUCAAD) NUCA=6
BAPOCA) -NUCA+CACE=0
BAVECA) -CACE+CAFE+CAVE=0
BACAFE) CAFE=2
NUGAAD) NUGA=5
BAPOGA) -14NUGA+GACE<0
BAVEGA) -GACE+GAVE+GAFE+GAAC<0
BAGAFE) GAFE=13
BAGAAC) GAAC=1
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+ JVMAFE+ JVMAAC+JVMADM -365NUADMA-182.5NUJVMA-TCMA<0

BAMAAG) 87MIFJNA+87MIFJOM+87MIFJEP+87MIFJEL+87MIFJOC
+123BTNA+123BTOM+92CBOM-MAAG<0
BAMAPE) 30NUVA+20NUCA-MAPE<0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM-365NUADFM-182.5NUJVFM-TCFM<0
BAFMAG) 38MIFJNA+38MIFJOM+38MIFJEP+38MIFJEL+38MIFJOC +52BTNA+52BTOM+38CBOM -FMAG<0
BAFMPE) 4.5NUGA-FMPE<0
TFADMAFE) ADMAFE>19
TFADMAAC) ADMAAC>54
TFJVMAFE) JVMAFE>19
TFJVMAAC) JVMAAC>54
TFJVMAAC) JVMADM>45.6
TFADFMDM) ADFMDM>221.6
TFADFMFE) ADFMFE>19
TFADFMAC) ADFMAC>54
TFJVFMDM) JVFMDM>205.3
TFJVFMFE) JVFMFE>19
TFJVFMAC) JVFMAC>54
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=2
NUJVFM) NUJVFM=4
End

ANNEX IV - MODELS FOR NEW TECHNOLOGIES

Alternative model new technologies - very small farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE
St
BACUAG) +5000MIFJNA+ 5000MIFJOM+ 5000MIFJEP+ 5000MIFJEL+ 5000MIFJOC
+28500BTNA+28500BTOM+ 4000CBOM+ 243000MIFJNANO+ 243000MIFJOMNO+
243000MIFJEPNO+ 243000MIFJELNO+ 243000MIFJOCNO+1603000BTNANO+1603000BTOMNO-
CUAG=0
BARTAG) 300MIVE + 1000FJVE + 350BTVE + 400CBVE-RTAG=0
BARTPE) +15000CAVE+1000GAVE+100OVVE-RTPE=0
BACUTC) 1000TCMA+1000TCFM-CUTC=0
BACUFX) CUFX>15225
BACUFE) CUFE>16000
TENA1) SUNA<0.2223
TENA2) MIFJNA+MIFJNANO-SUNA<0
TENA3) BTNA+BTNANO-SUNA<0
TEOM1) SUOM<0.1111
TEOM2) MIFJOM+MIFJOMNO-SUOM<0
TEOM3) BTOM+BTOMNO+CBOM-SUOM<0
TEEP1) SUEP < 0.4444
TEEP2) MIFJEP+MIFJEPNO-SUEP<0
TEEL1) SUEL <0.1111
TEEL2) MIFJEL+MIFJELNO-SUEL <0
TEOC1) SUOC <0.1111
TEOC2) MIFJOC+MIFJOCNO -SUOC <0
BAMI) -350MIFJNA-150MIFJOM-500MIFJEP-400MIFJEL-400MIFJOC-2000MIFJNANO-
2000MIFJOMNO-2000MIFJEPNO-2000MIFJELNO-2000MIFJOCNO +MIFE+MIVE<=0
BAFJ) -200MIFJNA-75MIFJOM-100MIFJEP-30MIFJEL-20MIFJOC-1500MIFJNANO-1500MIFJOMNO-
1500MIFJEPNO-1500MIFJELNO-1500MIFJOCNO +FJFE+ FJVE <= 0
BABT) -500BTNA-1000BTOM-10000BTNANO-10000BTOMNO+ BTFE+BTVE <=0
BACB) -80CBOM+CBVE<=0
BAMIFE) MIFE=20
BAFJFE) FJFE=5
BABTFE) BTFE=60
NUCAAD) NUCA=2
BAPOCA) -NUCA+CACENO+CACE=0
BAVECA) -CACE-2CACENO+CAVE=0
NUGAAD) NUGA=2
BAPOGA) -10NUGA+GACE<0
BAVEGA) -GACE+GAFE+GAVE<0
BAVEOV) -10NUGA+OVVE<0
BAGAFE) GAFE=7
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+JVMAFE+JVMAAC+JVMADM
-365NUADMA-182.5NUJVMA-TCMA<0

BAMAAG)28MIFJNA+28MIFJOM+28MIFJEP+28MIFJEL+28MIFJOC+26BTNA+26BTOM+32CBOM+28
MIFJNANO+28MIFJOMNO+28MIFJEPNO+28MIFJELNO+28MIFJOCNO+26BTNANO+26BTOMNO -
MAAG<0
BAMAPE) 22.8 NUCA-MAPE<0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM
-365NUADFM-182.5NUJVFM-TCFM <0
BAFMAG) 36MIFJNA+36MIFJOM+36MIFJEP+36MIFJEL+36MIFJOC +24BTNA+24BTOM+26CBOM+
36MIFJNANO+36MIFJOMNO+36MIFJEPNO+36MIFJELNO+36MIFJOCNO+24BTNANO+24BTOMNO -
FMAG<0
BAFMPE) 7.6NUGA-FMPE<0
TFADMAFE) ADMAFE>11
TFADMAAC) ADMAAC>29
TFJVMAFE) JVMAFE>11
TFJVMAAC) JVMAAC>29
TFJVMADM) JVMADM>22.8
TFADFMDM) ADFMDM>221.6
TFADFMFE) ADFMFE>11
TFADFMAC) ADFMAC>29
TFJVFMDM) JVFMDM>182.5
TFJVFMFE) JVFMFE>11
TFJVFMAC) JVFMAC>29
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=1
NUJVFM) NUJVFM=2
End

