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Characterization of Rice Production System in Terms of the Value Chain in Kamacupa and Catabola Municipalities Province of Bié in Angola

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Doctor of Philosophy in Tropical Knowledge and Management

Characterization of Rice Production in Terms of the Value Chain in Kamacupa and Catabola Municipalities Province of Bié in Angola

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A Dissertation carried out on the PhD in Tropical Knowledge and Manegement, under the supervision of Professors PhD José Paulo Pimentel Castro Coelho (ISA, UL), PhD Fernando Brito Soares (Nova SBE, UNL) and PhD Amílcar Mateus de Oliveira Salumbo (AFC, AJES)

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CHARACTERISATION OF RICE PRODUCTION SYSTEM IN TERMS OF THE VALUE CHAIN IN KAMACUPA AND CATABOLA MUNICIPALITIES PROVINCE OF BIÉ IN ANGOLA

Pascoal Jeremias Chiambo

A Dissertation carried out on the PhD in Tropical Knowledge and Management, under the supervision of Professors

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ABSTRACT

In Angola, rice is the most consumed food after maize and cassava. However, there is a limited number of in-depth scientific research on the production systems of the culture. This study aims at the characterization of rice production systems in Angola, using the value chain approach. The study is expected to help decision makers to design policies that should increase rice productivity. The work consists of 5 chapters. After the introduction, Chapter 2 deals with the state of the art of rice in Angola. Chapter 3 describes rice production systems in the municipalities of Kamacupa and Catabola, province of Bié. Chapter 4 seeks to understand how rice value chain management works and finally, Chapter 5 identifies some proposals for possible solutions.

Keywords: Rice, Characterization, Value chains, Management

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ABBREVIATION INDEX AND ACRONYMS

ADS - Agrarian Development Station

AEO - Organized Economic Operator

AfDB - African Development Bank

ARI - African Rice Initiative

CEIC-UCAN - Centre for Studies and Scientific Research of the Catholic University of Angola

CFB - Benguela railway

CIRAD - Centre Internationale en Recherche Agronomique pour le Développement

DRC - Democratic Republic of Congo

EAH - Entrepreneurial Agricultural Holdings

ENSAN - National Strategy for Food and Nutrition Security

FAO - Food and Agriculture Organisation

FFH - Family Farms Holdings

FIDA - International Agricultural Development Fund

GCC - Global Commodity Chains

GDP - Gross Domestic Product

GRiSP - Global Rice Science Partnership

IAD - Agrarian Development Institute

ICCO - International Cocoa Organization

IFPRI - International Food Policy Research Institute

IITA - International Institute of Tropical Agriculture

INE - National Institute of Statistics

INRA - Institut National de la Recherche Agronomique

INRH - National Institute of Water Resource

IRRI - International Rice Research Institute

JICA - Japan International Cooperation Agency

MAAIF - Ministry of Agriculture, Animal Industry and Fisheries

MINAGRIF - Ministry of Agriculture and Forestry

MOSAP - Family Agriculture Development and Marketing Project

NRDS - National Rice Development Strategy Angola

PASAN - Nutrition Security Action Plan

PDMPSA - Medium Term Development Program of Agriculture Sector

PEDLP - Long-term Development Program

PND - National Development Plan

PRODESI - Program support National Production, Diversification and Import Substitution.

SSAC - Sub-Saharan African Country

USDA - Agriculture Department of United State

VC - Value Chain

VCA - Value Chain Annalise

VGC - Global Value Chain

CHAPTER 1. INTRODUCTION

1.1. Background of Research

Food is the basic need of all life on earth for survival, as well as an instrument for maintaining national independence, prestige, and honour of a nation. Food security is not only an essential aspect of human development but also the prime goal of any nation. Country food security is essential for achieving stability since responsible governments cannot tolerate food insecurity particularly in the face of mounting population pressure, leading to further widening of already existing disparities (Ahmad 2009; Yangling, 2017).

The world's population has steadily increased from 6.1 billion in 2000 to 7.7 billion in 2019, and the estimate is to reach 9.8 billion by 2050 (FAOSTAT 2016; Max *et al.*, 2020). Because of this rapid growth, which is causing a threat to food security, there is a need to stimulate growth and productivity for increasing agricultural output in order to meet the high demand for food. Agriculture is essential to support most of the world's growing population in terms of nutrition, as well as employment and income generation (Sawaneh *et al*., 2013; GRiSP, 2013; Yangling, 2017). In the 21st century agriculture remains fundamental as it accounts for one-third of gross domestic product (GDP) and three-quarters of employment in Sub-Saharan Africa. Agriculture, however, is more vulnerable to climate change than any other sector. A warming climate could cut crop yields by more than 25%. Agriculture and land-use change are also responsible for between 19–29% of global greenhouse gas emissions (World Bank, 2013).

The Angolan economy is mostly dependent on oil, which represents 45% of national GDP and more than 90% of exports. The country growth was almost entirely been driven by rising oil production, which surpassed 1.4 million barrels per day (World Bank, 2019). A sharp decline in oil prices since 2014 has harmed the oil-dependent economy, and real GDP shrank by 0.2% in 2017 and an estimated 0.7% in 2018. Fiscal revenues declined by more than 50% between 2014 and 2017. Fiscal consolidation through the better mobilisation of nonoil fiscal revenue and spending cuts reduced the budget deficit to an estimated 2.8% of GDP in 2018 from 4.8% in 2017. But public debt, mostly external, increased from 40.7% of GDP in 2014 to an estimated 80.5% in 2018, raising concerns about its sustainability (AEO, 2019).

The country's external imbalances created a shortage of foreign currency, which dampened growth in the nonoil sectors. In January 2018, the central bank adopted a more flexible foreign exchange regime that resulted in an overall depreciation rate of more than 40%. Inflation decreased from 31.7% in 2017 to an estimated 21.1% in 2018. As oil prices recovered, the current account deficit stabilised at 0.1% of GDP in both 2017 and 2018 (AEO, 2019).

Poverty incidence fell from 68% in 2000 to 37% in 2018, is more important in rural areas (58%) than in urban areas (19%). On a scale of 0 to 1, Angola's Human Capital Index was 0.36 in 2018, pointing out to poor education and health conditions which limit the opportunities for the poor. Given the dimensions and factors underlying such a low level of human capital resources, investments and adequate distribution mechanisms in health, education, sanitation and social protection are crucial. (World Bank Group 2018). The unemployment rate was estimated at 20% in 2018 and remained high among young people in urban areas (38%) (AEO, 2019).

Today, according to the USDA GAIN reports (2015) Angola is Africa's fifth largest economy where oil production is its main contributor. According to the Africa Development Bank (AfDB, 2016), livestock and forestry contribute about 12% to the GDP and 42% of total employment, with women, providing an estimated 70% of agricultural labour (AfDB, 2018).

Although Angola has the resources to become one of the leading agricultural countries in Africa, currently it only cultivates 8% of its 58 million hectares of the available agricultural land; about 90% of farms in Angola are small to medium, and the country imports almost 90% of its food needs (Pacheco *et al*., 2011). Agriculture is the main supplier of the food consumed in the country, although insufficient to meet all needs. The low productivity recorded reflects the low use of modern technology, and although the country has a reasonable potential for agriculture, the fact that it generally employs outdated methods of production justifies its poor performance.

1.2. Problem Definition

In presence of the situation described above and given the potential for rice production in Angola is it necessary and urgent to implement measures that can overcome it. Namely the increase in yields, the investment in processing plants and, most important, lead the small family farm sector to adopt the technologies necessary for an increasing and sustained rice production.

Currently, agriculture production is still predominantly rain-fed, non-market oriented, and based on rudimentary technologies and environmentally unsound practices. The country´s agricultural production is often on a small scale poor quality and costly to assemble for sustainable market supply. In addition, the farmers are not organized for the purchase of inputs and marketing of their produce efficiently, thereby incurring in high production and marketing costs that affect the profitability of their enterprises (Pacheco *et al*., 2011).

Over the recent years, Angola has initiated several strategies to boost the agricultural sector.

In the PND (2018-2022) - National Development Plan, PDMPSA (2018-2022) - Medium-Term Development Program of Agricultural Sector and PRODESI (2018) - Program to Support National Production, Diversification and Import Substitution, rice cultivation and production are considered by the Government as a strategy for strengthening food and nutritional security and import substitution (MINAGRIF, 2018). Thus, rice development strategy is in line with both national policies and international commitments that Angola has ratified aimed at improving the livelihood in rural communities through enhancing household food security and incomes.

Given the abundant water resources, and a favourable climate, the government is committed to use the agricultural sector as a key driver of economic diversification away from oil. However, inadequate rural agricultural infrastructures such as roads, irrigation systems and unreliable electricity supply, as well as low use of yield enhancing inputs and modern technologies, are strong constraint to achieving that objective. Moreover, lack of skills, limited access to credit, weak research and extension services to support to farmers and inefficient land management system are also responsible for the low agricultural productivity.

In Angola, rice is the most consumed food after maize and cassava. At a time when the country population increases at an approximate annual rate of 3.27% associated to an economic and financial crisis, demand for food is increasing and prices are getting higher. Currently the country lives mainly on imports, spending big sums to import more than 400,000 tonnes of rice per year to meet the internal market needs. This situation, exacerbated by the fact that some countries have banned or restricted their rice exports, is leading to a shortage and a rise in prices on the world market. These problems threaten the food security of the Angolan population, increasing hunger and poverty every few years. However, the country has the potential to invest in national rice production, thus replacing imports.

The relaunch of rice cultivation and production requires the government to invest mainly in knowledge and infrastructures related to the entire value chain, from the supply and availability of inputs to production, transport, storage, processing, marketing and distribution. The government plays a crucial role in boosting this sector. It should, above all, create a favourable business environment and, whenever possible, operate public-private partnerships and participatory management with beneficiaries.

However, there is a reduced number of in-depth studies on the reality and nature of agricultural rice production in Angola. Even less are those who study and characterize this reality in terms of production systems and value chains. Such a study, based on the agroclimatic conditions of the Angolan territory, the prevailing production systems and the technologies used as well as on the value chains and respective key actors, is therefore very useful and necessary.

This study will stimulate farmers to increase production by taking advantage of all the favourable resources the country has to rice production. In the wake of the problem raised, it must be bear in mind that in the region under study there are different rice production systems that need to be understood and taken into account, considering their relevance the improvement of rice crop management techniques.

1.3. Research objectives

The general objective of this dissertation is, precisely, to develop the first steps of a study that, taking advantage of the favourable conditions of the territory, may identify the most adequate production systems that can improve the productivity and income of farmers. Additionally, throughout this dissertation, we will also deal with the description and characterization of rice production systems and the respective value chains to understand and identify the main existing constraints. In doing so, the study helps us to identify what are the main possibilities for intervention to increase the efficiency, productivity and income of rice producers, as well as what will be the best policies to adopt to promote the expansion and improvement of cultivation of rice in Angola.

Specifically, this study aims to:

i. Characterize the rice sector in Angola, particularly its potential natural resources, specifically in the municipalities of Kamacupa and Catabola;

ii. Identify the relevant limiting factors and variables that distinguish the different rice production systems in the municipalities of Kamacupa and Catabola;

iii. Perform a detailed analysis of the rice production system in Kamacupa and Catabola municipalities;

iv. Describe and understand the operation of rice value chains in Angola, particularly in Kamacupa and Catabola, to know their weaknesses and strengths, as well as the opportunities and threats they face, in order to achieve better results;

v. Suggest strategies, measures and actions for the development of rice production in Angola.

Additionally, some of the research questions addressed in the present study are:

a) What are the main factors that determine the different rice production systems in the Kamacupa and Catabola Municipalities?

b) In what ways do these factors represent characteristics that define the different production systems?

c) How will the mapping of value chains serve as a basis for adding value to the product and ensuring food security from the producer's perspective?

d) Is the technical itinerary of production used in the different rice production systems economic, social and environmentally sustainable?

1.4. Scope of work

The work has five chapters. Chapter 1 starts with an introduction, where a generic and summarized approach about the state of food and rice production in the world, in Africa and in Angola, is presented.

Chapter 2 refers to the issue of Rice Crop Growth and Food Security Reinforcement in Angola. It is a literature review about the rice sector in the country, discussing and analysing the objectives that can be achieved. This consists in starting from the agroecological potential of the Angolan territory, passing through a summary characterisation of the different scales of existing rice production systems in the country and ending with a diagnosis of the main fragilities and constraints that limit the expansion of the area and productivity of the rice crop. The main aim of the suggested strategy is to contribute to increasing the quantity and quality of rice production to ensure a sufficient quantity of rice necessary to meet the needs of the internal market demand. For that matter, the suggestion is that public policies should be able to support rice producers through actions such as providing farmers with new technologies and modern sustainable rice cultivation techniques, promoting local agricultural experimentation and rural extension, as well as helping farmers to reduce post-harvest losses and marketing risks. The theme was developed and published in an article in the Journal of Rice Research: open access (Chiambo, *et al*., 2019a).

The Chapter 3 characterizes the rice production system in Kamacupa and Catabola municipalities of the province of Bié in Angola. A survey questionnaire on rice production and processing conditions was carried out, interviewing rice producers in Central Plateau of Angola, to get data which may guide the government, the agricultural policymakers, the students and the researchers in devising measures for improving rice production technology. The results of this chapter are published in the Direct Research Journal of Agriculture and Food Science (Chiambo, *et al*., 2019b).

Chapter 4 aims at understanding the rice value chain in Angola, namely, constraints, opportunities, and strategies to increase productivity. It analyses and assesses the value chain formation process in the rice sector and the role of the involved stakeholders that increase the product value for consumers through organised cooperation. While it does not coincide with the traditional value chain concept, it describes the full range of activities required to bring a product or service from conception through the different stages of production, distribution and final disposal after use. For small farms to intensify production in high potential areas, efficient pre- and post-harvest services, are required to contribute to economic growth and reduce poverty. This chapter is addressed to agricultural value chains, and to help small farmers understand how agricultural value chains work. It provides some examples of agricultural value chains, discusses why it is essential for farmers to consider themselves part of an agricultural value chain, lists the potential benefits of agricultural value chains, and discusses different strategies for them to grow or improve their involvement with agricultural value chains. The difficulties faced by key actors in the rice value chain in accessing services have been largely reviewed, showing how incentives for the commercial delivery of services to smallholders differ between staple foods, traditional crops, and high-value product supply chains. The major challenge in providing services to smallholder farmers in Angola concerns the coordination of services development and delivery. Different forms of intermediary institutions to achieve this coordination are also examined. The theme was developed and published in Direct Research Journal of Agriculture and Food Science (Chiambo, *et al*., 2020). Chapter 5 is about overall conclusions and future works.

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CHAPTER 2. ANGOLA: RICE CROP GROW AND FOOD SECURITY REINFORCEMENT

Abstract

Rice is the staple food of more than three billion people around the world. In Angola it is the most consumed food after maize and cassava. Currently the country lives mainly on imports, spending big sums to import more than 400,000 tonnes of rice per year to meet the internal market needs. This situation is exacerbated by the fact that some countries have banned or restricted their rice exports, leading to a shortage and a rise in prices on the world market. These problems threaten the food security of the Angolan population, increasing hunger and poverty every few years. However, the country has the potential to invest in national rice production, thus replacing imports. This work analyses and discusses how this objective can be achieved, starting from the agroecological potential of the Angolan territory, passing through a summary characterization of the different scales of existing rice production systems in the country and ending with a diagnosis of the main fragilities and constraints that limit the expansion of the area and productivity of the rice crop. The main aim of the suggested strategy is to contribute to increase the quantity and quality of rice production in order to ensure that sufficient quantities of rice are available to meet the needs of the internal market demand. For that, public policies should be able to support rice producers through activities such as providing farmers with new technologies and modern sustainable rice cultivation techniques, promoting local agricultural experimentation and rural extension, as well as helping farmers to reduce post-harvest losses and marketing risks.

Key-words: Angola, Rice production, agricultural zoning, food security, policies and strategies.

2.1. Introduction

Rice consumption in Angola is only second to those of maize and cassava. Moreover, it is an important component of food security for the majority of households (FAOSTAT, 2017). Although it is steadily increasing, the 7.3 kg annual per capita rice consumption in Angola (FAOSTAT, 2017) is still modest when compared with other Sub-Saharan African Countries (SSAC) like Mali and Senegal where the consumption is 60 and 70 kg per capita per annum, respectively (Zenna *et al.*, 2010; Alencar *et al.*, 2017) or when confronted with the main world rice consuming countries, as it can be seen in Figure 2.1.

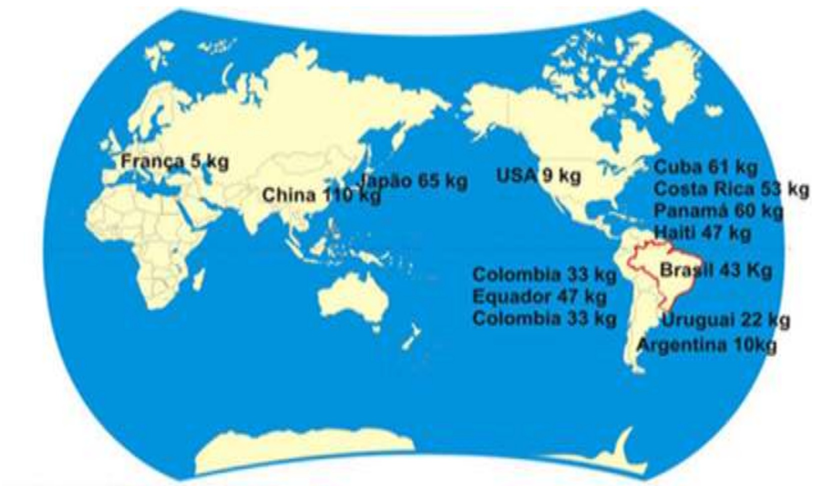

Figure 2.1. Rice consumption models.
Source: Milovanovic *et al*., 2017.

The leading Angolan regions in rice production are Uige, Zaire, Malanje, Bié, Lunda Norte, Cuanza Norte, Cuanza Sul, Moxico and Cuando Cubango (Diniz, 1998; Schellinge *et al.,* 2015), in which valleys rice finds a favourable environment for its development (FAOSTAT, 2015).

Angola total harvested rice area in 2016/2017 was 39,412 hectares, producing 61,000 tonnes corresponding to an average yield of 1.5 tonnes per hectare, which is very low when compared with other SSA countries productivity. In fact, average rice yields across Africa are 2.5 tonnes per hectare while world best productivities reach 8.3 tonnes per hectare [1] (FAOSTAT, 2016).

Several biophysical and socioeconomic constraints explain the low productivity. The most intense and frequent are: low soil fertility and lack of fertilization; inadequate or inefficient methods of soil preparation; use of low yielding varieties; drought and lack of irrigation; pests and diseases (IAD, 2016). Last but not the least, about 80% of Angolan rice producers are inefficient small-scale farmers. Economic growth and rapid urbanization of the country in recent years determined a rapid growing demand which could not be satisfied by the stagnant production, immediately translating into rapidly increasing imports.

The growth of imports obviously deteriorates the trade balance, additionally requiring foreign exchange, which became scarcer particularly after the 2014 fall in oil prices. But there is an additional problem.

The world rice market is relatively narrow. Only 5% of the world production is internationally traded, as compared with 25% for soybeans or 20% for wheat. International supply of rice is then residual in relation with world production. This means that variability in production, caused for instance by bad harvest years in the largest producers, is directly passed to world international supply with the consequent implications for price variability.

In presence of such a situation and given the potential for rice production in Angola is it necessary and urgent to implement measures that can overcome it. Namely the increase in yields, the investment in processing plants and, most important, lead the small family

[1] Best practices = average of top 10 countries in the world by yield in the commodity

farm sector to adopt the technologies necessary for an increasing and sustained rice production.

In the following sections we will address these issues, namely the current bottlenecks and opportunities, the production structure and the possible strategies to success.

2.1. Brief review of the national economy and Agricultural Sector

In Angola's economic and administrative history, rice began to deserve ruler's attention since 1849 (Castro, 1914). However, it was not until 1925 that the development of its production allowed for the first exports, which in that year amounted to 1,166 tonnes. From 1938 to 1967, Angola´s exports for five years ranged from 9,809 to 11,892 tonnes, which translated into monetary values from 10,084 to 38,808 contos[2] (Diogo, 1956). With the outbreak of World War II, Angola's rice had considerable demand, which was met by the precautionary measures of self-sufficiency adopted by the country's administration. Among the incentives granted, the exemption of import duties in 1932 for all the machinery destined to equipping the shelling and polishing rice industry was highlighted (Gouvéia 1968).

In the 1960s and 1970s, the country became an active participant in agro-livestock exports, which almost 60% of its consisted of coffee (48%) and sisal (5%), but also including maize, bananas, tobacco, cotton, beans, sugar, palm oil and rice. Agriculture was thus considered to be the main source of employment and wealth generator and the country was positioned as 4th largest exporter of coffee and sisal (Gouvéia, 1968; Azevedo *et al*., 1972).