Alternative model new technologies - small farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE
St
BACUAG) +5000MIFJNA+ 5000MIFJOM+ 5000MIFJEP+ 5000MIFJEL+ 5000MIFJOC +28500BTNA+28500BTOM+ 4000CBOM+ 243000MIFJNANO+ 243000MIFJOMNO+ 243000MIFJEPNO+ 243000MIFJELNO+ 243000MIFJOCNO+1603000BTNANO+1603000BTOMNO-CUAG=0
BARTAG) 300MIVE + 1000FJVE + 350BTVE + 400CBVE-RTAG=0
BARTPE) +15000CAVE+1000GAVE+100OVVE-RTPE=0
BACUTC) 1000TCMA+1000TCFM-CUTC=0
BACUFX) CUFX>15225
BACUFE) CUFE>16000
TENA1) SUNA<0.5
TENA2) MIFJNA+MIFJNANO-SUNA<0
TENA3) BTNA+BTNANO-SUNA<0
TEOM1) SUOM<0.25
TEOM2) MIFJOM+MIFJOMNO-SUOM<0
TEOM3) BTOM+BTOMNO+CBOM-SUOM<0
TEEP1) SUEP < 1
TEEP2) MIFJEP+MIFJEPNO-SUEP<0
TEEL1) SUEL <0.25
TEEL2) MIFJEL+MIFJELNO-SUEL <0
TEOC1) SUOC <0.25
TEOC2) MIFJOC+MIFJOCNO -SUOC <0
BAMI) -350MIFJNA-150MIFJOM-500MIFJEP-400MIFJEL-400MIFJOC-2000MIFJNANO-2000MIFJOMNO-2000MIFJEPNO-2000MIFJELNO-2000MIFJOCNO +MIFE+MIVE<=0
BAFJ) -200MIFJNA-75MIFJOM-100MIFJEP-30MIFJEL-20MIFJOC-1500MIFJNANO-1500MIFJOMNO-1500MIFJEPNO-1500MIFJELNO-1500MIFJOCNO +FJFE+ FJVE <= 0
BABT) -500BTNA-1000BTOM-10000BTNANO-10000BTOMNO+ BTFE+BTVE <=0
BACB) -80CBOM+CBVE<=0
BAMIFE) MIFE=20
BAFJFE) FJFE=5
BABTFE) BTFE=60
NUCAAD) NUCA=2
BAPOCA) -NUCA+CACENO+CACE=0
BAVECA) -CACE-2CACENO+CAVE=0
NUGAAD) NUGA=2
BAPOGA) -10NUGA+GACE<0
BAVEGA)-GACE+GAFE+GAVE<0
BAVEOV)-10NUGA+OVVE<0
BAGAFE) GAFE=7
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+JVMAFE+JVMAAC+JVMADM -365NUADMA-182.5NUJVMA-TCMA<0
BAMAAG)28MIFJNA+28MIFJOM+28MIFJEP+28MIFJEL+28MIFJOC+26BTNA+26BTOM+32CBOM+28MIFJNANO+28MIFJOMNO+28MIFJEPNO+28MIFJELNO+28MIFJOCNO+26BTNANO+26BTOMNO-MAAG<0
BAMAPE) 22.8 NUCA-MAPE<0

BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM
-365NUADFM-182.5NUJVFM-TCFM <0
BAFMAG) 36MIFJNA+36MIFJOM+36MIFJEP+36MIFJEL+36MIFJOC +24BTNA+24BTOM+26CBOM+
36MIFJNANO+36MIFJOMNO+36MIFJEPNO+36MIFJELNO+36MIFJOCNO+24BTNANO+24BTOMNO-
FMAG<0
BAFMPE) 7.6NUGA-FMPE<0
TFADMAFE) ADMAFE>11
TFADMAAC) ADMAAC>29
TFJVMAFE) JVMAFE>11
TFJVMAAC) JVMAAC>29
TFJVMADM) JVMADM>22.8
TFADFMDM) ADFMDM>221.6
TFADFMFE) ADFMFE>11
TFADFMAC) ADFMAC>29
TFJVFMDM) JVFMDM>182.5
TFJVFMFE) JVFMFE>11
TFJVFMAC) JVFMAC>29
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=1
NUJVFM) NUJVFM=2
End

Alternative model new technologies - Medium Farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE-CUAC
St
BACUAG) +117780MIFJNA+117780MIFJOM+117780MIFJEP+117780MIFJEL+117780MIFJOC +1567860BTNA+1567860BTOM+80050CBOM+ 492790MIFJNANO+ 492790MIFJOMNO+ 492790MIFJEPNO+ 492790MIFJELNO+ 492790MIFJOCNO+ 4340250BTNANO+ 4340250BTOMNO-CUAG=0
BARTAG) 300MIVE+1000FJVE+350BTVE+250CBVE-RTAG=0
BACUPE) 115000NUVA-CUPE=0
BARTPE) +350000VAVE+15000CAVE+2500GAVE+100OVVE-RTPE=0
BACUTC) 1000TCMA+1000TCFM-CUTC=0
BACUFX) CUFX>15905
BACUFE) CUFE>769000
BACUAC) CUAC>70000
TENA1) SUNA<1
TENA2) MIFJNA+MIFJNANO-SUNA<0
TENA3) BTNA+BTNANO+CBNA-SUNA<0
TEOM1) SUOM<0.5
TEOM2) MIFJOM+MIFJOMNO-SUOM<0
TEOM3) BTOM+BTOMNO+CBOM-SUOM<0
TEEP1) SUEP < 2
TEEP2) MIFJEP+MIFJEPNO-SUEP<0
TEOC1) SUOC <0.5
TEOC2) MIFJOC+MIFJOCNO -SUOC <0
TEEL1) SUEL <0.25
TEEL2) MIFJEL+MIFJELNO-SUEL <0
BAMI) -800MIFJNA-300MIFJOM-1500MIFJEP-300MIFJEL-400MIFJOC-4000MIFJNANO-4000MIFJOMNO-4000MIFJEPNO-4000MIFJELNO-4000MIFJOCNO+MIVE <=0
BAFJ) -200MIFJNA-100MIFJOM-600MIFJEP-40MIFJEL-50MIFJOC-1800MIFJNANO-1800MIFJOMNO-1800MIFJEPNO-1800MIFJELNO-1800MIFJOCNO +FJAC+FJVE <=0
BABT) -4700BTNA-5500BTOM-20000BTNANO-20000BTOMNO +BTFE+BTAC+ BTVE<=0
BACB)-300CBNA-5000CBOM+CBVE<=0
BABTFE) BTFE=20
BABTAC) BTAC=10
BAFJAC) FJAC=5
NUVAAD) NUVA=2
BAPOVA) -NUVA+VACE<0
BAVEVA) -VACE+VAVE=0
NUCAAD) NUCA=4
BAPOCA) -NUCA+CACENO+CACE=0
BAVECA) -CACE-2CACENO+CAVE+CAFE=0
BACAFE) CAFE=1
NUGAAD) NUGA=4
BAPOGA) -16NUGA+GACE<0
BAVEGA) -GACE+GAVE+GAFE+GAAC<0
BAVEOV) -16NUGA+OVVE<0
BAGAFE) GAFE=9

```
BAGAAC) GAAC=1
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+JVMAFE+JVMAAC+JVMADM
-365NUADMA-182.5NUJVMA-TCMA<=0
BAMAAG) 62MIFJNA+62MIFJOM+62MIFJEP+62MIFJEL+62MIFJOC
+106BTNA+106BTOM+63CBOM+62MIFJNANO+62MIFJOMNO+62MIFJEPNO+62MIFJELNO+62MIFJOCNO
+106BTNANO+106BTOMNO-MAAG=0
BAMAPE)182.5NUVA+15NUCA-MAPE=0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM
-365NUADFM-182.5NUJVFM-TCFM<=0
BAFMAG) 37MIFJNA+37MIFJOM+37MIFJEP+37MIFJEL+37MIFJOC
+84BTNA+84BTOM+28CBOM+37MIFJNANO+37MIFJOMNO+37MIFJEPNO+37MIFJELNO+37MIFJOCNO+8
4BTNANO+84BTOMNO -FMAG=0
BAFMPE) 7.6NUGA-FMPE=0
TFADMAFE) ADMAFE>15
TFADMAAC) ADMAAC>67
TFJVMAFE) JVMAFE>15
TFJVMAAC) JVMAAC>67
TFJVMADM) JVMADM>68.4
TFADFMDM) ADFMDM>143.4
TFADFMFE) ADFMFE>15
TFADFMAC) ADFMAC>67
TFJVFMDM) JVFMDM>136.9
TFJVFMFE) JVFMFE>15
TFJVFMAC) JVFMAC>67
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=3
NUJVFM) NUJVFM=1
End
```

Alternative model new technologies Large Farmers

Max RTAG+RTPE-CUAG-CUPE-CUTC-CUFX-CUFE-CUAC
St
BACUAG) + 513900MIFJNA+ 513900MIFJOM+ 513900MIFJEP+ 513900MIFJEL+ 513900MIFJOC +1468400BTNA+1468400BTOM+ 631500CBOM +781205MIFJNANO+ 781205MIFJOMNO+ 781205MIEPNO+98655FJEPNO+781205MIFJELNO+ 781205MIFJOCNO +5411100BTNANO+5411100BTOMNO -CUAG=0
BARTAG) 370MIVE + 1000FJVE + 400BTVE + 250CBVE-RTAG=0
BACUPE) 18000NUVA-CUPE=0
BARTPE) +250000VAVE+20000CAVE+3000GAVE-RTPE=0
BACUTC) 1000TCMA+1000TCFM-CUTC=0
BACUFX) CUFX>77902
BACUFE) CUFE>2061500
BACUAC) CUAC>40000
TENA1) SUNA<5
TENA2) MIFJNA+MFJNANO-SUNA<0
TENA3) BTNA+BTNANO-SUNA<0
TENA4) MIFJNA-BTNA+ MIFJNANO-BTNANO =0
TEOM1) SUOM<3
TEOM2) MIFJOM-SUOM+ MIFJOMNO-SUOMNO <0
TEOM3) BTOM+BTOMNO+CBOM-SUOM<0
TEOM4) MIFJOM+MIFJOMNO-BTOM-BTOMNO-CBOM=0
TEEP1) SUEP < 20
TEEP2) MIFJEP+MIFJEPNO-SUEP<0
TEEL1) SUEL <2
TEEL2) MIFJEL+ MIFJELNO -SUEL <0
TEOC1) SUOC <2
TEOC2) MIFJOC+ MIFJOCNO -SUOC <0
BAMI -1400MIFJNA-700MIFJOM-800MIFJEP-500MIFJEL-400MIFJOC+MIVE-8000MIFJNANO-8000MIFJOMNO-8000MIEPNO-8000MIFJELNO-8000MIFJOCNO+MIVE <=0
BAFJ) -700MIFJNA-400MIFJOM-1500MIFJEP-1200MIFJEL-1300MIFJOC- 2000MIFJNANO-2000MIFJOMNO-2500FJEPNO-2000MIFJELNO-2000MIFJOCNO + FJAC+FJVE <= 0
BABT) -3000BTNA-8000BTOM-30000BTNANO-30000BTOMNO +BTAC+BTFE+BTVE <=0
BACB) -5000CBOM+CBVE<=0
BABTFE) BTFE=25
BABTAC) BTAC=15
BAFJAC) FJAC=5
NUVAAD) NUVA=16
BAPOVA) -0.375NUVA+VACE<0
BAVEVA) -VACE+VAVE=0
NUCAAD) NUCA=6
BAPOCA) -NUCA+CACENO +CACE=0
BAVECA) -2CACENO -CACE+CAFE+CAVE=0
BACAFE) CAFE=2
NUGAAD) NUGA=5
BAPOGA) -14NUGA+GACE<0
BAVEGA) -GACE+GAVE+GAFE+GAAC<0

```
BAGAFE) GAFE=13
BAGAAC) GAAC=1
BATFMA) MAAG+MAPE+ADMAFE+ADMAAC+ JVMAFE+ JVMAAC+JVMADM -365NUADMA-
182.5NUJVMA-TCMA<0
BAMAAG) 87MIFJNA+87MIFJOM+87MIFJEP+87MIFJEL+87MIFJOC
+123BTNA+123BTOM+92CBOM+87MIFJNANO+87MIFJOMNO+87MIEPNO+87FJEPNO+87MIFJELNO+87
MIFJOCNO+123BTNANO+123BTOMNO -MAAG<0
BAMAPE) 30NUVA+20NUCA-MAPE<0
BATFFM) FMAG+FMPE+ADFMDM+ADFMFE+ADFMAC+JVFMFE+JVFMAC+JVFMDM-365NUADFM-
182.5NUJVFM-TCFM<0
BAFMAG) 38MIFJNA+38MIFJOM+38MIFJEP+38MIFJEL+38MIFJOC
+52BTNA+52BTOM+38CBOM+38MIFJNANO+38MIFJOMNO+38MIEPNO+38FJEPNO+38MIFJELNO+38MIF
JOCNO+52BTNANO+52BTOMNO -FMAG<0
BAFMPE) 4.5NUGA-FMPE<0
TFADMAFE) ADMAFE>19
TFADMAAC) ADMAAC>54
TFJVMAFE) JVMAFE>19
TFJVMAAC) JVMAAC>54
TFJVMAAC) JVMADM>45.6
TFADFMDM) ADFMDM>221.6
TFADFMFE) ADFMFE>19
TFADFMAC) ADFMAC>54
TFJVFMDM) JVFMDM>205.3
TFJVFMFE) JVFMFE>19
TFJVFMAC) JVFMAC>54
NUADMA) NUADMA=1
NUADFM) NUADFM=1
NUJVMA) NUJVMA=2
NUJVFM) NUJVFM=4
BAGASO) 162MIEPNO+130BTEPNO+153FJEPNO -GASOBA=0
BAAZOT) 48 MIEPNO+48 BTEPNO+36FJEPNO –AZOTBA=0
BAFOSF) 96 MIEPNO+ 96 BTEPNO+72FJEPNO – FOSFBA=0
BAPOTA) 48 MIEPNO+198 BTEPNO+36FJEPNO -POTABA=0
BAQUSE) 1 MIEPNO+1 FJEPNO -QUSEBA=0
BAQUHE) 2 MIEPNO-QUHEBA=0
BAQUIN) 3 MIEPNO+5 BTEPNO+3FJEPNO - QUINBA=0
BASACO) 80 MIEPNO+50 BTEPNO+ 30FJEPNO -SACOBA=0
End
```

Codes for defining variables and constraints

AC	Community activities
AD	Adult
DM	Domestic activities
AG	Agricultural
BA	Balance
BT	Potato
BV	Cattle
CA	Goat
EC	Growth
CB	Onions
CF	Family consumption
cha	plough
CR	Child
crack	cart
cta	Catana
DA	Availability year
Dal	Need in days of watering per year
Dan	Need for birthdays in the year
DB	Need for baptism days in the year
DC	Need for wedding days in the year
Dc	Need for harvest days in the year
DE	Need for evamba days in the year
DM	Domestic
DF	Need for funeral days per year
EL	Elunda
EP	Epia
exa	hoe
FE	Festivities
FI	Son
FJ	Beans
FM	Female
GA	Chicken
JV	Young
M	Labor
MA	Male

MB	Need for manpower days for cattle
MC	Need for manpower days for goats
mdo	axe
ME	Mother
MG	Need for days of labor to feed the chickens
MI	Corn
MO	Need for labor days for sheep
MOG	Need for days of labor to collect eggs from the hens
NA	Naca
NMI	Need for manpower on church activity days (NMI)
NMM	Need for manpower on municipal holidays
NMP	Need for labor on the country's holidays
NMp	Need for manpower on provincial holidays
NMS	Need for manpower on soba enthronement days
NU	Number
OC	Otchumbo
OM	Ombanda
OV	Sheep
PI	Dad
PE	Livestock
PRC	Pork
SU	Succession
TC	Contract work
TE	Terra
TF	Family work
VE	Selling