However, the post-independence war that lasted a little over two decades resulted in the destruction of the main productive fabric, and forced a significant part of the rural

[2] 1 conto is aproximatelly equivalent to 5 euros

population to move to the cities, limiting the agricultural production and consequently the rural commerce. In this way, migration and the dismantling of rural trade transformed an entrepreneurial agriculture that was increasingly market-oriented until the mid-1970s, into a predominantly subsistence farming today (Andrade *et al*., 2008; Pacheco *et al*., 2011; FAO, 2012).

Today, according to the USDA GAIN reports[3] Angola is Africa's fifth largest economy where oil production is the main contributor to the economy. According to the Africa Development Bank (AfDB, 2016), livestock and forestry contribute about 12% to the GDP and 42% of total employment, with women, providing an estimated 70% of agricultural labour (AfDB, 2018).

Although Angola has the resources to become one of the leading agricultural countries in Africa, currently it only cultivates 8% of its 58 million hectares of the available agricultural land, an estimated 90% of farms in Angola are small to medium, the country imports almost 90% of its food needs (Pacheco *et al*., 2011). Agriculture is the main supplier of the food consumed in the country, although insufficient to meet all needs. The low productivity recorded reflects the low use of technology, and although the country has a reasonable potential for agriculture, the fact that it generally employs ancestral methods of production justifies its poor performance.

2.2. Food import and food security

Currently, agriculture production is still predominantly rain-fed, non-market oriented, and based on rudimentary technologies and environmentally unsound practices. The country´s agricultural products are often of low volumes, poor quality and are costly to

[3] USDA GAIN reports (2015) – Agricultural Economic Fact Sheet-Foreign by United States Embassy in Angola. Available In: (https://gain.fas.usda.gov/.../Agricultural%20Economic%20Fact%2...). Accessed in May 7th, 2018.

assemble for sustainable market supply. In addition, the farmers are not organized for the purchase of inputs and marketing of their produce efficiently, thereby incurring in high production and marketing costs that affect the profitability of their enterprises (Pacheco *et al*., 2011).

Over the recent years, Angola has initiated several strategies to boost the agricultural sector. With abundant water resources, and a favourable climate, the government is committed to use the agricultural sector as a key driver of economic diversification away from oil. However, inadequate rural agricultural infrastructure such as roads, irrigation systems and unreliable electricity supply, as well as low use of yield enhancing inputs and technologies, are strong constraint to achieving that objective. Moreover, lack of skills, limited access to credit, weak research and extension services for support to farmers and inefficient land management systems are also responsible for low agricultural productivity. For example the Angola´s cereal yields increased from 662 kg/hectare in 2001 to 815 kg/ha by 2015, but remain below the Sub-Saharan average of 1,433 kg/ha. In addition, only 5.7 percent of the arable land is under cultivation nowadays (Angola, 2017).

At present, the country depends on the international market to satisfy about 90% of its food needs, being self-sufficient only in the production of cassava and banana. The main imported food and agricultural products in decreasing order of importance are: sugar, rice, chicken, wheat flour and other cereals, edible oils, followed by beef and pork, legumes and eggs (Carvalho, 2013).

Figure 2.2 clearly illustrates this situation in the case of rice. Up to 1975 production was enough to fill domestic demand. From then on, the incapacity of production to cope with the increased demand is evident.

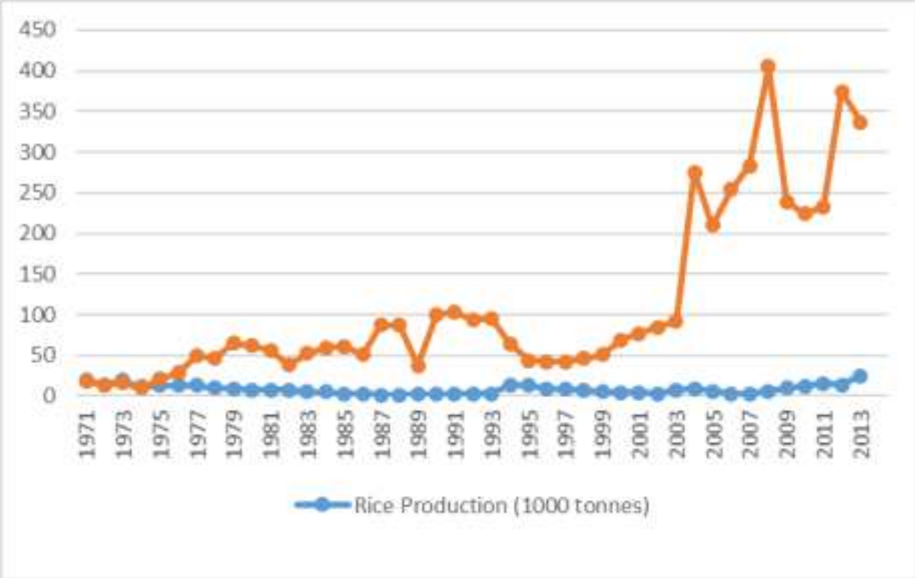

Figure 2.2. Angola Rice Production and Domestic Consumption (tonnes of milled equivalent).
Source: FAOSTAT, 2016.

This triggered the explosion of imports, particularly after 2003 as Figure 2.3 clearly shows.

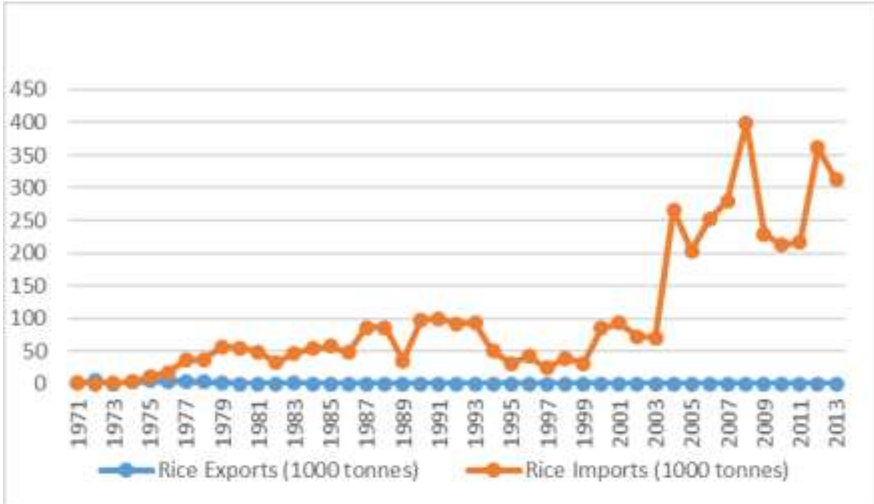

Figure 2.3. Angola Rice Exports and Imports (tonnes of milled equivalent).
Source: FAOSTAT, 2016.

In order to overcome the challenges of food production, it is necessary to adopt fiscal incentives to stimulate credit and even direct investments to rebuild the productive structure. It will be then possible to ameliorate the balance of trade through replacing imports and simultaneously foster the diversification of the economy and the generation of job opportunities, thus reducing external dependence.

Within this context, the National Strategy for Food and Nutrition Security (ENSAN) was created, based on the Food and Nutrition Security Action Plan (PASAN). This strategy included in the framework of the Strategic Long-term Development Program (PEDLP-2025) and its Medium Term Development Plan 2009-2013, as well as in the various sub-sectoral policies (ENSAN, 2009). The AfDB (African Development Bank) also established a partnership to boost the agriculture value chain[4].

Thus, rice development strategy is in line with both national policies and international commitments that Angola has ratified aimed at improving the livelihood of the majority of rural communities through enhancing household food security and incomes.

2.3. Angola rice potential and resources. Climatic, edaphic and superficial water resources of Angola

Angola is located in the tropical and subtropical zone of the south hemisphere, and its main topographic characteristics and the cold-water current of Benguela are determining factors for the characterization of the two main climatic seasons of the country (Palanque, 1995).

In Angola there are two well deferred climatic seasons: the rainy season and the dry season, the latter being popularly known in Angola as the *cacimbo* season. The rainy season, which is wormer and more humid, runs from October to April, while the dry season runs from May to September (MINADER, 2004). According to Köppen the main types of climate characterized by the intersection of sets of thermal regimes and rainfall regimes are: *Aw* (rainy tropical climate, dry season in winter), *Cwa*

[4] AfDB – Africa Devolopment Bank – www.afdb.org.

(mesothermic, humid, dry season in winter), *Cwb* (temperate climate with dry winter and hot summer), *BSh* (very hot steppe climate) and *BWh* (very hot desert dry climate) (Peel *et al.*, 2007).

According to the geographic location, topography and influx of sea currents, Ngolo (2014) highlights the predominance in Angola of four climatic types described below:

a) Humid tropical climate, mainly occurring in the north and northeast of the country, including the province of Cabinda and the coastal strip between Benguela and Quelo, characterized by annual precipitations over 1,200 mm, most of which occurring between September and May, with maximum monthly rainfall values around 300 mm in April, and a short rainy season between June and August. In this climatic type the average annual air temperature is higher than 22ºC.

b) Semi-humid tropical climate, occurs in the south of the humid tropical climate located in the central south and east of the country, approximately between the localities of Quibala (province of Cwanza Sul) - Sacama (Province of Moxico), Luena (Cuando Cubango Province), Lubango (Province of Huila), with annual rains ranging between 750 and 1,250 mm, maximum rainfall occurring in the month of March ranging from 200-300 mm. This climatic type presents a very dry period between June and September, with annual thermal averages ranging from 20 to 22 ºC in the East and 18 to 20ºC in the central zone, requiring irrigation for agricultural exploitation.

c) Dry tropical climate, occurs along the coast from the north of the municipality of Quelo to the centre of the municipality of Lobito. Annual rainfall ranges from 500 to 700 mm, with a monthly maximum of 130 mm in April and a minimum in May, with the dry period from May to September. The average annual temperature varies between 24 and 26 ºC, decreasing until 20 ºC towards the south in the provinces of Cunene and Cuando Cubango.

d) Tropical desert climate occurs in the southwest coast of the country between the northern municipality of Lobito (Benguela) and south of the municipality of Tombua (Cunene). This strip is wider in the south and presents average annual precipitation of less than 250 mm, with a maximum of 100 mm in the month of March and a dry period between May and September. The average annual temperature varies from 20 to 22º C. The southern end is even drier with average annual rainfall of less than 100 mm from January to April and a long dry period from May to December. Average annual temperatures range from 18 to 20ºC.

The described conditions, coupled with the duality of climatic conditions, physiographic conditions and availability of water resources, determine the agricultural potential of two large areas (Diniz and Aguiar, 1968): A rainfed zone complemented by small irrigation systems and large irrigation areas.

The rainfed zone comprises about 70% of the country where abundant rains are observed during a long season, and high temperatures allowing the production of a great variety of crops. This is the great extension of the interior of the country, with the Central Plateau and the Subplanning zones in the north of the country, and the great extension of the east in which the quantitative value of the precipitation varies between 1,200 and 1,800 mm. The relatively short dry season has low temperatures, sometimes with frost, limiting the interest of fresh, horticultural and fruit crops, which, however, may justify complementary irrigation in selected small areas. They are, in general, the conditions of interest for livestock production and rainfed agriculture (Diniz and Aguiar, 1968; Diniz, 1998; Serralheiro *et al*., 2008).

From the south to the west coast, slightly below the 800 mm isohyet, where the dry season is longer and where the precipitation, besides scarce, is irregular, the regions are suitable for the great irrigations. The great spots of soils with more interest for cultural intensification occur also in these regions: Alluvial, Limestone, Clay, Aridic, Calsialitic, Fersialitic (Serralheiro *et al.,* (s/d). The South and the western coast region, semi-arid or arid with fertile valleys are well suited to the great schemes of irrigation (Diniz and Aguiar, 1968).

Surface water availability is substantial, equivalent to almost 12,000 cubic meters per capita and per year (INRH (2018), but these areas of water resources do not match well with areas of demand for agriculture and domestic use (Jayne & Ameyaw, 2016). According to Ferreira and Guimarães (2003) only 4 of the 12 SADC countries (Angola, DR Congo, Zambia and Mozambique) do neither have a shortage of water resources nor are they expected to occur in the next 20 years. Angola is the most favoured of all these countries, in terms of availability of water resources, with the potential to provide water to neighbouring countries, as it is already the case with Namibia (from Cunene river) and Botswana (from Okavango river).

Soils are quite variable and in many cases changing within short distances (figure 2.4).

The south eastern part of the country has soils derived from Kalahari sands with very little cropping being carried out. Granitic and gneissic formations predominate in the highlands and plateau where the most productive cropping soils exist. Oxisols, which are of low fertility, acidic, low in organic matter, and commonly affected by aluminium toxicity, predominate. But there are large areas of alfisols and utisols that are reasonably fertile and suitable for crop production (Diniz and Aguiar, 1968).

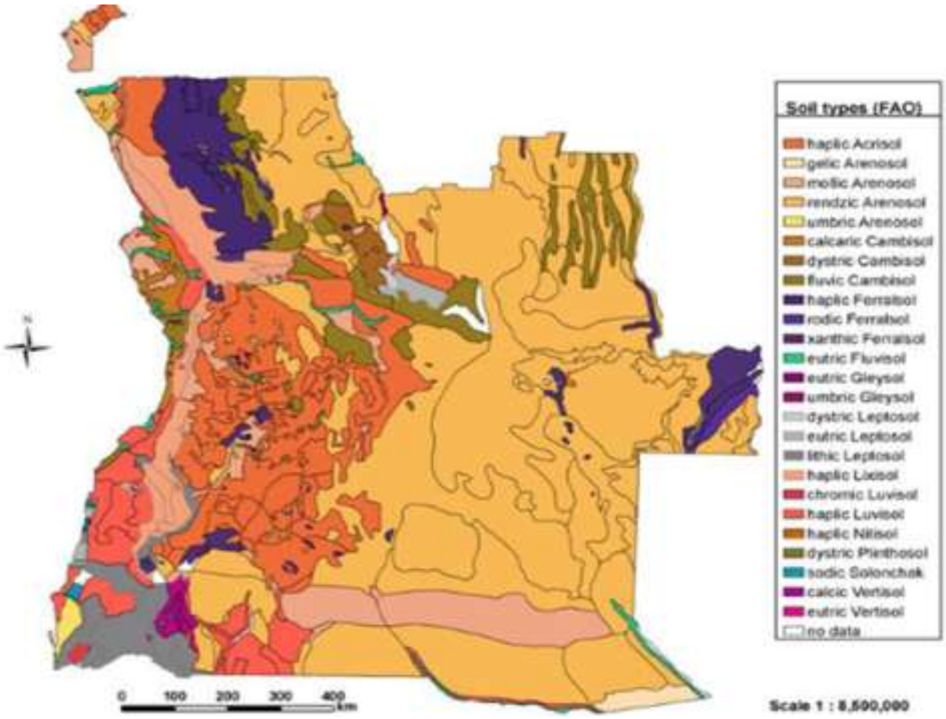

Figure 2.4. Soils type of Angola.
Source: Preetz *et al*., 2009.

Ferralitic and paraferralitic soils are widespread in central and northern parts of the plateau. The sandy soils of the coastal belt and parts of the foothills have low fertility and low water holding capacity and are prone to salinity problems. There is ample land of reasonable to good potential suitable for cultivation (Diniz and Aguiar 1968; Azevedo *et al*., 1972; Pacheco *et al*., 2011).

Soils of major interest for agricultural activity mainly for the exploitation of rice cropping are the hydromorphic soils (Gley soils and Psamo-hydromorphic soils) characterized by being subject to temporary or permanent flooding, due to ascending water movements, which cause intense reduction phenomena throughout all or part of their profile (Matias, 2000).

Rice can be successfully cultivated as long as it does not lack three important factors:

light, heat and water (Matias, 2000). Rice finds a favourable area for its development in the rivers valleys. It adapts to different types of soils, from sandy, peaty and clayey soils, whose mechanical composition varies according to the nature of alluvial deposits (Silva, 1983). However, a clay soil is the best to favour good organoleptic qualities to rice (Fonseca, 1936). In general, yields are comparatively higher and heavier, on finer textured soils than on thicker textured soils (Costa, 1973; Azevedo, 1972; Diniz, 1998).

2.4. Agriculture zoning

In order to better exploit the country agricultural potential and policies to increase the yield of a certain crop, it is essential to know the factors that allow the adoption of a region as being of good suitability for the crop to be cultivated, using the agricultural zoning method.

The agroclimatic zoning is a variation of agricultural aptitude zoning that aims to delimit in a region, areas with soil and / or climate characteristics suitable for the cultivation of a given crop (Ngolo, 2014).

Agricultural zoning becomes imperative for granting agricultural credit to producers and at the same time indispensable for the sustainable cultivation of tropical plants, since it favours the production of safer fruits from the food point of view. And zoning allows for the identification of areas that require a lower application of agrochemicals (Ngolo, 2014). When well targeted to regional and national agricultural development, it helps to provide technical assistance to producers.

Chagas *et al*. (2001) stated that the agricultural zoning for a given crop, is based on the agropedoclimatic variables of a given region which allow defining the aptitude to produce a crop. According to those authors, the fundamental variables to be taken into account are rainfall, sunshine, average maximum and minimum temperatures, soil physical and chemical properties, socioeconomic aspects of the region and the requirements of the crop to be installed.

Based on the potential described on studies made by Diniz (1998), there are three types of areas, depending on altitude, climatic factors and crop tradition, for rice cultivation in Angola.

These types are: low rivers under irrigation; surfaces flooded in the rainy season; and highlands during the rainy season (figure 2.5).

The most favourable areas to rice cultivation according to Diniz (1998) are those located on the flat surface because they bring together a set of climatic, topographic and pedological factors, which are very favourable to the crop, as well as aquifer resources. In these cases, the author takes into consideration three important aspects:

1) Cultivation areas involving poorly drained and periodically floodable plains of Bié and Malanje provinces;
2) Plateau areas of Cuanza Sul and Huila provinces, where rice cultivation should preferably focus on alluvial soils with thin textures of river bottoms, easily dominated by irrigation schemes;
3) Areas of the Lower Cunene, in relation to the low and fluvial terraces of the respective course and main tributaries and areas of the Low Cubango, in both cases dominated by thin Aluviossols.

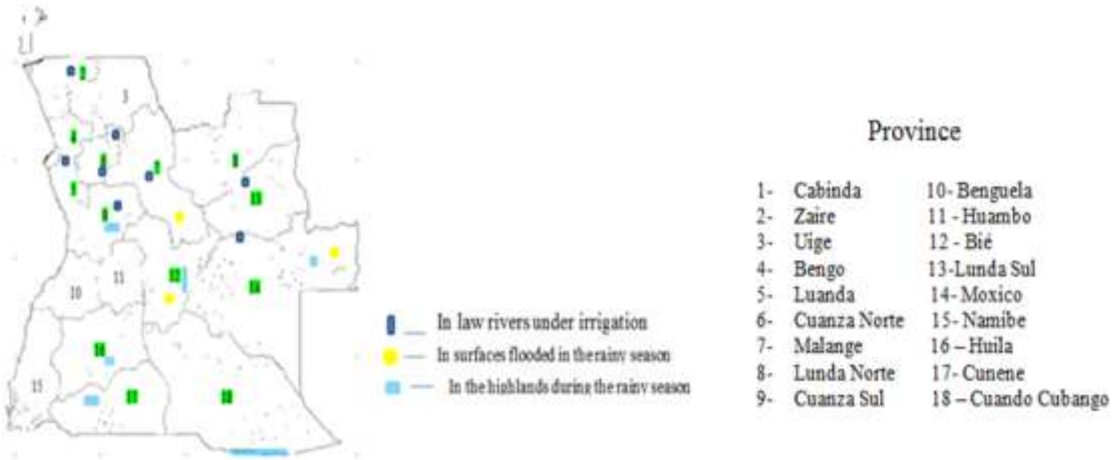

Figure 2.5. Traditional area and area more favourable to rice cultivation.
Source: Adapted from Diniz (1998).

However, the author points out that in the Lower Cunene zone a marginal strip extending discontinuously from Matala to Calueque is considered as a better zone due to the prevailing excellent climatic conditions (temperature, and daily thermal fluctuations, relative humidity, degree of insolation) and the presence of suitable soils.

Despite the innumerable potentialities, the current rice food situation in the country is quite surprising. Studies conducted by Schelling *et al*., (2015) have shown that both the proportion of appropriate arable land in use as well as the percentage of potential yield and income achieved (the "income range") are extremely low considering the environmental potential of Angola.

2.5. Rice production systems

Rice is a highly versatile crop that can be cultivated in a range of different ecosystems. In Angola most of the rice is cultivated under lowland rain-fed conditions, some with the aid of irrigation, and a smaller area of it is still cultivated under the rain-fed upland system (IAD, 2016). Many steps are involved in rice production from seed selection to post-harvest handling (Fonseca, 1936).

The rain-fed lowland system is predominant and largely used by small-scale farmers. The fields are bonded and flooded with rainwater for at least a part of the cropping season. In this system, the small-scale farmers adopt a method of haul direct sowing and in some cases direct seed in line. They rarely use the transplant method because they claim to be very labour-intensive (IAD, 2017).