ANNEX V – ELP OPTIMAL SOLUTIONS OF BASELINE MODELS

Very small farmers

LP OPTIMUM FOUND AT STEP 46

OBJECTIVE FUNCTION VALUE

1) 269513.1

VARIABLE	VALUE	REDUCED COST
RTAG	270240.000000	0.000000
RTPE	45000.000000	0.000000
CUAG	14501.900391	0.000000
CUPE	0.000000	1.000000
CUTC	0.000000	0.000000
CUFX	15225.000000	0.000000
CUFE	16000.000000	0.000000
MIFJNA	0.222300	0.000000
MIFJOM	0.111100	0.000000
MIFJEP	0.444400	0.000000
MIFJEL	0.111100	0.000000
MIFJOC	0.111100	0.000000
BTNA	0.222300	0.000000
BTOM	0.111100	0.000000
CBOM	0.000000	0.000000
MIVE	385.550018	0.000000
FJVE	97.787498	0.000000
BTVE	162.250000	0.000000
CBVE	0.000000	3668.750000
CAVE	2.000000	0.000000
GAVE	13.000000	0.000000
OVVE	20.000000	0.000000
TCMA	0.000000	1000.000000
TCMF	0.000000	1000.000000
SUNA	0.222300	0.000000
SUOM	0.111100	0.000000
SUEP	0.444400	0.000000
SUEL	0.111100	0.000000
SUOC	0.111100	0.000000
MIFE	20.000000	0.000000
FJFE	5.000000	0.000000
BTFE	60.000000	0.000000
NUCA	2.000000	0.000000
CACE	2.000000	0.000000
NUGA	2.000000	0.000000
GACE	20.000000	0.000000
GAFE	7.000000	0.000000
MAAG	36.668400	0.000000
MAPE	45.599998	0.000000
ADMAFE	11.000000	0.000000
ADMAAC	29.000000	0.000000
JVMAFE	11.000000	0.000000
JVMAAC	29.000000	0.000000
JVMADM	22.799999	0.000000
NUADMA	1.000000	0.000000
NUJVMA	1.000000	0.000000
FMAG	44.001602	0.000000
FMPE	15.200000	0.000000
ADFMDM	221.600006	0.000000
ADFMFE	11.000000	0.000000
ADFMAC	29.000000	0.000000
JVFMFE	11.000000	0.000000
JVFMAC	29.000000	0.000000
JVFMDM	182.500000	0.000000
NUADFM	1.000000	0.000000
NUJVFM	2.000000	0.000000
TCFM	0.000000	0.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BACUAG)	0.000000	1.000000
BARTAG)	0.000000	-1.000000
BARTPE)	0.000000	-1.000000
BACUTC)	0.000000	1.000000

BACUFX)	0.000000	-1.000000
BACUFE)	0.000000	-1.000000
TENA1)	0.000000	446500.000000
TENA2)	0.000000	300000.000000
TENA3)	0.000000	146500.000000
TEOM1)	0.000000	436500.000000
TEOM2)	0.000000	115000.000000
TEOM3)	0.000000	321500.000000
TEEP1)	0.000000	245000.000000
TEEP2)	0.000000	245000.000000
TEEL1)	0.000000	145000.000000
TEEL2)	0.000000	145000.000000
TEOC1)	0.000000	135000.000000
TEOC2)	0.000000	135000.000000
BAMI)	0.000000	300.000000
BAFJ)	0.000000	1000.000000
BABT)	0.000000	350.000000
BACB)	0.000000	4068.750000
BAMIFE)	0.000000	-300.000000
BAFJFE)	0.000000	-1000.000000
BABTFE)	0.000000	-350.000000
NUCAAD)	0.000000	15000.000000
BAPOCA)	0.000000	15000.000000
BAVECA)	0.000000	15000.000000
NUGAAD)	0.000000	11000.000000
BAPOGA)	0.000000	1000.000000
BAVEGA)	0.000000	1000.000000
BAVEOV)	0.000000	100.000000
BAGAFE)	0.000000	-1000.000000
BATFMA)	362.431610	0.000000
BAMAAG)	0.000000	0.000000
BAMAPE)	0.000000	0.000000
BATFFM)	186.698395	0.000000
BAFMAG)	0.000000	0.000000
BAFMPE)	0.000000	0.000000
TFADMAFE)	0.000000	0.000000
TFADMAAC)	0.000000	0.000000
TFJVMAFE)	0.000000	0.000000
TFJVMAAC)	0.000000	0.000000
TFJVMADM)	0.000000	0.000000
FADFMDM)	0.000000	0.000000
TFADFMFE)	0.000000	0.000000
TFADFMAC)	0.000000	0.000000
TFJVFMDM)	0.000000	0.000000
TFJVFMFE)	0.000000	0.000000
TFJVFMAC)	0.000000	0.000000
NUADMA)	0.000000	0.000000
NUADFM)	0.000000	0.000000
NUJVMA)	0.000000	0.000000
NUJVFM)	0.000000	0.000000

NO. ITERATIONS= 46

Small farmers

LP OPTIMUM FOUND AT STEP 37

OBJECTIVE FUNCTION VALUE

1) 629150.0

VARIABLE	VALUE	REDUCED COST
RTAG	648000.000000	0.000000
RTPE	45000.000000	0.000000
CUAG	32625.000000	0.000000
CUPE	0.000000	1.000000
CUTC	0.000000	0.000000
CUFX	15225.000000	0.000000
CUFE	16000.000000	0.000000
MIFJNA	0.500000	0.000000
MIFJOM	0.250000	0.000000
MIFJEP	1.000000	0.000000
MIFJEL	0.250000	0.000000
MIFJOC	0.250000	0.000000
BTNA	0.500000	0.000000
BTOM	0.250000	0.000000
CBOM	0.000000	281500.000000
FJVE	226.250000	0.000000
BTVE	440.000000	0.000000
CBVE	0.000000	0.000000
CAVE	2.000000	0.000000
GAVE	13.000000	0.000000
OVVE	20.000000	0.000000
TCMA	0.000000	1000.000000
TCMF	0.000000	1000.000000
SUNA	0.500000	0.000000
SUOM	0.250000	0.000000
SUEP	1.000000	0.000000
SUEL	0.250000	0.000000
SUOC	0.250000	0.000000
MIFE	20.000000	0.000000
FJFE	5.000000	0.000000
BTFE	60.000000	0.000000
NUCA	2.000000	0.000000
CACE	2.000000	0.000000
NUGA	2.000000	0.000000
GACE	20.000000	0.000000
GAFE	7.000000	0.000000
MAAG	82.500000	0.000000
MAPE	45.599998	0.000000
ADMAFE	11.000000	0.000000
ADMAAC	29.000000	0.000000
JVMAFE	11.000000	0.000000
JVMAAC	29.000000	0.000000
JVMADM	22.799999	0.000000
NUADMA	1.000000	0.000000
NUJVMA	1.000000	0.000000
FMAG	99.000000	0.000000
FMPE	15.200000	0.000000
ADFMDM	221.600006	0.000000
ADFMFE	11.000000	0.000000
ADFMAC	29.000000	0.000000
JVFMFE	11.000000	0.000000
JVFMAC	29.000000	0.000000
JVFMDM	182.500000	0.000000
NUADFM	1.000000	0.000000
NUJVFM	2.000000	0.000000
TCFM	0.000000	0.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BACUAG)	0.000000	1.000000
BARTAG)	0.000000	-1.000000
BARTPE)	0.000000	-1.000000
BACUTC)	0.000000	1.000000
BACUFX)	0.000000	-1.000000
BACUFE)	0.000000	-1.000000
TENA1)	0.000000	446500.000000
TENA2)	0.000000	300000.000000
TENA3)	0.000000	146500.000000
TEOM1)	0.000000	436500.000000
TEOM2)	0.000000	115000.000000
TEOM3)	0.000000	321500.000000
TEEP1)	0.000000	245000.000000
TEEP2)	0.000000	245000.000000
TEEL1)	0.000000	145000.000000
TEEL2)	0.000000	145000.000000
TEOC1)	0.000000	135000.000000
TEOC2)	0.000000	135000.000000
BAMI)	0.000000	300.000000
BAFJ)	0.000000	1000.000000

BABT)	0.000000	350.000000
BACB)	0.000000	400.000000
BAMIFE)	0.000000	-300.000000
BAFJFE)	0.000000	-1000.000000
BABTFE)	0.000000	-350.000000
NUCAAD)	0.000000	15000.000000
BAPOCA)	0.000000	15000.000000
BAVECA)	0.000000	15000.000000
NUGAAD)	0.000000	11000.000000
BAPOGA)	0.000000	1000.000000
BAVEGA)	0.000000	1000.000000
BAVEOV)	0.000000	100.000000
BAGAFE)	0.000000	-1000.000000
BATFMA)	316.600006	0.000000
BAMAAG)	0.000000	0.000000
BAMAPE)	0.000000	0.000000
BATFFM)	131.699997	0.000000
BAFMAG)	0.000000	0.000000
BAFMPE)	0.000000	0.000000
TFADMAFE)	0.000000	0.000000
TFADMAAC)	0.000000	0.000000
TFJVMAFE)	0.000000	0.000000
TFJVMAAC)	0.000000	0.000000
TFJVMADM)	0.000000	0.000000
TFADFMDM)	0.000000	0.000000
TFADFMFE)	0.000000	0.000000
TFADFMAC)	0.000000	0.000000
TFJVFMDM)	0.000000	0.000000
TFJVFMFE)	0.000000	0.000000
TFJVFMAC)	0.000000	0.000000
NUADMA)	0.000000	0.000000
NUADFM)	0.000000	0.000000
NUJVMA)	0.000000	0.000000
NUJVFM)	0.000000	0.000000

NO. ITERATIONS= 37

Medium Farmers

LP OPTIMUM FOUND AT STEP 36

OBJECTIVE FUNCTION VALUE

1) 2155171.

VARIABLE	VALUE	REDUCED COST
RTAG	3611338.750000	0.000000
RTPE	886400.000000	0.000000
CUAG	1167854.750000	0.000000
CUPE	230000.000000	0.000000
CUTC	89808.062500	0.000000
CUFX	15905.000000	0.000000
CUFE	769000.000000	0.000000
CUAC	70000.000000	0.000000
MIFJNA	1.000000	0.000000
MIFJOM	0.259677	0.000000
MIFJEP	2.000000	0.000000
MIFJEL	0.000000	60000.000000
MIFJOC	0.000000	20000.000000
BTNA	0.000000	142074.843750
BTOM	0.500000	0.000000
CBOM	0.000000	156763.218750
MIVE	3877.903320	0.000000
FJVE	1420.967773	0.000000
BTVE	2720.000000	0.000000
CBVE	300.000000	0.000000
NUVA	2.000000	0.000000
VAVE	2.000000	0.000000
CAVE	3.000000	0.000000
GAVE	54.000000	0.000000
OVVE	64.000000	0.000000
TCMA	0.000000	431.935486
TCFM	89.808067	0.000000
SUNA	1.000000	0.000000
CBNA	1.000000	0.000000
SUOM	0.500000	0.000000
SUEP	2.000000	0.000000
SUOC	0.000000	0.000000
SUEL	0.000000	0.000000
FJAC	5.000000	0.000000
BTFE	20.000000	0.000000
BTAC	10.000000	0.000000
VACE	2.000000	0.000000
NUCA	4.000000	0.000000
CACE	4.000000	0.000000
CAFE	1.000000	0.000000
NUGA	4.000000	0.000000
GACE	64.000000	0.000000
GAFE	9.000000	0.000000
GAAC	1.000000	0.000000
MAAG	255.100006	0.000000
MAPE	425.000000	0.000000
ADMAFE	15.000000	0.000000
ADMAAC	67.000000	0.000000
JVMAFE	15.000000	0.000000
JVMAAC	67.000000	0.000000
JVMADM	68.400002	0.000000
NUADMA	1.000000	0.000000
NUJVMA	3.000000	0.000000
FMAG	162.608063	0.000000
FMPE	30.400000	0.000000
ADFMDM	143.399994	0.000000
ADFMFE	15.000000	0.000000
ADFMAC	67.000000	0.000000
JVFMFE	15.000000	0.000000
JVFMAC	67.000000	0.000000
JVFMDM	136.899994	0.000000
NUADFM	1.000000	0.000000
NUJVFM	1.000000	0.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BACUAG)	0.000000	1.000000
BARTAG)	0.000000	-1.000000
BACUPE)	0.000000	1.000000
BARTPE)	0.000000	-1.000000
BACUTC)	0.000000	1.000000
BACUFX)	0.000000	-1.000000
BACUFE)	0.000000	-1.000000
BACUAC)	0.000000	-1.000000
TENA1)	0.000000	325000.000000
TENA2)	0.000000	250000.000000
TENA3)	0.000000	75000.000000
TEOM1)	0.000000	212925.156250
TEOM2)	0.240323	0.000000
TEOM3)	0.000000	212925.156250

TEEP1)	0.000000	860000.000000
TEEP2)	0.000000	860000.000000
TEOC1)	0.500000	0.000000
TEOC2)	0.000000	0.000000
TEEL1)	0.250000	0.000000
TEEL2)	0.000000	0.000000
BAMI)	0.000000	300.000000
BAFJ)	0.000000	1000.000000
BABT)	0.000000	350.000000
BACB)	0.000000	250.000000
BABTFE)	0.000000	-350.000000
BABTAC)	0.000000	-350.000000
BAFJAC)	0.000000	-1000.000000
NUVAAD)	0.000000	131328.218750
BAPOVA)	0.000000	350000.000000
BAVEVA)	0.000000	350000.000000
NUCAAD)	0.000000	6479.032227
BAPOCA)	0.000000	15000.000000
BAVECA)	0.000000	15000.000000
BACAFE)	0.000000	-15000.000000
NUGAAD)	0.000000	34000.000000
BAPOGA)	0.000000	2500.000000
BAVEGA)	0.000000	2500.000000
BAVEOV)	0.000000	100.000000
BAGAFE)	0.000000	-2500.000000
BAGAAC)	0.000000	-2500.000000
BATFMA)	0.000000	568.064514
BAMAAG)	0.000000	568.064514
BAMAPE)	0.000000	568.064514
BATFFM)	0.000000	1000.000000
BAFMAG)	0.000000	1000.000000
BAFMPE)	0.000000	1000.000000
TFADMAFE)	0.000000	-568.064514
TFADMAAC)	0.000000	-568.064514
TFJVMAFE)	0.000000	-568.064514
TFJVMAAC)	0.000000	-568.064514
TFJVMADM)	0.000000	-568.064514
TFADFMDM)	0.000000	-1000.000000
TFADFMFE)	0.000000	-1000.000000
TFADFMAC)	0.000000	-1000.000000
TFJVFMDM)	0.000000	-1000.000000
TFJVFMFE)	0.000000	-1000.000000
TFJVFMAC)	0.000000	-1000.000000
NUADMA)	0.000000	207343.546875
NUADFM)	0.000000	365000.000000
NUJVMA)	0.000000	103671.773438
NUJVFM)	0.000000	182500.000000