This system is typically prone to drought, only one crop per year is possible, and fields are subject to flooding in a depth of as much as 50 cm during part of the season. Production is very low and variable, in part because all the work is done manually, and major problems and restrictions include the low quality of the seeds, the water control (both drought and flood) the soil fertility as well as weed management.

With full water control and taking into account all the other production factors, the attainable yields should be around 3 to 6 tonnes per hectare (Lewis and Wilson, 2015), but actual yields in Angola are much lower (typically 0.35-0.70 ton/ha). The quality of the paddy is low due to poor water management and delays in harvesting as farmers wait for their fields to dry out. Doing so, the harvested paddy is frequently drier than optimal (IAD, 2017).

In the irrigated lowland system the rice is grown in fields that are flooded during most of the growing cycle with a water depth of 5-20 cm. Average yields of paddy from these fields are between 3 and 6 tonnes per hectare and per cycle. The paddy quality is generally good and the supply of water can be controlled (Carriço, 2017).

The soil preparation consists mainly in a sequence of tillage, harrowing and levelling of the land. Land levelling ensures uniform distribution and depth of irrigation water on the field and saves the amount of irrigation water needed (Bouman *et al.*, 2005). Farmers usually maintain their rice field flooded with a water layer of 5–10 cm during the cropping cycle until several days before harvesting (Kriesemer, 2013).This system has the advantage of leading to higher yields per hectare and is practiced mainly by the large-scale farmers, involving large commercial farms and trading companies (Diogo,1956). A critical issue facing the rice sector is the low productivity (FAOSTAT, 2017). An output of paddy cropping at 1.3 tonnes/ha is low even by African standards (average of 2.5 tonnes/ha) and very low by Asian standards (average of 4.4 t/ha) (Lewis and Wilson, 2015).

2.6. Typology of rice farmers and processors

Mbomba *et al*., (2009), based on a study by Primo *et al*. (2006) stated: "*Angolan agricultural sector is dominated by family farms which represent almost all production units, since the business units represent only 0.2% of the total. In terms of area occupied, the situation is slightly different, the business units occupying about 40.7% of the area. As a result of this duality between number and area, the average area of family units is quite small, about 1.37 hectares that contrasts with the 515.1 hectares of the business sector*".

As in other Sub-Saharan African countries, (Uganda, Tanzania, Nigeria, Mozambique and Ghana) most of the rice produced in Angola is under the control of small farmers (Sie, 2010). These small farmers, managed by women, men and young people, produce rice mainly for domestic consumption and the surplus, if it exists, is sold at local markets or directly to the final consumer. Some of them exchange their surplus rice production with the seed for the next agricultural season.

Kilimo, (2012) classifies rice farmers into three categories:

i) *small-scale farmers* who constitute about 80% of all the rice farmers and cultivates less than 2 hectares of land using rudimental technology;

ii) *medium-scale farmers* who constitute about 15% of all rice farmers and cultivate between 2 and 6 hectares of land using variable technology;

iii) *large-scale farmers* who constitute about 5% of all the rice farmers and cultivates over 6 hectares of land normally included in rice irrigation schemes using more advanced technology.

In spite of this typology, most rice farmers cultivate less than 1 hectare of land according to the author. Although the total number of farmers engaged in rice cultivation is unknown, official sources from the Institute for Agrarian Development (IAD) estimate that in the agricultural campaign of 2015/2016 about 1,269,159 families were involved in Family Farms Holdings (FFH), cultivating maize, rice, beans, massambala (*Sorghum vulgare*) and potatoes. The same report highlighted the number of Entrepreneurial Agricultural Holdings (EAH) which was about 12,892 (IAD, 2017). The productivity reached for rice cultivation in the same year was 1.23 tonnes/hectare in FFH and 2 tonnes/hectare in EAH (CEIC, 2017).

Table 2.1 describes the six large-scale farms existing today in Angola with rice production areas ranging from 2,000 to 10,000 hectares.

Table 2.1. **Presentation of large-scale rice farms today existing in Angola.**

Designation	**Total available area (ha)**	**Total cultivated area (ha)**	**Location**
Sociedade Arrozal de Kamacupa	2,000	500	Kamacupa – Bié
Fazenda Longa	3,000	1,500	Cuando-Cubango
Fazenda Agro-Industrial de Sanza-Pombo	10, 000	5,000	Uige
Fazenda de Ombandja	5,000	2,000	Cunene
Capanda Polo Development Society	300	100	Malange
Fazenda Agro-pecuária	10,000	6,000	Moxico

Source: Brautigam (2015).

All the farms are state property, except *Rice Kamacupa Society* that is private

(Brautigam, 2015). Most of these farmers are sponsored by GESTERRA[5] and CAMCE[6] (Brautigam, 2015).

In the years 1960s to 1970s, before the armed conflict, the country had 26 rice processing factories in full operation with production capacities varying from 1 to 12 tonnes in 8 hours (Diogo, 1956). Table 2.2 shows the existing rice mills factories in Angola that, are still inoperative as result of the conflict.

Table 2.2. Rice mills inoperative existing today in Angola.

Province	Number	Production capacity (tonnes in 8 hours)	Location
Benguela	1	1	Lobito
Bié	7	1 – 12	Kuito, Catabola, Kamacupa
Cuanza-Sul	3	1 – 3	Gabela, Seles
Lunda	2	2 – 10	Minungo, Saurimo
Malanje	4	2 – 10	Malange, Capunda, Songo, Katepa
Moxico	3	4 – 12	Cavungo, Vila Luso, Lumeje
Huila	2	3 – 8	Lubango, Dongo
Zaire	4	2 – 3.6	Damba, Negaje, Sanza-Pombo, São Salvador

Source: Adapted from Diogo (1956).

Currently paddy[7] is hulled manually, using a mortar and pestle. Each rice-producing family has one of these artefacts, which process almost 90% of the rice produced. Normally rice processed in this way is only for own consumption, because the quality of the final product is not attractive in the market. Most consumers prefer imported rice (IAD, 2017).

In some regions, such as Moxico and Lunda Norte, paddy rice is sold to local or regional traders who use small local mills to process it. Some paddy production is also sold directly to mill owners, who in turn sell their processed products to merchants and

[5] GESTERRA – Arable Land Management is a public limited company incorporated in 2004 by public funds and protected by the Angolan Ministry of Agriculture. http://www.gesterra.angola.com/projectos.php.
[6] CAMCE is, a subsidiary of the China National Machinery Industry Corporation, proposed to Construct mills.
[7] "paddy", i.e., what has been harvested from the field and threshed but not yet milled

rural families. There is a very limited value addition, particularly in the hulling stage, because most small factories have antique and low quality processing machines generating a high percentage of broken grains (IAD, 2017)[8].

At the level of the Angolan agribusiness sector, there are 4 units of rice mills in operation, one in Sanza Pombo (Uíge) with a capacity of 1,200 tonnes/month, two in Malanje and in Cuando Cubango with a processing capacity of 40 tonnes of rice per day each, and one in Bié with a capacity of 3,800 tonnes /month (CEIC, 2017).

The rice produced in these units is packed in 50 to 100 kg bags and most of it is supplied to the armed forces in the provinces of Benguela, Luanda and Moxico. In addition, they provide seeds to local farmers through the Agrarian Development Station (ADS). The idea of the entrepreneur is to buy rice from small farmers as a way to encourage them to increase the area of cultivation. Some medium and large processors pack and sell their rice, practicing prices that vary according to the needs and the purchasing power of local markets (IAD, 2017).

2.7. Respective roles of women, men and youth

Men and women farmers have different responsibilities in the rice production systems. Their tasks vary from region to region. According to FAO[9], women play an important role in the food security process, as they form the majority of the workforce in agriculture (Msaki *et al*., 2015). Women are also involved in all aspects of the rice value chain, particularly planting, weeding, bird scaring, harvesting, processing and trading. On the other hand men are mostly involved in the land preparation works. Both, men and women are engaged in rice harvesting and threshing (Rahman *et al.*, 2016).

[8] The price of hulled rice is more or less: Price of hulled rice = (price of paddy)*(1/hulling ratio) + hulling costs

[9] www.fao.org/rice2004/en/f-sheet/factsheet9.pdf

Although women are the key factor in the value chain process, their contribution is often neglected in terms of salary, access to credit, and decision-making compared with men. So, an effective strategy could be the promotion the role of women in decision making, awarding them dignity and esteem (Msaki *et al*., 2015; Lahore *et al*., 2016).

Rural life is becoming increasingly less attractive to young people who are less involved in rice production. Most of the youth prefer to seek jobs in urban areas. Low profitability, poor security of land tenure and high risks are just some of the reasons why youngsters are leaving rural areas to seek jobs in cities. This causes a danger to future production and food security (Shah, 2017). Growing youth unemployment, ageing farmers and declining crop yields under traditional farming systems requires engaging youth in agriculture a high priority (GRisp, 2016; Shah, 2017).

A study conducted by Lewis and Wilson (2015) in Tanzania, Ghana, Mali and Nigeria showed that small farmers have limited access to market-focused value chains. Their main selling points are the small traders, and many of them are farmers who buy paddy for the purpose of seed (which, frequently, is sold below the fair price). Poor road access and long distances from major urban markets are further barriers that impede not only small farmers becoming larger, but also the development of more trade-focused companies with stronger linkages to markets. Overcoming these obstacles would further facilitate the adoption of technology, which in turn would increase productivity.

2.8. Limiting factors

The problem of rice production in Angola is already well studied, therefore it is only necessary to enter the phase of practical realizations. From the colonial past when the country was producing for export, the seed problem was already considered to be one of the most pressing, with high percentages of cracks outside world standards, lack of purity of variety, presence of foreign seeds in lots that caused the occurrence of many red berries, which commercially devalues the product. The presence of savage forms of rice that stay on the ground also contributes to adulterate the cultural variety. Today the official services do not have an organism for seed certification, so it has been the responsibility of the producer to obtain his own seed (Diogo, 1956).

In other hand the thin infrastructure development as a legacy of insecurity in areas formerly held by UNITA; the farm location with respect to markets, the transport costs, the behaviour of the real exchange rate causing input price distortions, namely in seed, fertilizer, and machines, the fragmented rice value chain, lack of adequate rice milling facilities; high production costs; poor infrastructure; lack of adequate human resources in the value chain and inadequate policy environment. These and others are some of the main factors limiting the increase in rice production in Angola. Despite these challenges, it is possible to transform the Angolan rice sector into a competitive, income and employment generating sector.

2.9. Strategies for rice development in Angola

It is essential to conduct studies on rice production, industry and trade, and there are several models that can be taken as references. Some such as those from FAO[10] were used in many sub-Saharan African countries and the results were promising.

Considering the situations of rice cultivation in Asia, and in African countries such as Tanzania, Ghana, Uganda, Mali, Nigeria and Kenya in terms of production, industry and trade (Seck *et al.*, 2012; MAAIF, 2012; Kilimo, 2012) it is useful to try to identify the analogies and differences that result if we compare the rice activity of Angola and

[10] http://www.fao.org/docrep/003/x2243t/x2243t05.htm

those countries.

When we look at the situation of rice in these countries, we can see that the lines of action that currently are widely adopted are:

a) Adaptation to Irrigation;
b) Increase in the use of fertilizers;
c) Study of varieties adapted to the environment;
d) Establishment of the most rational pricing policies.

Regarding these items, we have already tried to give a detailed account of the way in which they have been tried to solve them. So it seems to us of great interest to compare such solutions with the rice policy of Angola, in what concerns promotion and commercialization.

In Ghana, the model used to promote sustainable rice production consisted in using a combination of strategies including different times of planting, water management control practice, use of fertilizers, choice of rice variety to plant, and use of herbicides (Tabi *et al.*, 2012). Mali created a Participatory Modelling Applied to Seed Systems involving different stakeholders (farmers, FOs, NGOs, research groups, seed growers, etc.). The model allows to simulate favourable mechanisms for conservation, maintenance and use of varietal diversity in family farming systems (Clavel *et al.*, 2015).

In Uganda the increase in production of rice is attributed to a combination of factors such as: appropriate government policy, intensive promotion of the commodity, availability of improved rice varieties and other relevant technologies and the increased consumption of rice driven mostly by rapid urbanization as well as the relatively high rate of population growth (Kilimo, 2012).

Based on those positive political will and interventions that produced outstanding achievements we understand that to realize the potential and capitalize on the current demand-driven production momentum for Angola, there is a need to inject adequate technological and financial investments into the rice sector. Such investment in innovation platforms would galvanize the whole value chain and the resulting scaling-out of relevant technologies would ensure sustainable rice production.

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CHAPTER 3. CHARACTERIZATION OF THE RICE PRODUCTION SYSTEM IN CAMACUPA AND CATABOLA MUNICIPALITIES OF THE PROVINCE OF BIÉ IN ANGOLA

Abstract

An assessment of rice production and processing in Camacupa and Catabola municipalities of the province of Bié in Angola was carried out in this research. Results revealed that 61% of farmers in those two municipalities use manual labour in seedbed preparation, while 49% use tractors but complemented with manual instruments. It was also observed that the farmers in the study area predominantly used 12-24-12 (N-P-K) and ammonium sulphate (NH_4SO_2). The application method was mostly by manual broadcasting over the planted area. Results also recorded that rice harvesting usually takes place from May to June. The paddy yield varied from 200-1800 $kg.ha^{-1}$ depending upon the availability of resources, management of crops and the socio-economic status of the growers. The paddy results are packed in a bag, mainly, or in a bottle, if it is destined to seed. Results also showed that mechanization of rice production and processing had not received much attention since most farmers still use the traditional manual labour and traditional in the production and processing of rice. We have also found that rice productivity is positively correlated with the level of education, the tractor usage, the rate of application of fertilizers, the sowing date (the later the better, the line coverage, the place of sale (in markets is better) and the processing methods (mechanized is better). On the other hand, productivity is negatively correlated with the municipality (Catabola is better), the village (Ndembei, Kalila and Kalohuma, are better) and the age of the farmers (i.e. the younger, the more significant workforce and higher productivity).

Key words: Rice Production, Processing, Traditional and Business sectors.

3.1. Introduction

Rice production systems vary significantly from country to country as well as from location to location, which affects the performance and the potential of its production. Rice is cultivated under temperate, subtropical, and tropical climatic conditions with weather varying from arid and semiarid to sub-humid and humid (Rao *et al.,* 2017; Okeke & Oluka, 2017). The cultivation of rice begins with land preparation to prepare the seedbed, which could include land clearing, construction of dykes, soil tillage, ploughing and levelling with the aid of earth-moving equipment, depending on the size of the farm (Ayanda & Folounsho, 2019). After land preparation, planting begins by planting either water-soaked rice or dry rice seeds. Seeds can be sown either manually (in small farms) or mechanically (in large farms), but in developed countries, low flying planes broadcast rice seeds onto already prepared fields (Oluk and Okeke, 2017). If rice is not planted directly in the field, after a month or less of growth, the seedlings are transplanted in bunches from nursery beds to the main field (Oluk and Okeke, 2017). First, weeding is done 1 month after transplant or 21 days after germination for those planted directly in the field. Second weeding is generally done 36 days after the first weeding (Okeke & Oluka, 2017). According to (Corranza & Treakle 2014; Carriço, 2017), 60% of African farmers use manual labour since sowing to processing.

Threshing of rice follows the harvesting operation, and in a full-mechanized system, harvesting and threshing are done simultaneously with a combined harvester. After harvesting, rice is threshed manually or mechanically, and it is packed in bags of 10, 25 or 50 kg. Before milling, rice grain is dried in order to reduce the moisture content to about 19% to avoid breakage of seeds during milling (Oluka and Okeke, 2017). The drying can be done naturally by sunshine spreading the rice on the tarpaulin (developing countries), or by drying machines through artificially heated air (developed countries). After rice is processed at a mill using automated processes. The paddy rice undergoes many processes like hulling, polishing, grading, destoning, etc., before marketing or storage (Oluka and Okeke, 2017). Traditional or mechanized methods mostly do the production and processing of rice in Central Plateau of Angola. Studies conducted by Chiambo *et al*., (2019) showed that there are two types of rice production systems, namely the permanent flood system, which is much practised by the business sector, and the rain-fed system, practised by the traditional sector.

The high level of food imports in the country demand adequate attention and assistance to the family farming and processors of agricultural food materials. Various agricultural wastes, such as rice straw, are being used for animal feed and manure. After maize and cassava, rice is one of the most valuable food staples for a large share of the Angolan population. However, mechanization of its production and processing in many rural areas has not received much attention, making production, processing and even storage difficult for the farmers.

The main issue of rice production in Central Plateau of Angola is that farmers face difficulties in its production and processing because of their inadequate knowledge of newer methods of land preparation such as tillage, seed planting or sowing, fertilizer application, weed and pest control methods, harvesting, threshing, processing and storage of the farm product.

The hypothesis is that if farmers thought of new methods of rice production and processing, one could expect an increase in output and consequently an income improve.

The agronomic practice is a vital issue that plays a crucial role in increasing crop productivity. However, we do not find any study to deal with farmers' practice, the productivity of rice crops and the representation of women in agriculture in particular in the Bié region. Thus, the present study was undertaken to generate valuable information regarding agronomic practice, the performance of rice cultivation in different seasons and roles of women in households in Camacupa and Catabola municipalities. Therefore, this research aims to obtain data on rice production and processing in Central Plateau of Angola, which will guide the government, the agricultural policymakers, the students and the researchers in devising measures for improving/ or mechanizing rice production and processing in the area.

The specific objectives of the study were as follows:

1. Describe rice cropping systems, the status of varietal adoptions, farmers' crop management practice and level of access to extension services;
2. Assess the profitability of rice grown in the different seasons; and
3. Evaluate the roles of women in farming and other decision-making processes.

3.2. Materials and Methods

3.2.1. Study area

The province of Bié has been purposely chosen for the reason that rice is historically cultivated in the region where its inhabitants cultivate rice by habit and/or tradition using rudimentary exploitation techniques. Rice cultivation in the province of Bié focuses mainly on river basins, wetland areas and highlands areas in the rainy season, involving poorly drained and periodically flooded explanations. Uncontrolled flood rice is produced with the highest specific incidence in the municipalities of Kamacupa and Catabola (Diniz, 1998). Our study is directed at these two municipalities of the province of Bié (Figure 3.1).

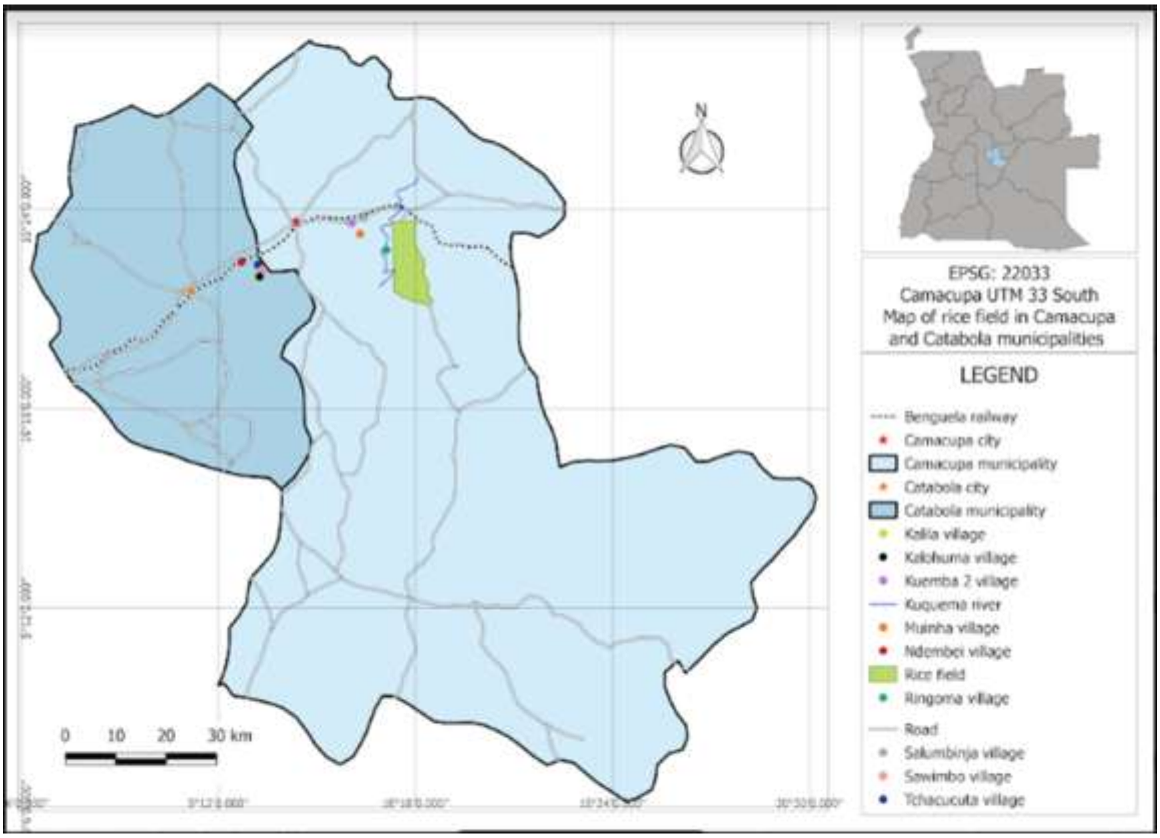

Figure 3.1. Camacupa and Catabola municipalities[11].