NO. ITERATIONS= 36

Large Farmers

LP OPTIMUM FOUND AT STEP 44

OBJECTIVE FUNCTION VALUE

31358600,00

VARIABLE	VALUE	REDUCED COST
RTAG	65232000,000000	0,000000
RTPE	1748000,000000	0,000000
CUAG	28192000,000000	0,000000
CUPE	288000,000000	0,000000
CUTC	4962000,000000	0,000000
CUFX	77902,000000	0,000000
CUFE	2061500,000000	0,000000
CUAC	40000,000000	0,000000
MIFJNA	5,000000	0,000000
MIFJOM	3,000000	0,000000
MIFJEP	20,000000	0,000000
MIFJEL	2,000000	0,000000
MIFJOC	2,000000	0,000000
BTNA	5,000000	0,000000
BTOM	3,000000	0,000000
CBOM	0,000000	0,000000
MIVE	26900,000000	0,000000
FJVE	39695,000000	0,000000
BTVE	38960,000000	0,000000
CBVE	0,000000	213,619995
NUVA	16,000000	0,000000
VAVE	6,000000	0,000000
CAVE	4,000000	0,000000
GAVE	56,000000	0,000000
TCMA	3829,600098	0,000000
TCFM	1132,400024	0,000000
SUNA	5,000000	0,000000
SUOM	3,000000	0,000000
SUEP	20,000000	0,000000
SUEL	2,000000	0,000000
SUOC	2,000000	0,000000
FJAC	5,000000	0,000000
BTAC	15,000000	0,000000
BTFE	25,000000	0,000000
VACE	6,000000	0,000000
NUCA	6,000000	0,000000
CACE	6,000000	0,000000
CAFE	2,000000	0,000000
NUGA	5,000000	0,000000
GACE	70,000000	0,000000
GAFE	13,000000	0,000000
GAAC	1,000000	0,000000
MAAG	3768,000000	0,000000
MAPE	600,000000	0,000000
ADMAFE	19,000000	0,000000
ADMAAC	54,000000	0,000000
JVMAFE	19,000000	0,000000
JVMAAC	54,000000	0,000000
JVMADM	45,599998	0,000000
NUADMA	1,000000	0,000000
NUJVMA	2,000000	0,000000
FMAG	1632,000000	0,000000
FMPE	22,500000	0,000000
ADFMDM	221,600006	0,000000
ADFMFE	19,000000	0,000000
ADFMAC	54,000000	0,000000
JVFMFE	19,000000	0,000000
JVFMAC	54,000000	0,000000
JVFMDM	205,300003	0,000000
NUADFM	1,000000	0,000000
NUJVFM	4,000000	0,000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BACUAG)	0,000000	1,000000
BARTAG)	0,000000	-1,000000
BACUPE)	0,000000	1,000000
BARTPE)	0,000000	-1,000000
BACUTC)	0,000000	1,000000
BACUFX)	0,000000	-1,000000
BACUFE)	0,000000	-1,000000
BACUAC)	0,000000	-1,000000
TENA1)	0,000000	135700,000000
TENA2)	0,000000	0,000000
TENA3)	0,000000	135700,000000
TENA4)	0,000000	579100,000000
TEOM1)	0,000000	1576700,000000
TEOM2)	0,000000	0,000000
TEOM3)	0,000000	1576700,000000

TEOM4)	0,000000	20100,000000
TEEP1)	0,000000	1157100,000000
TEEP2)	0,000000	1157100,000000
TEEL1)	0,000000	746100,000000
TEEL2)	0,000000	746100,000000
TEOC1)	0,000000	809100,000000
TEOC2)	0,000000	809100,000000
BAMI)	0,000000	370,000000
BAFJ)	0,000000	1000,000000
BABT)	0,000000	400,000000
BACB)	0,000000	463,619995
BABTFE)	0,000000	-400,000000
BABTAC)	0,000000	-400,000000
BAFJAC)	0,000000	-1000,000000
NUVAAD)	0,000000	45750,000000
BAPOVA)	0,000000	250000,000000
BAVEVA)	0,000000	250000,000000
NUCAAD)	0,000000	0,000000
BAPOCA)	0,000000	20000,000000
BAVECA)	0,000000	20000,000000
BACAFE)	0,000000	-20000,000000
NUGAAD)	0,000000	37500,000000
BAPOGA)	0,000000	3000,000000
BAVEGA)	0,000000	3000,000000
BAGAFE)	0,000000	-3000,000000
BAGAAC)	0,000000	-3000,000000

BATFMA)	0,000000	1000,000000
BAMAAG)	0,000000	1000,000000
BAMAPE)	0,000000	1000,000000
BATFFM)	0,000000	1000,000000
BAFMAG)	0,000000	1000,000000
BAFMPE)	0,000000	1000,000000
TFADMAFE)	0,000000	-1000,000000
TFADMAAC)	0,000000	-1000,000000
TFJVMAFE)	0,000000	-1000,000000
TFJVMAAC)	0,000000	-1000,000000
TFJVMAAC)	0,000000	-1000,000000
TFADFMDM)	0,000000	-1000,000000
TFADFMFE)	0,000000	-1000,000000
TFADFMAC)	0,000000	-1000,000000
TFJVFMDM)	0,000000	-1000,000000
TFJVFMFE)	0,000000	-1000,000000
TFJVFMAC)	0,000000	-1000,000000
NUADMA)	0,000000	365000,000000
NUADFM)	0,000000	365000,000000
NUJVMA)	0,000000	182500,000000
NUJVFM)	0,000000	182500,000000

NO. ITERATIONS= 44

ANNEX VI – ELP OPTIMAL SOLUTIONS MODELS OF ALTERNATIVE SCENARIOS

New technologies - very small farmers

LP OPTIMUM FOUND AT STEP 48

OBJECTIVE FUNCTION VALUE

1) 2501235.

VARIABLE	VALUE	REDUCED COST
RTAG	3234900.000000	0.000000
RTPE	75000.000000	0.000000
CUAG	777440.187500	0.000000
CUPE	0.000000	1.000000
CUTC	0.000000	0.000000
CUFX	15225.000000	0.000000
CUFE	16000.000000	0.000000
MIFJNA	0.000000	1557000.000000
MIFJOM	0.000000	1742000.000000
MIFJEP	0.000000	1612000.000000
MIFJEL	0.000000	1712000.000000
MIFJOC	0.000000	1722000.000000
BTNA	0.000000	1750500.000000
BTOM	0.000000	1575500.000000
CBOM	0.000000	1869000.000000
MIFJNANO	0.222300	0.000000
MIFJOMNO	0.111100	0.000000
MIFJEPNO	0.444400	0.000000
MIFJELNO	0.111100	0.000000
MIFJOCNO	0.111100	0.000000
BTNANO	0.222300	0.000000
BTOMNO	0.111100	0.000000
MIVE	1980.000000	0.000000
FJVE	1495.000000	0.000000
BTVE	3274.000000	0.000000
CBVE	0.000000	0.000000
CAVE	4.000000	0.000000
GAVE	13.000000	0.000000
OVVE	20.000000	0.000000
TCMA	0.000000	1000.000000
TCFM	0.000000	1000.000000
SUNA	0.222300	0.000000
SUOM	0.111100	0.000000
SUEP	0.444400	0.000000
SUEL	0.111100	0.000000
SUOC	0.111100	0.000000
MIFE	20.000000	0.000000
FJFE	5.000000	0.000000
BTFE	60.000000	0.000000
NUCA	2.000000	0.000000
CACENO	2.000000	0.000000
CACE	0.000000	15000.000000
NUGA	2.000000	0.000000
GACE	20.000000	0.000000
GAFE	7.000000	0.000000
MAAG	36.668400	0.000000
MAPE	45.599998	0.000000
ADMAFE	11.000000	0.000000
ADMAAC	29.000000	0.000000
JVMAFE	11.000000	0.000000
JVMAAC	29.000000	0.000000
JVMADM	22.799999	0.000000
NUADMA	1.000000	0.000000
NUJVMA	1.000000	0.000000
FMAG	44.001602	0.000000
FMPE	15.200000	0.000000
ADFMDM	221.600006	0.000000
ADFMFE	11.000000	0.000000
ADFMAC	29.000000	0.000000
JVFMFE	11.000000	0.000000
JVFMAC	29.000000	0.000000
JVFMDM	182.500000	0.000000
NUADFM	1.000000	0.000000
NUJVFM	2.000000	0.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BACUAG)	0.000000	1.000000
BARTAG)	0.000000	-1.000000
BARTPE)	0.000000	-1.000000
BACUTC)	0.000000	1.000000
BACUFX)	0.000000	-1.000000
BACUFE)	0.000000	-1.000000
TENA1)	0.000000	3754000.000000
TENA2)	0.000000	1857000.000000
TENA3)	0.000000	1897000.000000
TEOM1)	0.000000	3754000.000000
TEOM2)	0.000000	1857000.000000
TEOM3)	0.000000	1897000.000000
TEEP1)	0.000000	1857000.000000
TEEP2)	0.000000	1857000.000000
TEEL1)	0.000000	1857000.000000
TEEL2)	0.000000	1857000.000000
TEOC1)	0.000000	1857000.000000
TEOC2)	0.000000	1857000.000000
BAMI)	0.000000	300.000000
BAFJ)	0.000000	1000.000000
BABT)	0.000000	350.000000
BACB)	0.000000	400.000000
BAMIFE)	0.000000	-300.000000
BAFJFE)	0.000000	-1000.000000
BABTFE)	0.000000	-350.000000
NUCAAD)	0.000000	30000.000000
BAPOCA)	0.000000	30000.000000
BAVECA)	0.000000	15000.000000
NUGAAD)	0.000000	11000.000000
BAPOGA)	0.000000	1000.000000
BAVEGA)	0.000000	1000.000000
BAVEOV)	0.000000	100.000000
BAGAFE)	0.000000	-1000.000000
BATFMA)	362.431610	0.000000
BAMAAG)	0.000000	0.000000
BAMAPE)	0.000000	0.000000
BATFFM)	186.698395	0.000000
BAFMAG)	0.000000	0.000000
BAFMPE)	0.000000	0.000000
TFADMAFE)	0.000000	0.000000
TFADMAAC)	0.000000	0.000000
TFJVMAFE)	0.000000	0.000000
TFJVMAAC)	0.000000	0.000000
TFJVMADM)	0.000000	0.000000
TFADFMDM)	0.000000	0.000000
TFADFMFE)	0.000000	0.000000
TFADFMAC)	0.000000	0.000000
TFJVFMDM)	0.000000	0.000000
TFJVFMFE)	0.000000	0.000000
TFJVFMAC)	0.000000	0.000000
NUADMA)	0.000000	0.000000
NUADFM)	0.000000	0.000000
NUJVMA)	0.000000	0.000000
NUJVFM)	0.000000	0.000000

NO. ITERATIONS= 48

New technologies - small farmers

LP OPTIMUM FOUND AT STEP 0

OBJECTIVE FUNCTION VALUE

1) 5612775.

VARIABLE	VALUE	REDUCED COST
RTAG	7318000.000000	0.000000
RTPE	75000.000000	0.000000
CUAG	1749000.000000	0.000000
CUPE	0.000000	1.000000
CUTC	0.000000	0.000000
CUFX	15225.000000	0.000000
CUFE	16000.000000	0.000000
MIFJNA	0.000000	1557000.000000
MIFJOM	0.000000	1742000.000000
MIFJEP	0.000000	1612000.000000
MIFJEL	0.000000	1712000.000000
MIFJOC	0.000000	1722000.000000
BTNA	0.000000	1750500.000000
BTOM	0.000000	1575500.000000
CBOM	0.000000	1869000.000000
MIFJNANO	0.500000	0.000000
MIFJOMNO	0.250000	0.000000
MIFJEPNO	1.000000	0.000000
MIFJELNO	0.250000	0.000000
MIFJOCNO	0.250000	0.000000
BTNANO	0.500000	0.000000
BTOMNO	0.250000	0.000000
MIVE	4480.000000	0.000000
FJVE	3370.000000	0.000000
BTVE	7440.000000	0.000000
CBVE	0.000000	0.000000
CAVE	4.000000	0.000000
GAVE	13.000000	0.000000
OVVE	20.000000	0.000000
TCMA	0.000000	1000.000000
TCFM	0.000000	1000.000000
SUNA	0.500000	0.000000
SUOM	0.250000	0.000000
SUEP	1.000000	0.000000
SUEL	0.250000	0.000000
SUOC	0.250000	0.000000
MIFE	20.000000	0.000000
FJFE	5.000000	0.000000
BTFE	60.000000	0.000000
NUCA	2.000000	0.000000
CACENO	2.000000	0.000000
CACE	0.000000	15000.000000
NUGA	2.000000	0.000000
GACE	20.000000	0.000000
GAFE	7.000000	0.000000
MAAG	82.500000	0.000000
MAPE	45.599998	0.000000
ADMAFE	11.000000	0.000000
ADMAAC	29.000000	0.000000
JVMAFE	11.000000	0.000000
JVMAAC	29.000000	0.000000
JVMADM	22.799999	0.000000
NUADMA	1.000000	0.000000
NUJVMA	1.000000	0.000000
FMAG	99.000000	0.000000
FMPE	15.200000	0.000000
ADFMDM	221.600006	0.000000
ADFMFE	11.000000	0.000000
ADFMAC	29.000000	0.000000
JVFMFE	11.000000	0.000000
JVFMAC	29.000000	0.000000
JVFMDM	182.500000	0.000000
NUADFM	1.000000	0.000000
NUJVFM	2.000000	0.000000

ROW	SLACK OR SURPLUS	DUAL PRICES
BACUAG)	0.000000	1.000000
BARTAG)	0.000000	-1.000000
BARTPE)	0.000000	-1.000000
BACUTC)	0.000000	1.000000
BACUFX)	0.000000	-1.000000