Kamacupa is a municipality of the province of Bié in Angola, located north of the capital city Cuito and represents the geodesic centre of Angola. It has 9,469 km2 and about 289 thousand inhabitants. It is bordered to the north by the municipalities of Nharea and Luquembe, to the east by the municipalities of Cuemba, Moxico and Lucha, to the south by the municipality of Chitembo and to the west by the municipalities of Catabola and Cuito. Catabola is a town and municipality in Bié Province in central Angola which is located 52.5 kilometres northeast of Cuito, and 15 kilometres on the road to Kamacupa and Catabola municipalities were purposely selected for this study based on their agronomic suitability and tradition of growing rice (Diniz, 1988; Chiambo *et al.*, 2019).

[11] Adapted by Quissindo, B.A.I

3.2.2. Methods

The study of the traditional rice sector included the collection of primary data through a semi-structured questionnaire and secondary data from published and unpublished reports.

The objective of the study was clearly explained to farmers for developing rapport with the villages to generate reliable data. The field survey was conducted covering all major rice-growing ecosystems of Kamacupa and Catabola municipalities to understand the cultural practices used by farmers, production constraints, type of variety of seed used and mode of implementation in the field.

The socio-economic profile, land ownership, rice management practices, biotic and abiotic stresses that limit rice productivity, harvest and post-harvest management practices and farmers perception on rice cultivation technology were also observed. Six villages out of 41 in Kamacupa and five villages out of 35 in Catabola municipalities covering all major rice-growing eco-systems were randomly selected. Catabola and Kamacupa have a total of 514,000 inhabitants spread over 76 villages, of which 1.903 are farmers involved in various agricultural activities (RGPH, 2014). The sample was chosen at random from rice farmers, covering 14.4% of villages (11) and 5.7% of farmers (110). The survey were done from June to October. Each farmer was individually surveyed in his/her own language while working in the field to ensure the reliability of their claims. Male respondents were asked about the role of women in household and agricultural activities and the participation of women in the decision-making process.

The total land area owned by farmers surveyed in both municipalities was about 15 ha. All 110 farmers surveyed practised dry seeding in rain-fed conditions. In order to understand the functioning of the rice value chain (rice row) in the business sector, an individual interview was done to the head of Farm Arrozeira Society of Camacupa. Also, the rice production system adopted in major irrigation and rain-fed rice ecosystems were also characterized. The data collected were cleaned before entering the computer and after they were treated and analysed by using the statistical program Statistica 10 version. The treatment of data involved Descriptive Statistics (expressed using numerical frequencies and percentages presented in descriptive statistical tables and figures), Analysis of Variance and comparison of means and multi regression methods.

3.3. Results and Discussion

3.3.1. Social characteristics of farmers

Table 3.1 presents the data of some of the social characteristics (Age, Marital status and Gender) of the 110 rice producers of the sample.

In terms of age, the survey showed that 35.45% of the respondents and rice producers are in the 40-50 age group, with a global age mean of 48.92 years. About 58% of the respondents are less than 50. Concerning the Marital status, most of the respondents are single but live in communion 75.5% (83)[12].

[12] In the sense of living without a civil or religious contract

Table 3.1. Social characteristics of the farmers (Age, Marital status and Gender).

Age				**Marital status (Ms)**			**Gender (G)**		
Years	**Freq.**	**%**	**Average (age)**	**Ms**	**Freq.**	**%**	**G**	**Freq.**	**%**
20-30	6	5,45		Single	83	75.50	Male	74	67.27
30-40	19	17.27		Married	17	15.45	Female	36	32.73
40-50	39	35.45		Widow	10	9.09			
50-60	35	31.82	48.92						
60-70	5	4.55							
70-80	6	5.45							
Total	110	100.00		Total	110	100.00		110	100.00

Source: Field Survey, 2018.

It means that middle-age farmers mostly practice rice farming. This finding is consistent with the findings of Faust & Christopher (2015), who reported that the mean age of rice farmers in their study was 49 years. It is only natural since the middle age classes, who are physically fit to withstand the stress and risks involved in rice production and are more mentally alert to embrace new techniques of production. Besides, male farmers, which represent 67.27% of sampled farmers, dominate rice production in the study area. This is in contrast to Ibitoye *et al.* (2012) who found out that there were more female rice farmers than males in their study area.

Table 3.2 presents data on other social characteristics (Years of Education, Household Number and Plot size) of the 110 rice producers of the sample.

Table 3.2. Social and economic characteristics of the farmers (Years of education, Household number and Plot size).

Years of education			Household numbers			Plot size (sq. meters)		
Years	**Freq.**	**%**	**Years**	**Freq.**	**%**	**Years**	**Freq.**	**%**
0	23	20.91	0	23	20.91	0	23	20.91
1	41	37.27	1	41	37.27	1	41	37.27
2	20	18.18	2	20	18.18	2	20	18.18
3	15	13.64	3	15	13.64	3	15	13.64
4	6	5.45	4	6	5.45	4	6	5.45
5	2	1.82	5	2	1.82	5	2	1.82
6	2	1.82	6	2	1.82	6	2	1.82
9	1	0.91	9	1	0.91	9	1	0.91
10	0	0.00	10	0	0.00	10	0	0.00
Total	110	100.00	Total	110	100.00	Total	110	100.00

Source: Field Survey, 2018

Theoretically, the level of education will favour the adoption of new technologies. Unfortunately, in our sample, less than 11% of the farmers have more than 4 years of education. Concerning the Household number, most of the respondents have less than 5 people (74; 67,3%). Lastly, the results showed that farmers in the study area are tiny-scale farmers (the mean plot size is 1360,52 square meters, and 98,18% of it are lower than 0,5 hectares) which makes mechanization difficult. This translates into the bulk of rice production for subsistence needs leaving little space for commercial purposes. Also, Ibitoye *et al.* (2012) and Faust & Christopher (2015) confirmed that (53.00%) of rice farmers in their study areas cultivated between 1-3 hectares.

3.3.2. Rice farmers experience the reason for growing rice and land tenure system

Table 3.3 shows that rice farming is practised amongst farmers in the study area (40,3% with less than 5 years of experience), with the average being 10,75 years. The table also explains the various reasons that have motivated farmers to engage in rice production. The main emphasis is that 80% (88) cultivate for reasons of habits or tradition of the village, while the minority does it for reasons of food taste 19% (21) and 0.9% (1) does it for test or pleasure. Concerning the land tenure regime, about 33,7% (37) are the owners of their plots, 21,7% (24) cultivate it under occupation, 20,4% (22) has been ceded to them by the interest shown in production. Within the remainder, 17,1% (19) cultivate lands inherited from their ancestors, and 7,1% (8) own the land for usufruct, a land tenure regime that imposes restrictions on long-term investments and loans.

Table 3.3. Rice farmers' experience, the reason for growing rice and land tenure system.

Experience in rice farming				**Rice growing**			**Land tenure system**		
Years	**Freq.**	**%**	**Average (Age)**	**Reason**	**Freq.**	**%**	**Tenure**	**Freq.**	**%**
0< x ≤ 5	44	40.30		Tradition	88	80.10	Proper	37	33.70
5< x ≤ 10	26	23.70		Taste	21	19.09	Occupied	24	21.70
10< x ≤ 15	16	14.40		Test/Pleasure	1	0.90	Ceded	22	20.40
15< x ≤ 20	12	10.90					Heritage	19	17.10
20< x ≤ 25	3	2.58	10.75				Usufruct	8	7.10
25< x ≤ 30	7	6.30							
30< x ≤ 35	1	0.91							
35< x ≤ 40	1	0.91							
Total	110	100,00		Total	110	100,00		110	100,00

Source: Field Survey, 2018.

3.3.3. Crop management practices

3.3.3.1. Equipment usage

The entire population sampled in the two municipalities uses manual instruments in all cultural operations, from soil preparation to processing. In our sample, 100% (110) use the hoe to prepare the soil, 11.8% (13) use rake for soil levelling, 50% uses machetes to cut trees, 70.9% (78) use knives and 29.1% (32) used sickles for harvesting. Only 49 farmers use a tractor at the first ploughing complementing the hoe, and a minority of 3 uses animal traction (3) (see Table 3.4).

Table 3.4. Types of equipment used in rice production.

Category	No	Yes	%age
Hoe	0	110	100.00
Rake	97	13	11.80
Machetes	55	55	50.00
Sickle	78	32	29.10
Knife	32	78	70.90
Tractor	61	49	44.50
Animal traction	107	3	2.70

Source: Field Survey, 2018.

Work from land preparation to processing relies mainly on the family's workforce. The lack of capital to finance the processing of rice prevents farmers from embracing rice production. Instead, they pay more attention to the production of beans, corn and vegetables, since these crops provide the income to supply the needs of their families.

The type of instruments and equipment presented above is an important indicator to measure the level of technological development of the agricultural producers surveyed. For now, the hoe, machete and knife are the visible faces of the technology used by the producers under study. It is still a rudimentary technology, although the use of mechanical traction is the only element that introduces a technological differentiation between cultivation practices.

3.3.3.2. Soil preparation, sowing and harvesting methods and time of crops

The research showed that the population of the sample was very heterogeneous concerning soil preparation. Since the production system is rain-fed, usually the soil preparation is done three months before sowing, beginning in July or August. In most cases, soil preparation begins with clearing the soil, joining and burning the grass, harnessing and spreading the ash over the ground. Figures in Table 3.5 show that 70% of farmers prepare the soil in August, 85 (77,2%) do the sowing in November and 69 (62,2%) harvest in June. While 30% prepare the soil in July, sow in October and harvest in May. It is clear from the survey that the land preparation practices adopted by farmers depend on their financial situation, plot size, soil nature and previous crop.

Table 3.5. Soil preparation, sowing and harvest month.

Soil preparation month	Freq.	%	Sowing month	Freq.	%	Harvest month	Freq.	%
July	34	30.00	October	25	22.70	May	41	37.30
August	76	70.00	November	85	77.30	June	69	62.70
Totals	110	100.00	Totals	110	100.00	Totals	110	100.00

Source: Field Survey, 2018.

Besides, tractors are unable to reach in the corner of the small plots so that farmers use spades to pulverize manually, which increases labour cost. When farmers use tractors for tillage, usually two passes are given by tractor for pulverizing the soil. Farmers mentioned that two passes by a tractor are adequate for making a good soil bed. The high rental charge of tractor represents a valid restriction for its adoption by many farmers.

Results also show that in all the sampled population in the studying area the rice is sowed directly at the definitive location, and the transplant method is not used, because it is rather laborious and does not compensate. Thus, approximately 56% of the farmers in the sampled area do direct sowing broadcasting, and 44% do the direct sowing in line, as shown in Table 3.6.

Table 3.6. Methods of land preparation and planting rice.

Propagation System			Land preparation		Planting method	
Transplanting (%)	Direct Seed on line (%)	Direct Seed broadcasting (%)	Manual (%)	Mechanical (%)	Manual (%)	Mechanical (%)
0	44.0	56.0	55.5	44.5	100	0

Source: Field Survey, 2018.

3.3.3.3. Rice varieties under cultivation

Table 3.7 illustrates the adoption rates for wide rice varieties in the 11 villages. *Carolino* and *Kessongo* were the major cultivars adopted by respectively about 53,6% and 23,6% of the farmers. *Cahilahila* and *Silewa* were adopted by respectively about 14,5% and 8,1% of the farmers respectively. The main motivations for adoption of different varieties included higher grain and straw yield, yield regularity, organoleptic properties and higher resistance to lodging and diseases.

Edible quality seeds are the main crucial component of crop production. Out of the 110 farmers interviewed, 82% acquire self-produced seeds, in the local market or neighbouring farmers; the other 28% (20) get it from the official Agriculture Department. Boloch *et al.* (2004), doing a similar study, also found that there was a high dependence on self-produced seeds that were not cleaned, stored or processed according to standard procedures.

The seed rate was found to be uniform (80 $kg.ha^{-1}$) and higher than that for official Agriculture Department recommendation (65 $kg.ha^{-1}$). It may be because farmers have a lack of knowledge on seed rates and germination rates of household seed are low.

Table 3.7. Seed varieties, sources and selection criteria.

Seed varieties			Seed sources			Selection criteria		
Varieties	**Freq.**	**%**	**Sources**	**Freq.**	**%**	**Criteria**	**Freq.**	**%**
Kessongo	26	23.6	self-produced, local market or neighbouring farmers	90	82.0	Yield	34	30.9
Carolino	59	53.6				Regularity	9	8.1
Cahilahila	16	14.5	official Agriculture Department	20	28.0	Flavour	40	36.3
Silewa	9	8.1				Resistance	27	24.5
Total	110	100	-	110	100	-	110	100

Source: Field Survey, 2018.

3.3.3.4. Pests, diseases and weed control

The enemies of the crop are related to the presence of weeds, pests and diseases. Weed flora varies from place depending on the type of soil and the cultural practices. Weeds are an essential biological constraint because they emerge simultaneously with rice seedlings. Weed control is not made by 54,5% of farmers in Camacupa municipality; this is due to the method of rice seeding in the field (direct broadcasting). For those who make manual weed control, 39% of farmers perform only one intervention and 6,3% only two (see Table 3.8); the average number of controls was bigger in the municipality of Catabola.

Table 3.8. Crop Control and number of controls.

Culture control enemy			Number of controls		
Category	**Freq.**	**%**	**Category**	**Freq.**	**%**
No control	60	54.5	0	60	54.5
Manual	50	45.5	1	43	39.0
Chemical	0	0.0	2	7	6.3
Total	110	110	-	110	100

Source: Field Survey, 2018.

All farmers in the sample reported that the most frequent diseases affecting rice are Brown rot sheath (*Pseudomonas fuscovaginae*) and Brown spot (*Cochliobolus myabeanus*). The most frequent pests are rice grasshopper, rice beetle, "saliva animal", birds, hippopotamus and rabbits. The control of pests and diseases is similar to that of weeds; only 45,5% of the farmers control rabbit attacks through the use of traps. Farmers do not have any control over the rest of the plagues.

3.3.3.5. Fertilizer usage, origin and transportation

Availability and application of organic fertilizer have been decreasing over time due to the reduction of the cattle number per household in the villages. Therefore, today, farmers are entirely dependent on chemical fertilizer for cropping, and the rate of application of the fertilizer has been increasing. Farmers apply fertilizers into two different top-dresses. The first top-dress includes 12-24-12 (NPK), while the second top dress includes ammonium sulphate (NH_4SO_2). Just a small number of all farmers interviewed were aware of and applied the recommended dose of fertilizers. However, the dose of fertilizers varied from 0-350 kg.ha^{-1} in the case of 12-24-12 (NPK), to the same amount in the case of ammonium sulphate. About 55% of them did not apply any type of fertilizer and 45% used between 50 and 317 kg ha^{-1} of dose 12-24-12 (NPK), and ammonium sulphate ($NH4SO_2$) (see Table 3.9). On average, farmers applied 84 kg.ha^{-1} of 12-24-12 and 60 kg.ha^{-1} of ammonium sulphate.

Table 3.9. Fertilizer rate application.

Rate (kg ha^{-1})	Ammonium Sulphate			
	Freq.	**%**	**Freq.**	**%**
0.00	60	54.55	61	55.45
0< x ≤ 50	1	0.91	1	0.91
50< x ≤ 100	7	6.36	12	10.91
100< x ≤ 150	3	2.73	23	20.91
150< x ≤ 200	27	24.55	10	9.09
200< x ≤ 250	7	6.36	2	1.82
250< x ≤ 300	1	0.91	0	0.00
300< x ≤ 350	4	3.64	1	0.91
Total	110	100.00	110	100.00

Source: Field Survey, 2018.

Research has shown that fertilizers are purchased in the formal or informal markets or the services of the Department of Agriculture (see Table 3.10). Of the farmers acquiring fertilizers, 16% bought it in the formal/informal markets and 29% in the Department of Agriculture. From purchase to destination, the fertilizer was transported by car (31,8%), hand (3,6%), hand car (1,82%), motor taxi (7,27%) or unknown means (54,55%).

Table 3.10. Source and means of transportation of the fertilizer.

Source of fertilizer	Freq.	%	Means of transportation	Freq.	%
Formal/Informal Markets	18	16.36	Car	35	31.82
Official Services	32	29.09	Hand	5	3.64
None	60	54.55	Handcar	2	1.82
			Motor taxi	8	7.27
			Missing	60	54.55

Source: Field Survey, 2018.

3.3.3.6. Harvesting and threshing

Rice in Catabola and Camacupa is mainly harvested and threshed manually. Harvesting is done in May and June when the whole plant is yellow, and 5 to 10 per cent of grains are dry, upon a tooth test to determine the moisture content. Another critical determinant factor for the time harvest is the frequent presence of birds on the panicle and the panicle inclination. About 58% of the harvest and 93% of threshing is made by M/W[13], followed by 38% of the harvest made by M/W/C[14] and 4 % of threshing made by M/C[15] (Table 3.11).

Table 3.11. Harvest and threshing acts.

Category	Harvest act		Threshing act	
	Freq.	%	Freq.	%
M/W	64	58.18	102	92.73
M/C	4	3.64	4	3.64
M/W/C	42	38.10	3	2.73
W	0	0.00	1	0.91

Source: Field Survey, 2018.

[13] M/W-men and women
[14] M/W/C-men, woman and child
[15] M/C-men and child

In harvesting activity, about 70,9% use knives and 29.1% use sickle (Table 4). Male and female farmers then carry the harvested paddy to a threshing floor that was previously prepared by removing weeds, sand and other debris. The threshing is done slowly to avoid breaking the rice grains using traditional harvesters. Then, using a special wooden stick, seeds are separated from straw in a very labour and time-consuming process. On average to thresh 1 hectare of paddy field requires 13–15 person-days of about 12 hours. With this method, the seed breakages and the contamination with sand are high. According to Weerakom *et al.,* (2010), this method of threshing is now seldom practised, and threshing is now done by trampling rice using a 4-wheel tractor or mechanical thresher. As the labour requirement for harvesting and threshing is high, mechanization is essential for sustainable rice production.

3.3.3.7. Processing and storage

About 86.3% of the rice produced is processed manually using traditional mills or mortars. The remaining 13.6% of the farmers use the husks available in the Department of Agriculture[16], that has a small processing capacity of 500kg.hour^{-1}. The artisanal processing results in grains of poor quality, less attractive to the consumer, which then prefers the imported rice. About 84% of processing is made by M/W[17], and about 85% of storage is made in bags (Table 3.12).

[16] There are only two processing machines located one in the department of the agriculture of the municipality of Catabola and another in the municipality of Camacupa.
[17] M/W-men and women

Table 3.12. Processing and storage acts.

Processing act			Storage act		
Category	**Freq.**	**%**	**Category**	**Freq.**	**%**
M/W	92	83.64	bags	93	84.55
M/C	2	1.82	bottle	11	10.00
M/W/C	5	4.55	Mat container	6	5.45
W	11	10.00	-	-	-

Source: Field Survey, 2018.

3.3.3.8. Yields (paddy rice)

The paddy yield varies from 200 to 1800 kg/ha depending upon the availability of resource crop management and the socio-economic status of the growers (Table 3.13).

Table 3.13. Paddy yield.

Yield (kg/ha)	Frequency	%
$200< x \leq 400$	2	1.82
$400< x \leq 600$	6	5.45
$600< x \leq 800$	45	40.91
$800< x \leq 1000$	24	21.82
$1000< x \leq 1200$	18	16.36
$1200< x \leq 1400$	7	6.36
$1400< x \leq 1600$	6	5.45
$1600< x \leq 1800$	2	1.82

Source: Field Survey, 2018.

As table 3.13 shows 40, 91% registered a yield from 600 to 800 $kg.ha^{-1}$; 21, 82% registered a yield from 800 to 1000 $kg.ha^{-1}$ and only 1,82% of the farmers reached yields from 1600 to 1800 kg.ha^{-1}. On average, the total yield was 894,38 kg.ha^{-1} (with a minimum of 359,71 kg.ha^{-1}; and a maximum of 1800,00 kg/ha.

3.3.4. Differences between the two municipalities

Table 3.14 gives a statistical description of the means of several variables that allow determining the difference between the rice producers of the two municipalities.

Table 3.14. Catabola and Kamacupa mean several socio-economic variables (*).

Variable	Catabola	Camacupa
Age*	44.64	52.48
Years of education*	2.08 a	1.28 b
Household number*	4.50	6.85
% of agricultural labour*	0.91	0.97
Rice cultivation experience	11.38	10.23
Productivity (kg. ha^{-1})*	1076.21	742.85
Application rate of fertilizer 12-24-12 (kg. ha^{-1})*	163.71	17.48
Number of controls*	0.90	0.20
Application rate of fertilizer ammonium sulphate (kg. ha-1)*	117.36	11.38

Source: Field Survey, 2018.

* variable means of the two municipalities are significantly different by F test (N=110; df:108; $p<0,05$)

According to Table 3.14, the significant differences observed between the two municipalities are the age of the farmers, the level of education, the number of households, the time devoted to agricultural work, the productivity achieved, the application rates of fertilizers and the number of controls of crop enemies. Catabola, compared to Camacupa, has a younger population, a higher average level of education, a higher household number, slightly more years of rice cultivation experience, higher application rates of fertilizers, more control number of crop enemies and, consequently, higher rice productivity.

3.3.5. Productivity, correlated and main explanatory variables

In order to establish the relationships between the different variables and productivity, we have explored the data through a correlation analysis. Table 3.15, synthesizes the statistically significant correlations (positive or negative) that we have found. From it we can deduce that rice productivity is positively correlated with the level of education (i.e., the higher the level of education, the greater the capacity for technological perception and adoption), the tractor usage (that accelerates fieldwork and allows to extend the cultivation of the fields), the rate of application of fertilizers; the sowing date (the later the better), the line coverage (i.e., involving all the family work force - M/W/C - is better), the place of sale (in markets is better) and processing methods (mechanized is better). On the other hand, productivity is negatively correlated with the municipality (Catabola is better), the village (Ndembei, Kalila and Kalohuma, are better) and the age of the farmers (i.e. the younger, the greater workforce and higher productivity).

Table 3.15. Significant Correlations between variables and productivity (p<0,05).

Variable	Productivity
Municipality	-0.529630
Village	-0.329861
Age	-0.279742
Years of education	0.204840
Tractor usage	0.493386
Rate of application of fertilizer 12-24-12 (kg/ha)	0.557567
Rate of application of fertilizer ammonium sulphate (kg/ha)	0,575979
Total fertilization cost (kg/ha)	0.589286
Sowing month	0.204935
Ground cover	0.305833
Place of sale	0.335937
Processing methods	0.317724

Source: Field Survey, 2018.

Finally, we have tested a step-by-step forward multiple regression analysis to identify the variables with the most significant explanatory power on final productivity achieved by the producers (Table 3.16).

Table 3.16. Regression Summary for Dependent Variable: Productivity (kg/ha).
(Adjusted R^2= 0,561; F(5,95)=26,558; p<0; Std. Error in estimate: 199,25)

	b*	Std.Err.	b	Std.Err.	t(95)	p-value
Intercept			-25844.487	10,449.469	-2.473	0.015
The first variable to enter: Number of controls	0.506	0.082	244.127	39.678	6.153	0.000
The second variable to enter: Age	-0.186	0.073	-5.125	2.026	-2.529	0.013
The third variable to enter: Processing methods	0.214	0.074	180.225	61.983	2.908	0.005
Fourth variable to enter: Sowing month	0.208	0.067	153.340	49.204	3.116	0.002

Source: Field Survey, 2018.

From the previous table, we can conclude that the final production achieved can be primarily explained by four variables: Number of controls (with an explanatory power of 43%); Age of producers (with the extra explanatory power of 2,5%), Processing method (with the extra explanatory power of 6,5%) and Sowing month (with the extra explanatory power of 3,8%). Those four variables have a total explanatory power of the productivity achieved by the farmers of 55,8%.

3.3.6. Gender and labour questions[18]

Men and women have different responsibilities in rice production systems. In the sampled area of this study, it was observed that women constitute bulk rice farmers. However, women have significant participation in various specific tasks of the cultivation of rice, such as transplanting/sowing (34 W; 69 M/W) weeding (11 W; 42

[18] The categories that we have considered are: M – man; W – woman; C – children, and the combination of those three (M/W; M/C; W/C; M/W/C).

M/W), harvesting (64 M/W; 42 M/W/C), threshing (101 M/W; 1 W; 3 M/W/C) or processing (92 M/W; 11 W; 5 M/W/C). These differences in gender roles are not always noticeable, but they must be recognized if rice production is to be increased, especially among the small-scale farmers. From Table 3.17, it seems that it is the man's specific tasks cutting trees (107) and opening the grooves (49). In the majority of cases, men only help women in tillage, weeding and ground cover, harvesting, threshing, and processing things that are traditionally the domain of women. Sometimes they also involved children, in several field activities, namely in bird and rabbit control.

The gender roles and responsibilities indicate how much time different household members devote to different tasks (and why) and shows how these tasks change according to the season and time of the day.

Table 3.17. Gender and labour questions.

Category	M	W	C	M/W	M/C	W/C	M/W/C	None
Tree cutting	107	-	-	2	1	-	-	-
Tillage	6	-	-	93	3	-	8	-
Clearing the field	24	-	-	34	2	-	50	-
Opening the grooves	49	-	-	-	-	-	-	61
Sowing	7	34	-	69	-	-	-	-
Ground cover	1	-	9	68	11	3	18	-
Bird control	9	-	93	-	8	-	-	-
Rabbits control	7	-	21	-	32	-	-	50
Fertilization	21	9	-	21	-	-	-	59
Weeding	2	11	-	42	-	-	-	55
Harvest	-	-	-	64	4	-	42	-
Threshing	-	1	-	102	4	-	3	-
Processing	-	11	-	92	2	-	5	-

Source: Field Survey, 2018.

The survey revealed that the participation of women in intercultural activities (e.g., tree cutting, opening grooves, and birds and rabbits control) is scarce. However, Figure 3.2 shows that the participation of male, female and children in farming reveals the substantial importance of the women in the crop system.

Women's contributions in decision making about farming, in particular, the selection of crops and crops cultivars to be grown in sowing, planting and harvesting dates as well as in hiring and selling labour is also negligible. However, women had equal roles as their male counterparts in decision making on buying and selling of property and livestock, the same occurring in the participation in borrowing groups and deciding marriage of children.

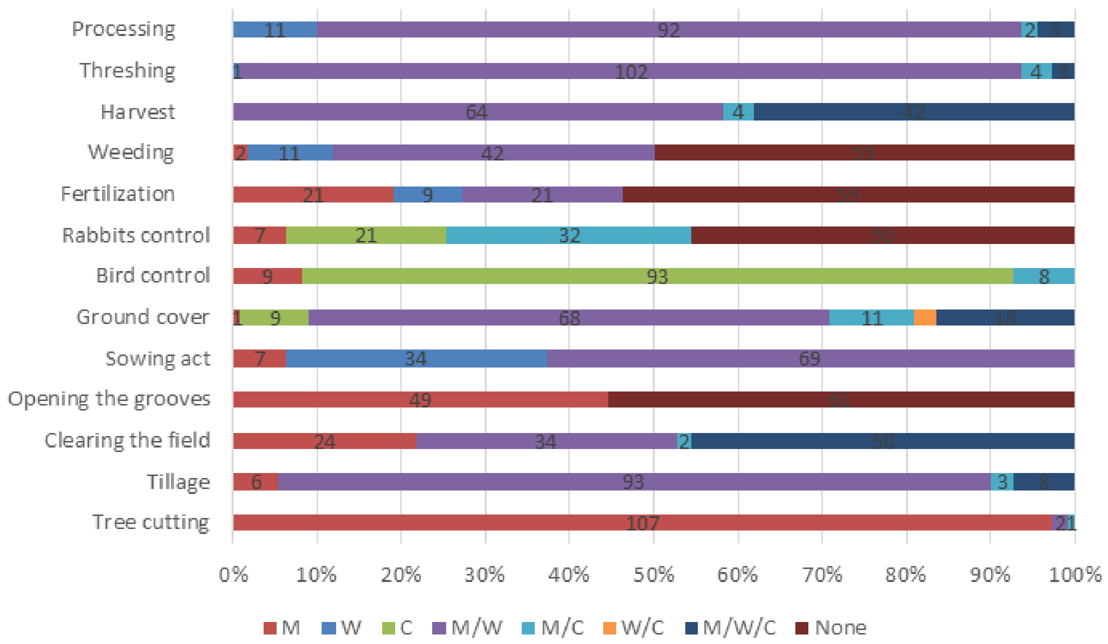

Figure 3.2. Labour and Gender usage.
Source: Field Survey, 2018.

3.3.7. The rice production system of the business sector in the study area

Previous studies by Chiambo *et al*., (2019) have shown that there are two types of rice production systems in Camacupa and Catabola municipalities, namely the "*permanent* *flooding system*" practised by the business sector and the "*rain-fed system*" practised by the traditional sector. In order to understand and contrast the differences between those two systems, a questionnaire interview was applied to the head of Farm "*Arrozeira Society of Camacupa*". The following results come from that questionnaire.

3.3.7.1. Characterization of the farm "Arrozeira Society of Kamacupa"

The farm is located in the southeast of the Camacupa Municipality, and it is irrigated from the Kuquema River. The farm, with a total area of 500 hectares, has a road network system, an irrigation system, with two pumping stations with six turbines, each turbine pumps 300 $l.s^{-1}$ of water, a drainage system and irrigation ditches. The sizes of the beds vary according to the topography of the land. In areas with regular geometry beds, dimensions vary from 34-38 hectares, and in irregular geometry areas, bed dimensions vary from 4-9 hectares. One of the fundamental aspects is the total independence of each plot in terms of the flooding and drainage. This is possible, given the well-carried levelling of the land.

3.3.7.2. Soil Preparation at the level of the business sector

The levelling of the ground is an aspect that deserves more attention during the preparation of the soil because when it is poorly done, it hinders the drainage and the aeration of the soil and the nutrients are easily dragged. This operation is carried out by means of a tractor that draws a levelling blade controlled by a system emitting laser beam that allows maintaining the same dimension of the ground, leaving it as uniform as possible.

Regarding laser land levelling, Meena *et al*., (2014) advocate that this system allow the levelling between 0 to 0.2% slopes so that there is a uniform distribution of water, enhancing resource use efficiency. Land laser levelling allows a 4% rise in area under cultivation due to the removal of bunds and channels; saves 10-15% water due to uniform distribution; increases resource (N and water) use efficiency; reduces the cost of production and enhances productivity. A precisely levelled field is, therefore, an essential prerequisite for successful direct-seeded rice cultivation.

3.3.7.3. Ground correction

For acidity correction (pH=4, 5) of the soil, it is applied 1 ton ha^{-1} of calcium carbonate ($CaCO_3$), adding up to 500 tons for the total cultivated area.

3.3.7.4. Fertilizing

Although the soil contains a good percentage of organic matter which the content is in the order of 7,4% (Gonçalves, n/d), it is necessary to balance the content of phosphorus (P_2O_5) and potassium (K_2O), because the soil levelling process causes a nutrient imbalance in the soil. Thus, 1.000 kg/ha of complex fertilizer containing 7-14-14 (N-P-K) and 3-2-9 (Ca-Mg-S) and vestigial concentration of boron (B), is also applied. This operation is carried out by means of a fertilizer spreader and tractor.

3.3.7.5. Chemical weeding

In order to prevent the growth of weeds, a pre-emergent herbicide with a concentration of 10 litres of glyphosate in 250 litres of water per hectare is applied.

3.3.7.6. Sowing

The type of sowing is direct and is done mechanically. On average, 65 kg/ha are sown in rows of 20 cm apart and at a depth of 2 to 3 cm.

3.3.7.7. Varieties

The seed variety used is type UN10 from the Chinese company WINA ll Seeds. Before sowing, a germination test is made. This consisted of placing 100 seeds in water for 7 days, and that resulted in a 98% efficacy of germinated power. The UN10 has a cycle of 150 days, meaning that, if the sowing date is late, this cycle is forced, implying early maturation, and thus compromising the yield of the crop. Thus, it is essential that the sowing date occurs in the months of October to November, never going beyond mid-January.

3.3.7.8. The flood of beds

The process starts 3 days after sowing and uses two turbines pumping 600 $l.s^{-1}$ of water with the engine running 24 hours a day. At the same time, the irrigation channel floodgates are opened to allow gradual flooding of already sown plots. It usually takes 48 hours of continuous water flooding to achieve soil saturation. The expected productivity with this technology is around 6.000 kg/ha.

3.3.7.9. Production destination

The rice produced is harvested with 20 to 21% moisture content, then artificially dried to 13% moisture and, finally, stored in the husk. Afterwards, it is peeled, bagged and sold. Potential buyers are the armed forces, the population of different points of the country in particular of the provinces of Bié, Huambo, Benguela and Moxico. The company supports the Agrarian Development Institute by distributing seeds to farmers to promote rice production in every municipality. This data is essential to map the market chain.

3.3.7.10. Water management

As a permanent flooding system, the farm has the Kuquema River as a source of water. Once the cultural cycle is finished, the extra water is drained back into the river. When the water level in the Kuquema is high, this drainage needs to be done with the support of the Pumping Station. This data is vital for assessing the environmental impact of wastewater on the Kuquema River aquatic ecosystem.

3.3.8. Differences and Similarities between the business and the Traditional Rice Sectors

Table 3.18 refers to the factors that make it possible to distinguish the two production systems in terms of the technology used.

According to this data, it is noticeable that there are great differences in terms of the Systematization of the field, the Cultural Operations, the Harvest, the Threshing, the Processing and the Destination of production and in the equipment used. However, there is the similarity that both the business and the traditional sectors use the direct sowing method. The difference is that while for the traditional sector, the sowing method is manual, and in most cases, it is broad casting, in the business sector, it is entirely mechanized**.** The rice value chain in the business sector is complete, whereas, in the traditional sector, it is very fragmented and has no mechanized tools for processing rice to obtain grain quality.

Rice cultivation in the traditional sector is motivated by the food family needs, the tradition, the habits and the customs of the region, while for the business sector cultivation is motivated for commercial purposes, which imposes the permanent quality improving the grain to make it increasingly competitive in the market. All the advantages fall to the business sector that makes a significant investment that translates into the final yield and economic return of the culture.

Table 3.18. Differences and similarities between the business and the traditional rice sectors

Technical Itinerary	Business sector	Traditional sector
Systematization of the field	Road network Pump station Watering ditches Ditch ditches	In some cases
Cultural operations	Mechanized tillage Ground levelling Correction of soils Chemical weeding Gradation Fertilization Direct sowing Open irrigation canals Field flooding	In some cases In some cases only if the sowing is direct on line It has not applied In some cases only In some cases only In some cases only It has not applied In some cases
Harvest and threshing	Combined harvester	Is usually made with a knife or sickle
Drying	Determination of moisture content (dryer)	Extend to tarpaulins
Storage	Silos or in a bag of 5, 10, 25 and 50 kg	Store in bags/bottles
Processing	Mechanized (Use of debarking machine)	Handcrafted (artisanal)
Destination of production	Farmers Agrarian Development Institute Armed forces General Population	Consumption Seed Conservation Sale
Equipment	Heavy disc harrowing Tractor fertilizer spreader Tractor with a rotating Disc Harrow Leveller Tractor Rotary Excavator Seed drill Combine harvester	Manual Instruments

Source: The author

3.4. Conclusions

The rural population, despite being mostly young, does not nevertheless have sufficient preparation, knowledge, means and motivation to be able to develop an efficient agrarian activity. This situation is aggravated by the fact that among farmers, there is still a predominance of subsistence agriculture, with a non-commercial, non-productive and unprofessional vision.

Rice-rice-rice is the dominant cropping pattern in the village. Farmers' practice of rice farming is highly inconsistent with recommendation practice in terms of the time of establishing crops, seeds and fertilizers rates and pesticides. A typical example is the fact that farmers apply lower doses of fertilizers due to lack of knowledge and money.

Women are intensively participating in post-harvest processing of crops and other household activities as well as household decisions other than farming. In short, rice production is of great interest to farmers. However, poor access to extension service, lack of good quality seed, phosphorous fertilizers, pesticides and power supply were identified as barriers to achieve better performance of rice production and expected higher returns. Overcoming these bottlenecks and better price conditions may enhance better farm productivity and profitability in rice production.

Rice production has been widely practised during the last several decades in Camacupa and Catabola municipalities. The farmer's survey described in the present study identified several short to long-term measures to enhance the productivity and production needed to meet the growing demand for future years.

Lack of control of crop enemies, non-use of fertilizers and adequacy of sowing date in relation to the varieties used are some of the factors that underlie low productivity.

Thus measures relating to the expansion of field schools to give farmers adequate knowledge of appropriate cultivation methods and establish a partnership especially with regard to rice processing between business and traditional sectors would be vital to leveraging the agricultural rice sector in the region.

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CHAPTER 4. UNDERSTANDING THE RICE VALUE CHAIN IN ANGOLA: CONSTRAINTS, OPPORTUNITIES, AND STRATEGY TO INCREASE THE PRODUCTIVITY

Abstract

This work discusses the issues of value chain management and development in agribusiness. In particular, based on the study of Agriculture in Angola, it analyses and assesses the value chain formation process in the rice sector and the role of the involved stakeholders that increase the product value for consumers through organized cooperation. Value chain concept, describes the full range of activities required to bring a product or service from conception through the different stages of production, distribution to consumers and final disposal after use. It provides some examples of agricultural value chains, discusses why farmers must consider themselves part of an agricultural value chain, lists the potential benefits of agricultural value chains, and talks about different strategies for them. Farmers can move on to grow or improve their involvement with agricultural value chains. The difficulties faced by key rice value chain actors in accessing services have been reviewed, showing how incentives for the commercial delivery of services to smallholders differ between staple foods, traditional crops, and high-value product supply chains. The major challenge in providing services to smallholder farmers in Angola concerns the coordination of service development and delivery. Different forms of intermediary institutions to achieve this coordination are also examined.

Keywords: Value chain, Rice crop, Angola, Small-farmer

4.1. Introduction

Currently, there is a growing interest in the use of value chains in many different fields, in particular in the context of agriculture. The value chain is not an object that can be seen, but it is merely a useful way of understanding how the world of producing, buying and selling things works (Cuddeford, 2014). The analysis of the value chain is essential for understanding the markets, their relationships, the participation of different actors and the critical restrictions that limit the growth of livestock production and, consequently, the competitiveness of small farmers. Currently, these farmers receive only a tiny fraction of the final value of their output, even though, in theory, the risks and rewards should be shared along the chain (Kajananthan and Achchchthan, 2012).

Every person is part of a value chain in one way or another, as producers, consumers of goods and services, processors, retailers or finance providers. The chain stretches from growers to our kitchens (Cuddeford, 2014). According to Chokheli (2016) at one end of the agricultural value chain are the producers and the farmers who grow crops and raise animals. At the other end are the consumers who eat, drink, wear and use the final products. And in the middle, there are thousands of men and women and small and large businesses. Each person and each company performs one small step in the chain, and each adds value along the way by growing, buying, selling, processing, transporting, storing, checking, and packaging (Min Z n/d).

In the agricultural chain, banks, governments, and agricultural research play essential roles in supporting the chain by providing loans, establishing laws and policies, and developing ways for farmers to participate more successfully in value chains. Radio stations also have an essential supporting role in providing information about prices, value chain successes, innovations and opportunities for small farmers to be involved in value chains (Keshelashvili, 2018).

Given a large number of smallholders in African agriculture, their integration into global agricultural value chains is of crucial importance. The Food and Agriculture Organization estimates that smallholders supply up to 80% of food in sub-Saharan Africa; therefore, the interactions of smallholders with global value chains are of great interest. Smallholders face many obstacles in accessing global markets, most notably in terms of meeting strict standards of production, but also in ensuring continuous supply (Acosta, 2003). However, smallholder farmers increasingly participate successfully in global value chains through the initiatives of leading firms and entrepreneurs that have included them. Indeed, some supply chains depend heavily on smallholder farmers, according to the nature of the crop in question (like coffee or cocoa). Similarly, as larger farmers integrate with global value chains; formal employment opportunities are created in rural areas, which may have a positive impact on development in the surrounding region (AfricaRice, 2016).

For Angola, in particular, one of the significant constraints to the performance of the agriculture sector is the weak value chain linkages from production, processing, marketing as well as limited extension support. The inclusion of farmers in a value chain would be one of the best opportunities to take advantage of their production and an incentive in increasing production. According to Chiambo *et al.*, (2019) the Angolan small rice farmers still use traditional methods in production, without any innovations, resulting in low yields. It is a fact that the vast majority of subsistence farmers grow some crops or raise some animals for sale. Even in the most remote areas, many subsistence farmers are connected to markets, and sell small amounts of their produce in local markets or to traders who visit their villages and farms. Cuddeford (2014) emphasize that value chains are all about human interactions. Moreover, they are about linkages between people and businesses who transfer or exchange products, money, knowledge, and information.

According to FAO (2016) value chain analysis is particularly useful for new producers including poor producers in poor countries who are trying to enter global markets in a manner that would provide for sustainable income growth. It is also useful as an analytical tool in understanding the policy environment that provides for the efficient allocation of resources within the domestic economy, notwithstanding its primary use as an analytic tool for understanding how firms and countries participate in the global economy. Value chain analysis can explain why the poor may face barriers to trade and how to overcome these barriers (Mitchell *et al*., 2009).