BACUFE)	0.000000	-1.000000
TENA1)	0.000000	3754000.000000
TENA2)	0.000000	1857000.000000
TENA3)	0.000000	1897000.000000
TEOM1)	0.000000	3754000.000000
TEOM2)	0.000000	1857000.000000
TEOM3)	0.000000	1897000.000000
TEEP1)	0.000000	1857000.000000
TEEP2)	0.000000	1857000.000000
TEEL1)	0.000000	1857000.000000
TEEL2)	0.000000	1857000.000000
TEOC1)	0.000000	1857000.000000
TEOC2)	0.000000	1857000.000000
BAMI)	0.000000	300.000000
BAFJ)	0.000000	1000.000000
BABT)	0.000000	350.000000
BACB)	0.000000	400.000000
BAMIFE)	0.000000	-300.000000
BAFJFE)	0.000000	-1000.000000
BABTFE)	0.000000	-350.000000
NUCAAD)	0.000000	30000.000000
BAPOCA)	0.000000	30000.000000
BAVECA)	0.000000	15000.000000
NUGAAD)	0.000000	11000.000000
BAPOGA)	0.000000	1000.000000
BAVEGA)	0.000000	1000.000000
BAVEOV)	0.000000	100.000000
BAGAFE)	0.000000	-1000.000000
BATFMA)	316.600006	0.000000
BAMAAG)	0.000000	0.000000
BAMAPE)	0.000000	0.000000
BATFFM)	131.699997	0.000000
BAFMAG)	0.000000	0.000000
BAFMPE)	0.000000	0.000000
TFADMAFE)	0.000000	0.000000
TFADMAAC)	0.000000	0.000000
TFJVMAFE)	0.000000	0.000000
TFJVMAAC)	0.000000	0.000000
TFJVMADM)	0.000000	0.000000
TFADFMDM)	0.000000	0.000000
TFADFMFE)	0.000000	0.000000
TFADFMAC)	0.000000	0.000000
TFJVFMDM)	0.000000	0.000000
TFJVFMFE)	0.000000	0.000000
TFJVFMAC)	0.000000	0.000000
NUADMA)	0.000000	0.000000
NUADFM)	0.000000	0.000000
NUJVMA)	0.000000	0.000000
NUJVFM)	0.000000	0.000000

NO. ITERATIONS= 0

New technologies - Medium Farmers

LP OPTIMUM FOUND AT STEP 49

OBJECTIVE FUNCTION VALUE

14113410,00

VARIABLE	VALUE	REDUCED COST
RTAG	23234500.000000	0.000000
RTPE	946400.000000	0.000000
CUAG	8604732.000000	0.000000
CUPE	230000.000000	0.000000
CUTC	377850.000000	0.000000
CUFX	15905.000000	0.000000
CUFE	769000.000000	0.000000
CUAC	70000.000000	0.000000
MIFJNA	0.000000	2184990.000000
MIFJOM	0.000000	2434990.000000
MIFJEP	0.000000	1574990.000000
MIFJEL	0.000000	2494990.000000
MIFJOC	0.000000	2454990.000000
BTNA	0.000000	2582610.000000
BTOM	0.000000	2302610.000000
CBOM	0.000000	1390800.000000
MIFJNANO	1.000000	0.000000
MIFJOMNO	0.500000	0.000000
MIFJEPNO	2.000000	0.000000
MIFJELNO	0.250000	0.000000
MIFJOCNO	0.500000	0.000000
BTNANO	1.000000	0.000000
BTOMNO	0.500000	0.000000
MIVE	17000.000000	0.000000
FJVE	7645.000000	0.000000
BTVE	29970.000000	0.000000
CBVE	0.000000	0.000000
NUVA	2.000000	0.000000
VAVE	2.000000	0.000000
CAVE	7.000000	0.000000
GAVE	54.000000	0.000000
OVVE	64.000000	0.000000
TCMA	167.399994	0.000000
TCFM	210.449997	0.000000
SUNA	1.000000	0.000000
CBNA	0.000000	2394750.000000
SUOM	0.500000	0.000000
SUEP	2.000000	0.000000
SUOC	0.500000	0.000000
SUEL	0.250000	0.000000
FJAC	5.000000	0.000000
BTFE	20.000000	0.000000
BTAC	10.000000	0.000000
VACE	2.000000	0.000000
NUCA	4.000000	0.000000
CACENO	4.000000	0.000000
CACE	0.000000	15000.000000
CAFE	1.000000	0.000000
NUGA	4.000000	0.000000
GACE	64.000000	0.000000
GAFE	9.000000	0.000000
GAAC	1.000000	0.000000
MAAG	422.500000	0.000000
MAPE	425.000000	0.000000
ADMAFE	15.000000	0.000000
ADMAAC	67.000000	0.000000
JVMAFE	15.000000	0.000000
JVMAAC	67.000000	0.000000
JVMADM	68.400002	0.000000
NUADMA	1.000000	0.000000
NUJVMA	3.000000	0.000000
FMAG	283.250000	0.000000
FMPE	30.400000	0.000000
ADFMDM	143.399994	0.000000
ADFMFE	15.000000	0.000000
ADFMAC	67.000000	0.000000
JVFMFE	15.000000	0.000000
JVFMAC	67.000000	0.000000
JVFMDM	136.899994	0.000000
NUADFM	1.000000	0.000000
NUJVFM	1.000000	0.000000

New technologies Large Farmers

LP OPTIMUM FOUND AT STEP   44

OBJECTIVE FUNCTION VALUE

133490200,00

VARIABLE	VALUE	REDUCED COST
RTAG	207339008.000000	0.000000
RTPE	1868000.000000	0.000000
CUAG	68287360.000000	0.000000
CUPE	288000.000000	0.000000
CUTC	4962000.000000	0.000000
CUFX	77902.000000	0.000000
CUFE	2061500.000000	0.000000
CUAC	40000.000000	0.000000
MIFJNA	0.000000	2253695.000000
MIFJOM	0.000000	2683195.000000
MIFJEP	0.000000	1564695.000000
MIFJEL	0.000000	1920195.000000
MIFJOC	0.000000	1838695.000000
BTNA	0.000000	6857300.000000
BTOM	0.000000	4857300.000000
CBOM	0.000000	5925400.000000
MIFJNANO	5.000000	0.000000
MIFJOMNO	3.000000	0.000000
MIFJEPNO	20.000000	0.000000
MIFJELNO	2.000000	0.000000
MIFJOCNO	2.000000	0.000000
BTNANO	5.000000	0.000000
BTOMNO	3.000000	0.000000
MIVE	128000.000000	0.000000
FJVE	63995.000000	0.000000
BTVE	239960.000000	0.000000
CBVE	0.000000	0.000000
NUVA	16.000000	0.000000
VAVE	6.000000	0.000000
CAVE	10.000000	0.000000
GAVE	56.000000	0.000000
TCMA	3829.600098	0.000000
TCFM	1132.400024	0.000000
SUNA	5.000000	0.000000
MFJNANO	0.000000	0.000000
SUOM	3.000000	0.000000
SUOMNO	0.000000	0.000000
SUEP	20.000000	0.000000
SUEL	2.000000	0.000000
SUOC	2.000000	0.000000
FJAC	5.000000	0.000000
BTAC	15.000000	0.000000
BTFE	25.000000	0.000000
VACE	6.000000	0.000000
NUCA	6.000000	0.000000
CACENO	6.000000	0.000000
CACE	0.000000	20000.000000
CAFE	2.000000	0.000000
NUGA	5.000000	0.000000
GACE	70.000000	0.000000
GAFE	13.000000	0.000000
GAAC	1.000000	0.000000
MAAG	3768.000000	0.000000
MAPE	600.000000	0.000000
ADMAFE	19.000000	0.000000
ADMAAC	54.000000	0.000000
JVMAFE	19.000000	0.000000
JVMAAC	54.000000	0.000000
JVMADM	45.599998	0.000000
NUADMA	1.000000	0.000000
NUJVMA	2.000000	0.000000
FMAG	1632.000000	0.000000
FMPE	22.500000	0.000000
ADFMDM	221.600006	0.000000
ADFMFE	19.000000	0.000000
ADFMAC	54.000000	0.000000
JVFMFE	19.000000	0.000000
JVFMAC	54.000000	0.000000
JVFMDM	205.300003	0.000000
NUADFM	1.000000	0.000000
NUJVFM	4.000000	0.000000