But what is a value chain, and why is it essential for small farmers, namely for rice growers in Angola?

This paper is a literature review about agricultural value chains and aims at helping small farmers to understand how agricultural value chains work. Gives some examples of agricultural value chains, discusses why the integration of farmers in the value chain is essential and mentions different strategies that farmers can follow to improve or upgrade their involvement in agrarian value chains. Mitchell and Coles (2009) point out that a systematic literature review is a summary of research that uses explicit methods to perform a thorough literature search and critical appraisal of individual studies to identify valid and applicable evidence. A key feature of systematic reviews is their objective and transparent approach for identifying and weighing both published and unpublished evidence (for the effectiveness of given interventions) while minimizing biases.

Following standard systematic review protocols, the methodology consisted of an in-depth review of published and unpublished documents and collection of primary information in the field through focus group discussions.

4.1.1. Historical background and concepts of the value chain

In this section, a brief overview of the development of the value chain concept is performed. It clarifies to what kind of research questions value chain analysis has been applied and how the term value chain is being used.

The value chain concept has been used since the beginning of the millennium, primarily by those working in agricultural development in developing countries. Although there is no universally accepted definition of the term, it usually refers to the whole range of goods and services necessary for an agricultural product to move from the farm to the final customer or consumer.

During the last decades, the underlying concept of the value chain was subject to different influences and objectives. The origin of value chain analysis is discussed from two distinct perspectives. One is related to 'filière concept' and the other to Wallerstein concept (Bair 2005; Faße *et al.*, 2009). From both, several frameworks have emerged and have been used to study individual firms, entire industries, industry clusters, as well as global networks. The well-known approaches are Porter's concept of the value chain, Gereffi's global commodity chain, and Humphrey's world economic triangle, the last two included in the idea of the global value chain (VGC) (Gereffi, 1994).

The 'filière concept' arises in the 1960s at the *Institute National de la Recherche Agronomique* (INRA). The *Centre Internationale en Recherche Agronomique pour le Développement* (CIRAD) as an analytical tool for empirical agricultural research used to gain a more structured understanding of economic processes within the production and distribution systems for agrarian commodities (Faße *et al.,* 2009; Lançon *et al.,* 2017). The filière was thus defined as a set of actors providing specific technical and economic functions in the process of producing and processing goods, from raw material to final product (Lançon *et al.,* 2017).

The 'filière concept' can be used to analyse the dynamics of integrating agriculture into agrifood and agro-industrial systems, measure the creation and distribution of wealth in these systems, and undertake activities to support the development of technical and organizational innovations (Gereffi, 1994; Kaplinsky and Morris, 2002; Yedan, 2019).

Terence Hopkins and Immanuel Wallerstein coined the term Global Commodity Chains (GCC) to indicate a network of labour and production processes whose result is a finished commodity (Korzeniewicz, 1994; Bair, 2014). The GCC was used to describe the relationship between the actors and activities involved in creating goods and services in the global economy. It endeavours to explain the social and organizational structure of the global economy and its dynamics by examining the commodity chains of a specific product or service (Lee, 2017).

In the mid-1980s, Porter developed the concept of the value chain in the context of his work on competitive advantage (Porter, 1985). He developed his idea to analyse specific activities through which companies may create value by breaking down their activities into value-added. Porter distinguished two important value-adding activities of an organization: primary activities (inbound logistics, operations, outbound logistics, marketing, and sales) and support activities (strategic planning, human resource management, technology development, and procurement) (Porter, 1985).

Currently and according to Porter (1985), Value Chain describes the full range of activities, which are required to bring a product or service from its conception, through the different phases of production, distribution to consumers, and final disposal after use.

Value chains do not exist in the sense of their having a tangible reality: “they are simply a framework for trying to understand how the world of business works” (Mitchell *et al.*, 2009).

The GTZ, in its "Value Links" Manuals, considers the value chain as the full range of parties involved, including all the stakeholders from producers, processors, dealers, distributors, wholesalers, retailers of a given product (Heinze, 2007; GTZ, 2007). These stakeholders are linked by a series of trade relations that ensure the movement of the product from the primary producers to the final consumers (GTZ, 2007). They are about links between people and businesses who transfer or exchange products, money, knowledge, and information. As the product moves from one player to another, it is assumed to gain value (Hellin and Meijer, 2006; GTZ, 2007). According to this point of view, the value chain takes the form of a series of links.

Value Chain Analysis (VCA) consists of the study of the structure and dynamics of the VC to draw up a strategy or an approach to the VC development, implements procedures to meet the constraints and/or to benefit from opportunities at multiple levels of the VC (Dekker, 2003; Zamora, 2016). Value chains work best when their actors cooperate to produce higher-quality products and generate more income for all participants along the chain. Value chains differ from supply chains, which refer to logistics: the transport, storage and procedural steps for getting a product from its production site to the consumer (Norton, 2014).

All the approaches mentioned describe production and consumption in terms of a chain linking together different activities and agents. The purpose of this article is not to judge which method is most relevant but to examine these concepts, which over time have become a framework for analysing the strategic choices made by companies, public authorities, and farmers' associations.

4.2. VCA4 Development Methodology

Several techniques are available, usually starting with qualitative research like supply chain mapping or surveying the industry. There are also network models for in-depth analysis of supply chains (Beamon, 1998; Bode, 2007; Brusset and Teller, 2017). Since value chain analysis is a systematic approach, it is crucial to conduct a scoping study before initiating VCA for mapping and analysing the whole chain, including stakeholders and aspects of the legal and regulatory environment. For VCA both qualitative and quantitative methodologies can be employed depending on the scope, scale, and purpose of research. The IFAD[19] (2016) developed a VC development methodology consisting of the following four stages:

1. Understanding the current state of the whole chain;
2. Mapping the current state and understanding the bottlenecks, and opportunities across the chain;
3. Developing a future state vision/Mapping the next chain;
4. Developing an action plan for a future goal.

In every case, Michel *et al*., (2009) indicated that the goal of the methodology is to provide decision-makers with a set of information that relates to sustainable development strategies. This is done by producing evidence-based elements (supported by indicators measured quantitatively or based on expert assessments). On the other

[19] International Fund For Agricultural Development

hand, the methodology to be used in the development of value chains should allow answering the framing questions presented below:

- What is the contribution of the VC to economic growth?
- Is this economic growth inclusive?
- Is VC socially sustainable?
- Is the VC environmentally sustainable?

Within this scenario, the framing questions (FQ) and the core questions (CQ) can be presented as in Table 4.1.

Table 4.1. Framing and core questions

<table>
<tr><th>Economic Analysis</th><th>Social Analysis</th><th>Environmental Analysis</th></tr>
<tr><td>FQ1. What is the contribution of the VC to economic growth?</td><td>FQ3. Is VC socially sustainable?</td><td>FQ4. Is the VC environmentally sustainable?</td></tr>
<tr><td>CQ1.1. Are the VC activities profitable for the entities involved?
CQ1.2. What is the contribution of the VC to the GDP?
CQ1.3. What is the contribution of the VC to the agriculture sector GDP?
CQ1.4. What is the contribution of the VC to public finance?
CQ1. 5. What is the contribution of the VC to the balance of trade?
CQ1.6. Is the VC viable in the international economy?</td><td>CQ3.1. Are working conditions throughout the VC socially acceptable and sustainable?
CQ3.2. Are our land and water rights socially acceptable and sustainable?
CQ3.3. Is gender equality throughout the VC acknowledged, accepted and enhanced?
CQ3.4. Are food and nutrition conditions acceptable and secure?
CQ3.5. Is social capital enhanced and equitably distributed throughout the VC?
CQ3.6. To what extent are major social infrastructures and services acceptable? Do the VC operations contribute to their improvement?</td><td>CQ4.1. What is the potential impact of the VC on resource depletion?
CQ4.2. What is the potential impact of VC on ecosystem quality?
CQ4.3. What is the potential impact of the VC on human health?</td></tr>
<tr><td colspan="2">FQ2. Is this economic growth inclusive?</td><td>-</td></tr>
<tr><td colspan="2">CQ2.1. How is income distributed across actors of the VC?
CQ2.2. What is the impact of the governance systems on income distribution?
CQ2.3. How is employment distributed across the VC?</td><td>-</td></tr>
</table>

Source: Adapted from Michel *et al*., (2009) Another methodology consists of using questionnaires/interviews to identify the key actors in the value chain in the area. The objective is to find out the key factors influencing the chain by typifying the strengths and weaknesses of each value chain actor and discover the opportunities and threats of each value chain actor. Additional suggestions can also be made for strengthening the sector along the line of socioeconomic benefits (Kajananthan and Achchchthan, 2012).

4.3. Foreign experience of VCA applied to rice crop

This section reports on rice value chain analysis projects that are implemented in several African countries such as Nigeria, Mali, and Tanzania and can serve as a model for many developing countries that have enormous potential for rice production such as Angola.

4.3.1. Nigeria rice value chain

Many analysts agree that a significant constraint in realizing self-sufficiency in rice production for export in Nigeria is the lack of functional irrigation. Currently, rain-fed upland and lowland rice account for about 77 per cent of the total production and are cropped between May and October in the South, and between June to October in the North. Rain-fed rice production allows for only one planting per year and increases the farmer's risk as he is dependent on unpredictable rainfall patterns (Africa Division, 2008).

Another constraint is the inability of farmers to process their produce. This procedure results in low sales and leaves most of the winnings to those who buy, process and sell to others within the value chain. However, these problems were seen as an opportunity for innovation in the rice production chain (Donovan and Gelli, 2019).

To reduce dependence on imported rice, and simultaneously develop the local rice industry, as well as to improve the process of adopting wide yielding varieties to increase rice productivity levels, Nigeria has taken several innovative development measures. Some include the African Rice Initiative (ARI), which aims to promote the dissemination of high yielding varieties and taking better advantage of irrigated areas (Hall *et al.,* 2001; Leeuwis, 2004; Hounkonnou *et al.,* 2012). The government controls rice imports and imposed a 10 per cent tax on rice imports to create a fund dedicated to the development of the local rice industry, including processing and marketing. The Nigerian government, recognizing the potential of irrigated agriculture, has invested in the use of improved technologies to further expand rice production (IFAD, 2016).

4.3.2. Tanzania rice value chain

Nkuba *et al.,* (2016) conducted a study on rice value chain analysis in Tanzania to provide rice actors with knowledge of the rice value chain and identify viable improvement strategies. The study identified key rice value chain actors at micro, meso and macro-levels (Figure 4.1.). At the micro-level, the key actors were input suppliers (mainly of fertilizers, herbicides, seeds, and implements), producers (small, medium and large farmers), collectors, processors, distributors (transporters, traders and wholesalers), retailers and consumers.

Most of the actors at the micro and meso levels were operating in isolation and scattered, with minimal linkage mechanisms between them and having limited business skills and a shortage of capital. At the macro-level, the rice value chain was supported by local government authorities, central government and providers of utilities such as electricity, roads, irrigation infrastructures, and storages facilities. In the vision of the authors, is still needed a robust investment in pre and post-harvest activities to attain a reliable, competitive rice value chain.

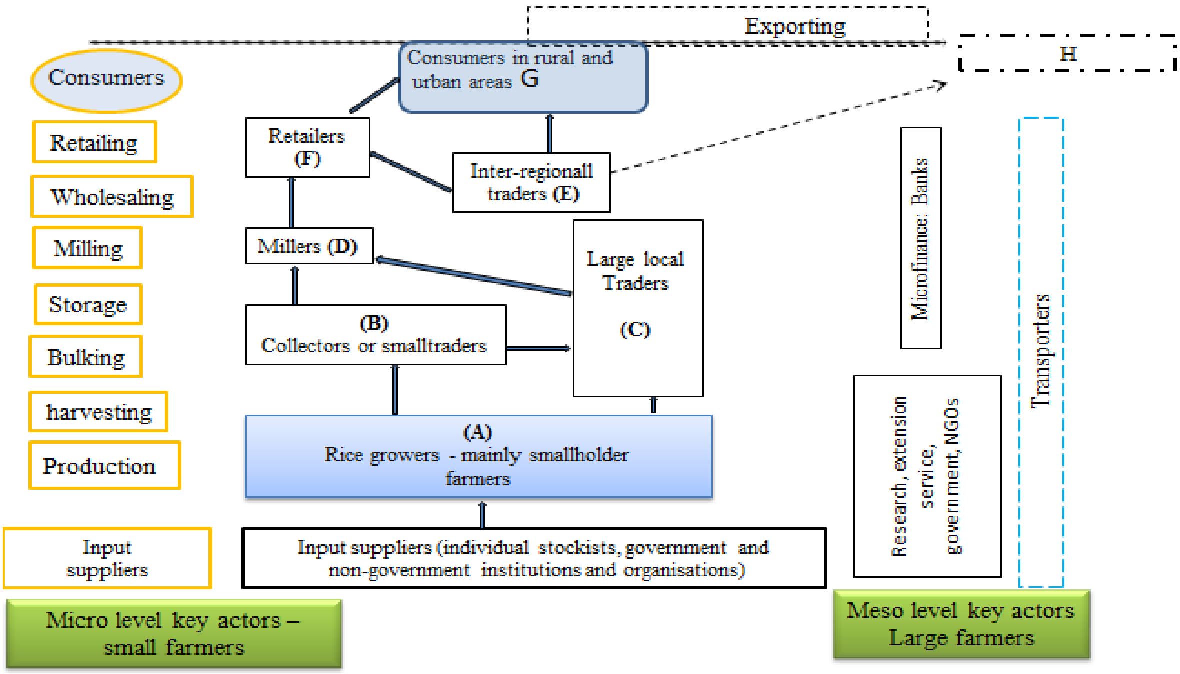

Figure 4.1. Rice subsector functions and participants in Tanzania.
Source: Adapted from (Nkuba *et al.*, 2016).

4.3.3. Mali rice value chain

In Mali, numerous reforms have been implemented in rice production in irrigated areas. Namely increasing the liberalization of rice production and marketing by reducing the role of the state and giving more power to the private sector to reduce the country's dependence on imports (Africa Division, 2008; Dordrecht *et al.*, 2017).

The program was funded by the European Union through bilateral cooperation and the methodological framework for the analysis was developed by the European Commission. It aimed at understanding to what extent the value chain allows for inclusive growth and whether it is both socially and environmentally sustainable (Michel and Coles, 2011). The rice value chain in Mali contributes significantly to social and economic growth and is fairly inclusive. Twenty per cent of farms grow rice, with more than 5 million Malians, (about a third of the population) directly involved in rice production.[20] The figure 4.1 clearly show the importance of the value chain to provide jobs. All actors in the value chain consider that the distribution of value added is (Michel *et al*., 2009) ‘reasonably’ fair and balanced.

The emerging paradigm of sustainable agricultural development and food security is based on the concept of innovation as a social process that takes place in a social system, involving not only research organizations but also other non-research related bodies and tasks (Klerkx *et al*., 2010; Kilelu *et al*., 2013). By definition and according to Hall *et al*., (2001); Clark *et al*. (2003) an innovative system is one that involves all major social actors, affecting the production, distribution of technical and institutional knowledge over time. The innovative system also includes interactive learning that occurs when an organization engages in the production, distribution, adaptation, and use of new experience; as well as institutions (norms, rules) that govern this interaction (Walts *et al*., 2006).

By coherence, the links that constitute a rice innovation system explain the fact that rice production is a process that occurs throughout the entire commodity chain with the involvement of different actors in each stage of production (Walts *et al.*, 2006; Erenstein *et al.*, 2004).

However, the innovative force of the whole process is a function of interaction, bonds, alliance and flow of knowledge. According to Zamora (2016) rightly pointed out that technical change and innovation have become much more interactive processes that can be guided by many different types of actors.

Rice's innovation system encompasses all actors, their interactions, and the political

[20] www.agrinatura-eu.eu

environment (IFAD, 2018). It tends to go beyond knowledge creation to address factors that affect the demand and use of knowledge in useful ways. Innovative performance depends not only on how the individual/actors act in isolation but also on how they interact with each other as part of a collective system of knowledge creation and use, e.g. the enabling environment that encourages continuous learning (World Bank, 2006).

4.4. Angola rice value chain

In PND[21] (2018-2022), PDMPSA[22] (2018-2022) and PRODESI[23] (2018) rice is considered by the government as a strategic food crop for strengthening food and nutritional security and import substitution (MINAGRIF, 2018). The provinces with a relatively high potential for rice cultivation are Lunda Sul, Cuando Cubango, Moxíco, Uíge, Malange, Bié and Huambo as shown in (Figure 4.2.) (GSA, 2018; Chiambo *et al.*, 2019).

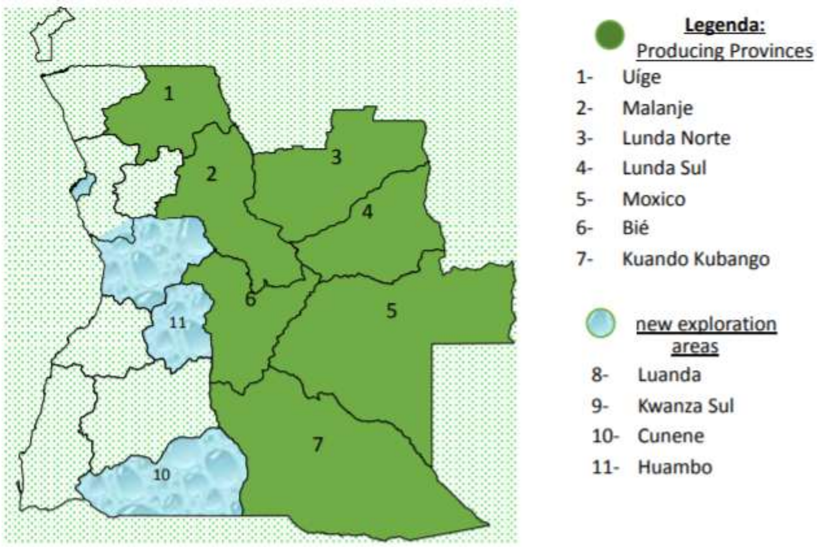

Figure 4.2. Map of potential producing provinces of rice.
Source: GSA (2018).

[21] National Development Plan
[22] Medium-Term Development Programme for the Agricultural Sector
[23] Program to Support National Production, Diversification and Import Substitution

4.4.1. Rice production areas visited in Angola

Five rice production areas were visited during the assignment, namely Huambo, Bié, Moxico, Cuando Cubango, and Malange. Two of these represented areas where JICA is actively trying to introduce and promote rice cultivation. Along this route, we had a conversation we the head of the agriculture departments and potential rice producers. Data on constraints present in the rice value chain, in general, was obtained and at the same time opportunities to improve the value chain in all aspects were explored. The following is a general description of the rice sector in the visited localities.

4.4.2. Huambo

In Huambo, about 97% of local farmers work in small plots. The rice crop is residual and circumscribed to some villages where it is made in small blocks irrigated through ditches. The province has favourable climatic characteristics. Although the region does not have any massive irrigation scheme, it has a high potential in water resources. The farmers are very motivated, although they have little knowledge about the crop. However, care must be taken to address the issues of low fertility of soils and cold periods that may damage the plants.

4.4.3. Moxico

The Moxico region was one of the largest producers of rice within the colonial era (1961-1971) with an average production of 27,000 tons/year and a yield of 1.5 tons/ha. The production was both in small and large scale farms. Production over 5 recent years (2010-2015) is reported in Table 4.2. There are 242 farmers' associations and 10 cooperatives in the province, some of which produce rice. Recently there are also plans to invite 4 private companies to grow rice in plots of 500 ha/each. The two companies have already tested the variety IRGA 424, bred in Brazil, which performed well.

Table 4.2. Production of rice over 5 recent years in Moxico Province

Year	Area (ha)	Production (tons)
2010/2011	9000	7200
2011/2012	6530	5224
2012/2013	3008	2406
2013/2014	7462	5970
2014/2015	8432	6745

Source: MINAGRIF (2018)

The region has excellent potential for rice cultivation (sufficient rain-fall and fertile soils), and its expansion is mainly limited by the lack of processing units. However, the province continues to discuss the invitation to companies to produce rice on a large scale, and the small farmers maintain interest in expanding the area of cultivation.

4.4.4. Cuando Cubango

In Cuando Cubango, most areas are rain-fed, depending on the rainfall of 700-800[24] mm on the western side of the region. The total cultivated area is about 1,600 ha, but a company with Chinese investment in Longa explores 1,300 ha of rice. The province does not have large-scale irrigation systems. Agricultural areas are located in the western part of the region because the south-eastern part is dry and the soils have low fertility. The company of Longa is one of the largest producers of rice. Small-scale rice production is currently limited, but there is great potential in an area of approximately 2,000 ha in Cuchi on the low-lying floodplain near the Canona River. The IAD/EDAs teams are highly motivated to convince small farmers to introduce rice cultivation in this area if seeds and fertilizers are provided.

[24] https://pt.climate-data.org/africa/angola/cuando-cubango-1447/

4.4.5. Malange

Malange has excellent characteristics for rice production, especially in the Northeast part, where there are vast tracts of lowland that can be flooded during the rainy season and where ferralic and psamo-ferralic soils are predominant. The altitude is between 1000-1250m, with precipitation between 1800-1900 mm and average annual temperatures of 21-22ºC.

The provincial government has allocated a reserve of about 30,000ha for rice cultivation and seeks to attract entrepreneurial farmers. At present rice production is practised only by family farmers, who use local seeds and those distributed by IAD[25] (mainly Chimbissa, Siam, California and Senta varieties). Irrigation systems are depleted, cultivation is done in lowland ("chanas") by taking advantage of the floods in the rainy season. The sowing is done by the broadcasting method, and the seeds have a considerable degree of mixture.

Farmers make fallows and neither apply fertilizers nor phytosanitary treatments, and nevertheless, they can obtain yields of around 2 tons/ha. The main obstacle to the expansion of this crop beyond the phytotechnical issues is processing. Access roads are still under rehabilitation, challenging to use, and there are no milling facilities nearby. The manual husking (with the pestle) is painful and time-consuming, and thus the milled rice serves almost exclusively for local consumption. In contrast, the rice consumed in the capital of the province and other areas is imported.

A Chinese company in a non-traditional rice growing area (Sunginge Field) tested 12 varieties and obtained 6tons/ha in a total area of 180 ha. However, the lack of milling in the region forced them to transport the production to Luanda where it is processed. The

[25] Agrarian Development Institute

rice they produce is also consumed by the workers of the company. There is a private company which is setting up a processing centre on the outskirts of the city of Malanje, and intends to buy rice from individual producers (mainly small-scale producers) process and market and also want to recover irrigation systems and repair access roads. Together with the use of suitable technological packages and the installation of Processing Centres near the production sites, the province has enormous potential as a rice-producing region. As a first step, the focus should be on small family producers who are highly motivated. This will take advantage of their productive potential and increase their incomes, which will undoubtedly result in an improvement of their living conditions.

Intending to turn subsistence agriculture into a commercial one in sustainable and market-oriented agriculture, the Government of Angola decided to give high priority to the production of cereals, focusing mainly on rice production. This strategy aims to achieve food security and meet the needs of the national agro-industries as part of the process of economic diversification, namely by using the country's marshlands where, with adequate investment in irrigation infrastructure, the crop is capable of yielding up to 7 tons/ha (MINAGRIF, 2018).

Angola strategic plan for 2018-2022 is to increase area and productivity. Its main objectives are: to increase rice production to 45,000 tons; to reach an average yield of 2.5 tons/ha; to supply 4,500 tons of fertilizer for rice cultivation; to select two varieties per eco-system; to make available to farmers 1.7 tons of improved seeds by 2022 (MINAGRIF, 2018). Table 4.3 shows the projection of rice consumption needs for a five-year horizon (2018-2022), assuming a population growth rate of 2.7% (INE[26],

[26] National Statistics Institute

2014) and a per capita consumption of 40 kg/ person/ year (NRDS, 2018).

Table 4.3. Projection of rice production, population, needs, and imports.

Year	Production (ton.)	Population[27] (hab.)	A necessity for consumption (ton.)	Import needs (ton.)
2018	29,733	27 135 263	485, 120	455, 387
2019	32,707	28 027 742	498, 218	465, 511
2020	35,977	28 949 574	511, 670	475, 693
2021	39,575	29 902 015	525, 485	485, 910
2022	43,533	30 885 721	539, 673	494, 140

Source: Adapted from NDP[28] (2017)

Although there is a need for increasing production, it is known that in an increasingly globalized and competitive economic environment, agriculture should not only be limited to increasing productivity *per se*. Continuous, sustained and coordinated monitoring of each stage of the value chain is required to improve product quality and reach a satisfactory income level for producers (Erenstein *et al.,* 2004). The role of the farmer is the most important, as, in most cases, he is not able to sell his products at rewarding prices, because the quality of the grain does not meet the requirements of the market compared to imported rice, which is the preference of most consumers. A study on the entire rice value chain is necessary to ensure profitability and sustainability for the farmers and all the other actors in the chain (Stockbridge *et al.,* 2003).

As presented by Kajananthan and Achchuthan (2012) Value Chain analysis is essential to an understanding of markets, their relationships, the participation of different actors, and the critical constraints that limit the growth of livestock production and consequently the competitiveness of smallholder farmers. These farmers currently receive only a small fraction of the ultimate value of their output, even if, in theory, risk

[27] 3.29% growth rate
[28] National Development Plan

and rewards should be shared down the chain.

4.5. Constraints and opportunities in the rice value chain in Angola

The value chain for rice is divided into three primary components: production, processing, and marketing, with various links between them, mostly associated with transport. In the visited areas, the rice value chain is very fragmented, and there is no follow-up in its horizontal and vertical coordination. As referred to by Gulati *et al.,* (2007) and Mitchell and Coles, (2011), vertical coordination refers to the synchronization of successive stages of production and marketing concerning the quantity and quality. While horizontal coordination is the process of creating closer relationships, formal or informal, among actors within a functional node of a value chain.

Several studies like (Stockbridg *et al.,* 2003) argue that the farmer organization can combine horizontal coordination with vertical coordination in the supply chain by adopting farmer cooperation and that contract farming can work better.

The main restrictions faced by the key actors in the rice value chains visited in this study are described below.

4.5.1. Constraints in input supply

There is no natural link between input suppliers and farmers, resulting in inadequate capital circulation. Most roads and rail infrastructure on the central plateau were built during the colonial period, and only limited improvements were made. As a result, most support in the region is reduced in coverage and unreliable.

4.5.2. The constraints in production

The cultivated areas are small, and production is mainly for family consumption, the remaining rice being sold in the husk or kept to serve as the payment for workers in the next agricultural season. The prices practised are quite low, and in many cases, there is no bond with the buyers. Frequently, they are not motivated to produce rice due to the lack of adequate processing machines to obtain quality grain.

Although IAD is present in the region and has been reported as one of the key actors in the rice value chain, its team focuses on fertilizer and seed distribution, leaving the rest of the operations unattended. There is the MOSAP[29] II project, but it focuses mostly on the post-harvest delivery and marketing aspects, leaving out production. Other restrictions at the farmer level include limited access and high financial costs, small farm size, low levels of farmer organization, low incomes, and high cost of agricultural inputs, minimal input use and minimal access to extension services on the farm.

Factors affecting yields include the use of rudimentary tools and equipment (e.g. hand hoe); lack of agronomic knowledge by farmers; and incidence of pests, weeds, worms, and diseases. Some areas are affected by soil exhaustion, due to previously over-cultivation of land.

4.5.3. The constraints in processing

Existing mills are of the traditional type, which only processes rice for the consumption of the farmer and his family. The processed rice is of poor quality, and the storage facilities do not provide adequate storage conditions. In most cases, the processors are the farmers themselves.

4.5.4. The constraints in consumption

Consumer´s preferences are not known by the farmers.

[29] Family Agriculture Development and Marketing Project

4.6. Opportunities for the rice value chain in Angola

The constraints, as mentioned earlier, may also be seen as prospective opportunities for chain improvement. From this perspective, we highlight:

4.6.1. Input supplying

Improvement in infrastructures and roads will increase the number of people interested in rice production and will concurrently facilitate access to credit.

4.6.2. Production

Increased importance of rice as a staple food in rural and urban areas; improvement of technology, research and extension services, roads and other media.

4.6.3. Processing

Government willingness to support farmers with processing machines will contribute to a motivational increase in rice cultivation by farmers.

4.6.4. Consumption

Change in eating habits that may increase the population income.

4.7. Discussion: actions to improve the rice value chain

According to (MINAGRIF, 2018), the profitability of rice production is essential to establish the right channel from the field to the consumers. The production outlets should be able to minimize post-harvest losses, stabilize the price of rice, and provide the conditions to create a favourable environment for processing and marketing.

The following are suggested actions needed to improve the rice value chain.

4.7.1. Post-harvest technology

Research and extension programs for post-harvest technology, such as threshing, drying, storage, husking, milling, and packaging, should be carried out practically and appropriately taking into account the production costs for small farmers.

Manual post-harvest processing of rice is laborious and time-consuming. It is one of the main limiting factors to the expansion of rice cultivation, especially in rural communities.

The Government, through MINAGRIF/IDA, should provide facilities for private companies to acquire and install industrial processing centres, and to provide subsidized credit service to small-scale farmers in a policy similar to that adopted for the distribution of maize mills.

The private owners (Figure 4.3 A and B) of the processing units should establish production contracts and guarantee the technical assistance to producers during the crop season. This means providing the appropriate technological packages for the production and harvesting of rice and buying it from the producer (individual or associated).

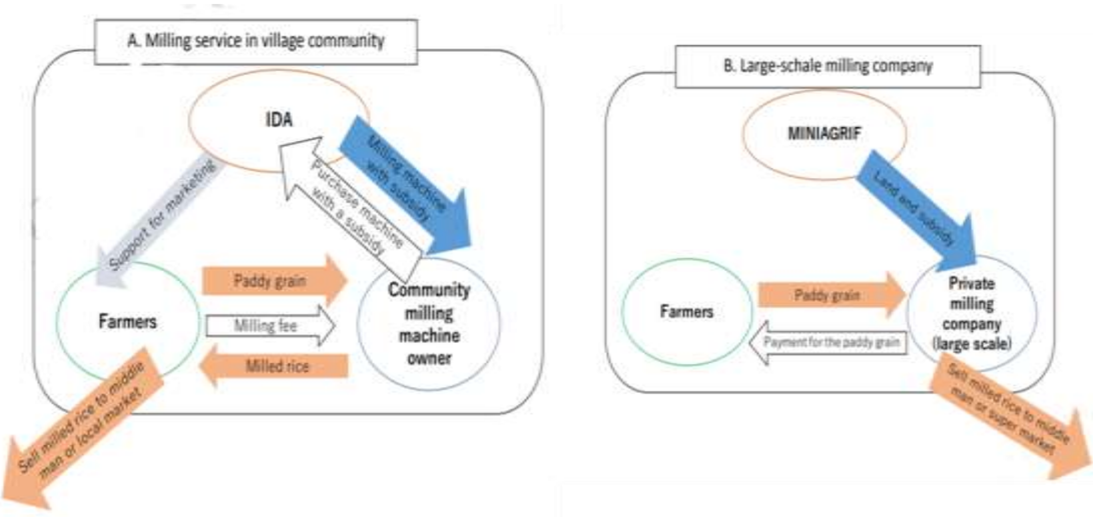

Figure 4.3. A/B- Flow of grain and money in post-harvest processing.
Source, NRDS, (2018)

The company purchasing the rice will then be responsible for processing and sales in both the internal and external markets. If the farmers do not have money to pay for the milling, they should be allowed to pay with rice grain in the same way as it happens with maize in some regions. Similar actions were implemented in countries such as Niger, Mali, and Nigeria, with numerous positive impacts (Africa Division, 2008) in terms of:

- Increased production and yields.
- Increased producer prices and linkage of producer prices to global market prices.
- Increased consumer prices.
- Greater competition within the sector due to an increased number of actors.
- Greater private investment.
- Increased number of actors in the value chain, including numerous traders and collectors, and the emergence of small village mills which currently account for the vast majority of rice milling in the country.

A value chain map graphically illustrates all the parts, and relationships between them, it is a visual tool that helps us understand how a particular industry works. Value chain maps demonstrate how a product in an enterprise moves from raw material through production, processing, and other steps until it eventually reaches the consumer. The map highlights the range of activities that occur within the value chain. It also outlines the transformation steps or functions, actors, relationships, and support services. The level of detail in a value chain map can vary, ranging from noting the essentials to highly comprehensive components (Poulton *et al*., 2009).

The other component in the value chain project design is the value chain map, represented by step four in Figure 4.4.

Figure 4.4. Value chain map.
Source: www.value-chains.org.

4.8. Value chain management: Strategy to develop the rice value chain in Angola

Rice cultivation in Angola is in a relaunch phase. Rice varieties and technologies used to go back to colonial times and have low productivity and reduced expansion in the country. In practice, the relaunch of rice cultivation will be a pioneering activity in which the Government should play a central role as a catalyst. It includes the burden of dynamising and structuring the whole value chain for this crop, particularly in guaranteeing the quantity and quality of seeds, research, dissemination, technological packages, rehabilitation of roads and irrigation infrastructures, processing and stimulation of commercialization/distribution circuits, as well as strengthening and supporting private initiatives in this sector.

The low supply of domestically produced rice, which is currently complemented by imports, makes the cultivation of this cereal a priority for the country's food security policy, especially in terms of nutritional and import substitution issues. The country's agricultural and irrigation potential coupled with strong domestic and regional demand turns rice cultivation into an attractive and promising business capable of generating income and employment. In the current context according to rice needs and potential, the key strategies for the development of the crop in Angola should focus on: (1) seeds; (2) fertilizers; (3) irrigation; (4) pests and disease control; (5) expansion of rice cultivation area; (6) development of the value chain; (7) research and extension capacity.

Additionally, it is essential to improve farmer access to inputs, particularly fertilizer, because in general, much of the fertilizer supply chain is poorly organized, leading to high prices and sub-optimal availability both in terms of quality and volume. Fertilizer procurement practices are particularly poor, leading to unavailability at critical times and high prices. Producer organizations need to be coached to enable them to become smart purchasers of inputs, and agro-input dealer networks need to be enlarged. Agro dealers need to be trained to supply information to farmers in a professional manner.

A critical credit line should be dedicated to the purchase of motor pumps to ensure that farmers can successfully adopt small-scale irrigated systems, to avoid the increasingly uncertain rainfall. Improving rice quality, and informing the Angolan consumers about the benefits and strengths of the condition of domestic rice is also crucial because in most cases, many Angolans are becoming rice consumers. Still, they are not yet conscious of the value of domestic rice. This information campaign has to go hand-in-hand with efforts to ensure that local rice is of good quality and therefore competitive vis-à-vis the imported one.

One strategy that seems to be to support and continue is to promote greater interconnection between companies and family producers. A case we studied in

Kamacupa gives us an idea of the type of relationships and impacts that can result as reported in the following section.

4.9. The rice value chain manage at the business level

4.9.1. The business sector

Unlike the traditional sector, which implements less sophisticated techniques because of the lack of investments in terms of production factors in quantity and quality appropriate for rice cultivation, the business sector grows considerably. The Kamacupa rice farm in Bié Province, in 2018 developed its industrial project in an area of 1,800 hectares with a production of 12,000 tons of paddy rice which response to the requests of consumers from different regions of the country (Figure 4.5).

Figure 4.5. Rice production in Kamacupa, Arrozal farm.

The business sector has a complete production chain where all actors interested in the production process are engaged. The company has drying equipment with a capacity of 90 tonnes, 4,000 tons for storage and a debarking unit with a production of five tonnes per hour (5 tons/ha) which represent a global investment around the US $10 million also can bag, pack and put rice on the commercial circuit. All rice produced is processed and marketed.

Rice is packed in bags of 15, 30, 50 and 75 kg, respectively, and stored on wooden pallets (Figure 4.6 B) to avoid contamination caused by the influence of moisture. Rice produced by the local business sector accounts for 25% of the cracks after processing it (Figure 4.6. A) meaning that is slightly damaged during the transformation process.

Rice cracker is the grain fragment whose length is less than three quarters of the average length of the typical grains of the variety (Narciso, 2015). According to Garcia (2017), the percentage of cracks (broken and defective grains during husking) are factors that determine the quality of the product on the market.

Figure 4.6. Rice packed in a 15 kg bag (left); Rice stored on wooden, pallets (right).

4.9.2. Distribution chain

The Benguela railway (CFB) that passes through the Kamacupa and Catabola Municipality has served as a vehicle for transporting rice to the East and South of the country, where large commercial areas promote the product outside the border of Angola such as the Democratic Republic Congo (DRC), Zambia and Namibia by national wholesalers (Figure 4.7).

Figure 4.7. Kamacupa rice marketing circuit.

Kamacupa rice has been the preference of Angolans and expatriates, especially those of advanced age for the taste and smells it offers.

4.9.3. Social impact of the project

As a result of the armed conflict that devastated the region, young workers on the farm have low levels of education. This situation led to farm management to teach professional courses in the handling of tractors, hulling machines and other equipment. It also provided seed support to associated farmers in the region.

4.9.4. The impact of the business sector on the traditional sector

The investment made by the business sector in the production of rice has served as a stimulus for all rice producers around the farm since with the assembly of the rice hulling unit it has enabled traditional farmers to sell their product in the business sector under more competitive conditions. According to the Farm Administrator, they built the factory intending to expand the farm's production area to over 1,800 hectares, counting with the spaces of traditional farmers spread over several locations of Kamacupa that have the support of the enterprise for the processing of their rice harvested. The machine can process six tons of rice per hour. It is an investment of 1,500 dollars (310 thousand kwanzas).

4.10. Conclusion

The present review allowed us to conclude that:

- Although there is no concrete definition of the value chain, the common consensus among the various authors is that it comprises the full range of activities necessary to bring a product or service from its conception, through the different stages of production, distribution to consumers and final disposal after use.
- Family farming in Angola is mainly focused on self-consumption. It is not because there is no desire to make it more extensive and achieve commercialization; local production is not competitive in the market. Among the several reasons that explain this fact, one of them is the lack of technical support and the assurance of farmers by the institutions responsible for facilitating productive factors and integrating the farmer into an adequate bank financing scheme that would allow him to gain motivation in producing more adding value to his product. The rice value chain in Angola is quite fragmented because the producer is unable to continue with post-harvest activities due to the lack of equipment that allows the product to be adequately processed so that it has a quality grain that can satisfy consumer expectations.
- Research has shown us that the related problem is solved by integrating the rice producer into a functional value chain into one where there is a good partnership relationship between the business sector and the traditional sector.
- The availability of processing equipment and facilities for transporting the product from the field to urban centres would serve as a motivational channel for the farmer to produce in quantity and quality. Therefore, post-harvest investment in the rice sector in

Angola would serve as a basis to deliver at the level corresponding to the natural resources that the country has for this crop.

- The market would be an incentive not only to increase production but also to improve its quality, since domestic production will have to be competitive, with imported rice. The experience of other developing countries´ projects could be inspiring for a profitable rice production expansion area in the country.
- The use of means of communication and dissemination at various levels (national, provincial, municipal, etc.) is of great importance. The use of such means would increase the effectiveness of catapulting rice cultivation to the highest levels in the country's cereal production and attract investors, donors and the interest in international institutions.

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CHAPTER 5. CONCLUSIONS AND FUTURE WORK

5.1. Conclusions

This research work has allowed us to identify the potential that the country has in terms of climatic fitness, water resources, and soil. This observation led to the conclusion that the country has all the necessary conditions and requirements for rice cultivation and production.

It was also evident that rice is, among other food crops that can take advantage of those conditions, a preference choice for production increase, given the burden of the annually imports of more than 400 thousand tons of rice in Angola.

With the resources that the country has, we believe that the large sum annually spent on rice imports could be invested in local production and post-harvest activities, namely the rehabilitation of infrastructures and all other factors that constitute constraints to enhance this sector.

The central plateau area is known for its rich history of land rain-fed rice due to the adequate rainfall in addition to the hydrographic basins that surround the region, which allows small-scale irrigation to be carried out as a complement to the rain-fed.

This study also allowed us to identify two major production systems, rainfed and permanent flooding. The first system that is adopted in the traditional sector includes the vast majority of the peasant population, which uses rudimentary means of production and is confronted with several limiting factors, ranging from acquiring the factors of production, means of processing, storage and marketing.

The system of permanent flooding, adopted by the business sector, which uses mechanized means in all stages of production, from soil preparation to processing. In the region under study, this sector is still in a relaunching phase; however, the existing operations have had promising results. This fact is visible evidence that if a substantial investment is made in the traditional sector, rice can be produced not only for domestic consumption but even for export.

The scenario for both production systems reveals that the rural population, despite being mostly young, still does not have adequate preparation, knowledge, means and motivation to develop a productive agricultural activity. This situation is aggravated by the fact that there is still a predominance of subsistence agriculture, with a non-commercial, non- efficient and non-professional view. For these farmers, the cultivation of rice is done following the tradition of its ancestors without innovations, while in the business sector there is a market-oriented vision which may foresee a potential reduction of imports.

We have also found that rice productivity is positively correlated with the level of education, the use of traction, the rate of application of fertilizers, the sowing date (the later the better), the line coverage, the place of sale (in markets is better) and the processing methods (mechanized is better). On the other hand, productivity is negatively correlated with the municipality (Catabola is better), the village (Ndembei, Kalila and Kalohuma, are better) and the age of the farmers (younger farmers reach higher productivity). Moreover we have concluded that the level of productivity achieved can be primarily explained by four variables: number of controls (with an explanatory power of 43%); age of producers (with the explanatory power of 2.5%), processing method (with the explanatory power of 6.5%) and sowing month (with the explanatory power of 3.8%). Those four variables explain 55.8% of the productivity achieved by the farmers. Thus, the expansion of field schools to give farmers adequate knowledge of appropriate cultivation methods and the establishment of a partnership, between the business and traditional sectors, especially with regard to rice processing would be vital to leveraging the agricultural rice sector in the region.

Concerning the gender and labour questions we have concluded that men and women have different responsibilities in rice production systems. Women’s have significant participation in various specific tasks of the cultivation of rice, such as transplanting/sowing, weeding, harvesting, threshing or processing. These differences in gender roles are not always noticeable, but they must be recognized if rice production is to be increased, especially among the small-scale farmers. Women's contributions in decision making about farming, as for instance the selection of crops cultivars to be grown in sowing, the planting and harvesting dates as well as in hiring and selling labour is negligible. However, women have equal roles as their male counterparts in decision making regarding buying and selling of property and livestock, the same occurring in the participation in borrowing groups and deciding on the marriage of children.

The value chain for rice is divided into three primary components: production, processing, and marketing, with various links between them, mostly associated with transport. In the visited areas, the rice value chain is very fragmented, and there is no follow-up in its horizontal and vertical coordination. The value chain of rice at the traditional level is quite fragmented because there are no conditions for processing, storage and means for disposal of the product. The rice produced is not competitive on the market in terms of the quality of the grain when compared to imported rice. This is due not only to the lack of use of edible quality seeds but mainly due to the post-harvest techniques that are used.

The mapping of value chains will serve as a basis for adding value to the product and guaranteeing food security from the perspective of the producer. So, our suggestion is to develop a more market-oriented production, to create an incentive not only to increase production but also to improve its quality, in order to be competitive with imported rice. The experience of projects in the local business sector in other developing countries referred to in this work can be inspiring for a lucrative expansion of the area of rice production in the country. For this purpose, we propose that partnerships be established in the North-South direction so that know-how can be transferred, allowing the potential of the country to be explored and become a source of wealth for the populations.

Summing up, the strategies listed in this work serve as a basis for decision-makers promotion of conditions that allow for: increased production of rice in quantity and quality; reduction of imports; improvement in the income of producers and their families thus increasing the population's quality of life. For that matter, public policies should be able to support rice producers by helping farmers to adopt new technologies and modern sustainable rice cultivation techniques, promoting local agricultural experimentation and rural extension, as well as helping farmers to reduce post-harvest losses and marketing risks.

When we look at the situation of rice production in other countries, we can see that the following lines of action are currently widely adopted:

a) Adaptation to Irrigation;
b) Increase in the use of inputs, particularly certified seeds and fertilizers;
c) Expand the research and extension capacity, namely on the study of varieties adapted to the environment, as well as on methods of pests and diseases control;
d) Development of the value chain and establishment of the most rational pricing policies.

This research work may also serve as a bibliographic collection for the student community which can be interested pursuing investigation lines in this sector.

5.2. Future work

- What are the environmental impacts of rice cultivation in the municipalities of Kamacupa and Catabola?
- What is the socio-economic vulnerability of populations dependent partially or totally on the rice crop?
- Is the production technique used in different rice production systems environmentally sustainable?

ANEXES

A1 - Angola rice, paddy production since 1961 to 2013

Year	Area *(ha)*	Yield *(hg/ha)*	Production *(tonnes)*	Seed *(tonnes)*	Price *(US$/tonne)*
1961	25000	11600	29000	1330	
1962	19000	12105	23000	1400	
1963	20000	12500	25000	1400	
1964	20000	13000	26000	1610	
1965	23000	13913	32000	1540	
1966	22000	13636	30000	1554	
1967	22200	14865	33000	1540	
1968	22000	6885	15148	1050	
1969	15000	10630	15945	1750	
1970	25000	11980	29950	1540	
1971	22000	12632	27791	1540	
1972	22000	9249	20347	1540	
1973	22000	13205	29051	1050	
1974	15000	11186	16779	1050	
1975	15000	13333	20000	1400	
1976	20000	10000	20000	1400	
1977	20000	10000	20000	1050	
1978	15000	10000	15000	980	
1979	14000	9286	13000	840	
1980	12000	9167	11000	770	
1981	11000	9091	10000	770	
1982	11000	9091	10000	630	
1983	9000	8889	8000	630	
1984	9000	8889	8000	420	
1985	6000	8333	5000	420	
1987	3000	6667	2000	210	
1988	3000	6667	2000	280	
1989	4000	7500	3000	221	
1990	3154	9512	3000	280	
1991	4000	10000	4000	318	

Year	Area (ha)	Yield (hg/ha)	Production (tonnes)	Seed (tonnes)	Price (US$/tonne)
1992	4339	9218	4000	350	
1993	5000	8000	4000	1680	
1994	24000	8750	21000	910	
1995	13000	14615	19000	560	
1996	8000	17500	14000	420	
1997	6000	20000	12000	350	
1998	5000	20000	10000	364	
1999	5200	14235	7402	301	
2000	4293	13454	5776	273	
2001	3894	13701	5335	259	
2002	3705	13198	4890	551	
2003	7867	13768	10831	786	
2004	11222	11584	13000	868	
2005	12397	6977	8650	542	
2006	7744	4947	3831	631	
2007	9012	5143	4635	1159	
2008	16551	5084	8414	1659	
2009	23707	6028	14291	1673	
2010	23905	7403	17697	1823	425,40
2011	26038	8914	23209	1833	441,80
2012	27902	7703	21492	2019	708,10
2013	29510	12744	37608	2067	430,00
2014	30068	14064	42288		422,70

A2 - Angola rice - total (Rice milled equivalent) since 1961 to 2013

Year	Imports (tonnes)	Import value (1000 US$)	Exports (tonnes)	Export value (1000 US$)	Domestic supply (tonnes)	Food supply (kg/cap/yr)	Production (tonnes)	Sotcks variation (tonnes)	Self-suff. %
1961	800	160	3300	320	17000	3,01	19000	0	111,76
1962	1100	250	2500	220	14000	2,41	15000	0	107,14
1963	2200	420	1400	140	17000	3,03	17000	0	100,00
1964	800	120	2100	230	16000	2,68	17000	0	106,25
1965	2444	423	1864	207	22000	3,69	21000	0	95,45
1966	2910	567	3549	413	19000	3,18	20000	0	105,26
1967	1964	417	2946	364	21000	3,41	22000	0	104,76
1968	1576	367	1937	246	10000	1,51	10000	0	100,00
1969	2004	469	1391	172	11000	1,66	11000	0	100,00
1970	4866	1080	1054	131	18000	2,69	20000	-6	111,11
1971	1303	283	3113	289	18000	2,64	19000	1	105,56
1972	377	65	5397	511	14000	1,93	14000	5	100,00
1973	959	348	4482	507	16000	2,28	19000	0	118,75
1974	2758	2171	3721	650	10000	1,40	11000	0	110,00
1975	11000	4700	3000	700	21000	2,96	13000	0	61,90
1976	17900	5800	2000	800	29000	4,02	13000	0	44,83
1977	35700	12500	0	0	49000	6,72	13000	0	26,53
1978	37138	15125	0	0	47000	6,30	10000	0	21,28
1979	56963	21727	0	0	65000	8,57	9000	0	13,85
1980	55082	24971	600	180	62000	7,82	7000	0	11,29
1981	49204	21959	0	0	56000	6,82	7000	0	12,50
1982	31861	12700	0	0	38000	4,53	7000	0	18,42
1983	47250	16500	0	0	52000	5,99	5000	0	9,62
1984	54017	17300	0	0	59000	6,55	5000	0	8,47
1985	58000	15700	0	0	61000	6,56	3000	0	4,92
1986	47825	11000	0	0	51000	5,34	3000	0	5,88
1987	86168	20000	0	0	87000	8,91	1000	0	1,15
1988	86005	28000	0	0	87000	8,68	1000	0	1,15
1989	35500	11000	0	0	37000	3,62	2000	0	5,41
1990	98600	27000	0	0	100000	9,47	2000	0	2,00
1991	100874	33191	0	0	103000	9,47	3000	0	2,91
1992	92000	33000	0	0	94000	8,37	3000	0	3,19
1993	93000	28000	0	0	95000	8,11	3000	0	3,16
1994	50000	16500	0	0	64000	5,25	14000	0	21,88
1995	31000	11000	0	0	44000	3,48	13000	0	29,55
1996	42500	15000	0	0	42000	3,23	9000	-10	21,43
1997	24000	7200	0	0	42000	3,18	8000	10	19,05

Year	**Imports** *(tonnes)*	**Import value** *(1000 US$)*	**Exports** *(tonnes)*	**Export value** *(1000 US$)*	**Domestic supply** *(tonnes)*	**Food supply** *(kg/cap/yr)*	**Productio n** *(tonnes)*	**Sotcks variation** *(tonnes)*	**Self-suff.** *%*
1999	31000	6600	0	0	51000	3,66	5000	15	9,80
2000	85233	20750	0	0	69000	4,80	4000	-20	5,80
2001	93769	22820	0	0	77000	5,20	4000	-20	5,19
2002	72372	16126	0	0	85000	5,59	3000	10	3,53
2003	70002	15730	0	0	92000	5,80	7000	15	7,61
2004	267129	60769	0	0	275000	7,27	9000	0	3,27
2005	205185	91543	0	0	210000	6,88	6000	0	2,86
2006	252847	75270	0	0	254000	6,85	3000	0	1,18
2007	281539	103607	0	0	283000	6,86	3000	0	1,06
2008	400645	260346	0	0	405000	7,12	6000	0	1,48
2009	230284	117955	0	0	239000	7,30	10000	0	4,18
2010	213267	103767	0	0	224000	7,09	12000	0	5,36
2011	218009	131790	0	0	233000	7,27	15000	0	6,44
2012	362209	215200	0	0	375000	8,73	14000	0	3,73
2013	430625	239691	0	0	337000	8,12	25000	0	7,42

FAOSTAT, 2017

A3 – The Survey Questionaire

SURVEY QUESTION

This survey aims to characterise the rice production systems

A: Characterisation of farmer

Village´s name ____________

Respondent´s name? ____________ **Gender** M ☐ W ☐ **Age** ☐

Birthplace ____________

Marital status:

Married ☐ Divorced ☐ Widow ☐ Single ☐ Separated ☐

Household ________ Education level ☐

Aa. How many years do you grow rice? ☐

A.1. Why do you grow rice?

Family tradition	Local custom	Pleasure	Habit

A1.1. Have you ever stopped growing rice? 0. No ___ 1. Yes_____ 3.a) Why? ____

A1.2. What area do you use to grow rice? ________ m2.

A1.3. Whose plot is it?

a) Own ☐

b) Leased ☐

c) Busy ☐

d) Inheritance ☐

e) Usufruct ☐

B. Mode of exploration.

B.1. What instrument do you use to grow rice?

a) Hoe ☐

b) Rake ☐

c) Tractor ☐

e) Animal traction ☐

f) Others ☐ Which are ____________

B.2 Production factors.

B.2.1. What are the seed varieties do you use? Variety name ____________

B2.2. **Characteristic / Provenance**

a) Location
b) Improved
c) Imported
d) Hybrid

B2.3 **Variety selection criteria**

a) Income
b) Resistant to pests and diseases
c) Easy storage
d) Good flavor

C **Type of sowing**

a) Direct in line
b) Direct broadcasting
c) Transplantation

D. **Do you use fertilizer or compost? 0._____; 1. ____.**

D1 **If yes, which?**

a) Ammonium
b) Urea
c) 12-24-12

D1.2. **If not why?**

a) Very expensive
b) Not available
c) There is no money.

D2. Where do you buy

a) Formal marcket
b) Informal marcket
c) Official Services

D2.1 **How you transport fertilizer and seeds**

a) By tax
b) By bicycle
c) By hand car
d) By motor bike
e) By car
f) Others Which one? ____________________

D3. **What type of pests are most frequent?**

a) Birds
b) Rabbits
c) Hippo
d) Others Which are?

D3.1. **How do you control these pests?**

a) Traps
b) Enclosure of the parcel with Cassette Tapes
c) Scarecrow
d) Stones

D4. Do you burn the rest of the previous crop? 0 1

D4.1. Do you use any type of manure? 0 1

D5. **Distribution of tasks in the field**

D5.1. **Who does what?**

Tasks	Designation						
	M	W	C	M/W	M/C	M/W/C	W/C
Cut theTrees							
Make tillage							
Clean field							
Open the grooves							
Sow							
Cover the ground							
Control the Birds							
Control the Rabbits							
Fertilize							
Weed							
Harvest							
Thresh							
Process							

D6 What is the destination of production?

a) For consumption ☐

b) To sell ☐

c) Other reasons, ☐ which ones? ______________________________

D6.1. If it is to sell, a) where_________. b) Sales price? ____ c) Who sells to? _______

D6.2. How do you process? __________________________________

A4 – Data and Statistical Analysis

A4.1. Descriptive statistics (of quantitative variables)

Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.
Age	110	48,92	26,0000	80,0	10,71
Years of education	110	1,65	0,0000	9,0	1,54
Household number	110	5,78	2,0000	10,0	2,21
% of agricultural labour	110	0,94	0,6000	1,0	0,11
Rice cultivation experience	110	10,75	3,0000	40,0	8,35
Plot size (m2)	110	1360,52	50,0000	20000,0	2056,70
Production (kg)	110	115,02	5,0000	2400,0	233,23
Productivity (kg/hectare)	110	894,38	359,7122	1800,0	297,21
Total seed quantity (kg)	110	10,88	0,4000	160,0	16,45
Seed quantity per hectare (kg/ha)	110	80,00	80,0000	80,0	0,00
Labour on soil preparation	110	2,37	1,0000	7,0	1,06
Labour on sowing	110	2,55	1,0000	8,0	1,20
Labour on harvest	110	2,57	1,0000	8,0	1,19
Animal traction rent cost	110	32,73	0,0000	1200,0	196,35
Tractor rent cost	110	1117,18	0,0000	9000,0	1865,40
Amount of fertilizer 12-24-12 (kg)	110	6,74	0,0000	200,0	20,06
Amount of fertilizer 12-24-12 per hectare (kg/ha)	110	83,95	0,0000	347,8	102,57
Total cost of fertilizer 12-24-12 (AKZ)	110	1522,73	0,0000	50000,0	4973,15
Total cost of fertilizer 12-24-12 per hectare (AKZ/ha)	110	17266,73	0,0000	69565,2	20666,66
Amount of ammonium sulphate (kg)	110	4,76	0,0000	150,0	14,97
Amount of fertilizer ammonium sulphate per hectare	110	59,56	0,0000	317,5	75,86
Total cost of fertilizer ammonium sulphate (AKZ)	110	839,45	0,0000	30000,0	2964,67
Total cost of fertilizer ammonium sulphate per hectare	110	9243,84	0,0000	47619,0	11479,69
Total fertilization cost (AKZ)	110	2362,18	0,0000	80000,0	7931,78
Total fertilization cost per hectare (AKZ/ha)	110	26510,57	0,0000	111111,1	31623,18
Freight cost (AKZ)	110	115,00	0,0000	900,0	158,77
Number of controls	110	0,52	0,0000	2,0	0,62
Price of rice in shelt (AKZ/kg)	110	32,27	0,0000	150,0	49,11
Price of processed rice (AKZ/kg)	110	23,73	0,0000	150,0	52,53

A4.2. Frequency Tables

Frequency table: Municipality				
Category	Freq	Cumulative	Percent	Cumul %
Catabola	50	50	45,45	45,45
Camacupa	60	110	54,55	100,00

Frequency table: Village				
Category	Freq	Cumulative	Percent	Cumul %
Ndembei	10	10	9,09	9,09
Kalila	10	20	9,09	18,18
Kalohuma	10	30	9,09	27,27
Sawimbo	10	40	9,09	36,36
Tchacucuta	10	50	9,09	45,45
Kwemba2	10	60	9,09	54,55
Salumbinja	10	70	9,09	63,64
Cateia	10	80	9,09	72,73
Muinha	10	90	9,09	81,82
Chingui	10	100	9,09	90,91
Ringoma	10	110	9,09	100,00

Frequency table: Gender				
Category	Freq	Cumulative	Percent	Cumul %
Man	74	74	67,27	67,27
Woman	36	110	32,73	100,00

Frequency table: Civil status				
Category	Freq	Cumulative	Percent	Cumul %
Single	83	83	75,45	75,45
Married	17	100	15,45	90,91
Widow	10	110	9,09	100,00

Frequency table: Age (years)				
Category	Freq	Cumulative	Percent	Cumul %
20<x<=30	6	6	5,45	5,45
30<x<=40	19	25	17,27	22,73
40<x<=50	39	64	35,45	58,18
50<x<=60	35	99	31,82	90,00
60<x<=70	5	104	4,55	94,55
70<x<=80	6	110	5,45	100,00

Frequency table: Years of education				
Category (years)	Freq	Cumulative	Percent	Cumul %
0	23	23	20,91	20,91
1	41	64	37,27	58,18
2	20	84	18,18	76,36
3	15	99	13,64	90,00
4	6	105	5,45	95,45
5	2	107	1,82	97,27
6	2	109	1,82	99,09
9	1	110	0,91	100,00

Frequency table: Household number				
Category	Freq	Cumulative	Percent	Cumul %
1	4	4	3,64	3,64
2	14	18	12,73	16,36
3	16	34	14,55	30,91
4	23	57	20,91	51,82
5	17	74	15,45	67,27
6	9	83	8,18	75,45
7	9	92	8,18	83,64
9	10	102	9,09	92,73
10	8	110	7,27	100,00

Frequency table: % of agricultural labour				
Category	Freq	Cumulative	Percent	Cumul %
,50<x<=,60	3	3	2,73	2,73
,60<x<=,70	9	12	8,18	10,91
,70<x<=,80	11	23	10,00	20,91
,80<x<=,90	2	25	1,82	22,73
,90<x<=1,00	85	110	77,27	100,00

Frequency table: Rice cultivation experience (years)				
Category	Freq	Cumulative	Percent	Cumul %
0<x<=5	44	44	40,00	40,00
5<x<=10	26	70	23,64	63,64
10<x<=15	16	86	14,55	78,18
15<x<=20	12	98	10,91	89,09
20<x<=25	3	101	2,73	91,82
25<x<=30	7	108	6,36	98,18
30<x<=35	1	109	0,91	99,09
35<x<=40	1	110	0,91	100,00

Frequency table: Reason for growing the crop				
Category	Freq	Cumulative	Percent	Cumul %
Tradition	65	65	59,09	59,09
Taste	21	86	19,09	78,18
Habit	23	109	20,91	99,09
Test	1	110	0,91	100,00

Frequency table: Standstill				
Category	Freq	Cumulative	Percent	Cumul %
Never	73	73	66,36	66,36
War	23	96	20,91	87,27
Disease	14	110	12,73	100,00

Frequency table: Plot size (m2)				
Category	Freq	Cumulative	Percent	Cumul %
0,00<x<=5000,00	108	108	98,18	98,18
5000,00<x<=10000,00	1	109	0,91	99,09
10000,00<x<=15000,00	0	109	0,00	99,09
15000,00<x<=20000,00	1	110	0,91	100,00

Frequency table: Production (kg)				
Category	Freq	Cumulative	Percent	Cumul %
0,000000<x<=500,0000	109	109	99,09	99,09
500,0000<x<=1000,000	0	109	0,00	99,09
1000,000<x<=1500,000	0	109	0,00	99,09
1500,000<x<=2000,000	0	109	0,00	99,09
2000,000<x<=2500,000	1	110	0,91	100,00

Frequency table: Productivity (kg/hectare)				
Category	Freq	Cumulative	Percent	Cumul %
200,0000<x<=400,0000	2	2	1,82	1,82
400,0000<x<=600,0000	6	8	5,45	7,27
600,0000<x<=800,0000	45	53	40,91	48,18
800,0000<x<=1000,000	24	77	21,82	70,00
1000,000<x<=1200,000	18	95	16,36	86,36
1200,000<x<=1400,000	7	102	6,36	92,73
1400,000<x<=1600,000	6	108	5,45	98,18
1600,000<x<=1800,000	2	110	1,82	100,00

Frequency table: Land tenure system				
Category	Freq	Cumulative	Percent	Cumul %
Proper	37	37	33,64	33,64
Busy	24	61	21,82	55,45
Given away	22	83	20,00	75,45
Heritage	19	102	17,27	92,73
Usufruct	8	110	7,27	100,00

Frequency table: Month soil preparation				
Category	Freq	Cumulative	Percent	Cumul %
August	76	76	69,09	69,09
July	34	110	30,91	100,00

Frequency table: Sowing month				
Category	Freq	Cumulative	Percent	Cumul %
November	85	85	77,27	77,27
October	25	110	22,73	100,00

Frequency table: Harvest month				
Category	Freq	Cumulative	Percent	Cumul %
May	41	41	37,27	37,27
June	69	110	62,73	100,00

Frequency table: Total seed quantity (kg)				
Category	Freq	Cumulative	Percent	Cumul %
0,00<x<=20,00	95	95	86,36	86,36
20,00<x<=40,00	13	108	11,82	98,18
40,00<x<=60,00	1	109	0,91	99,09
60,00<x<=80,00	0	109	0,00	99,09
80,00<x<=100,00	0	109	0,00	99,09
100,00<x<=120,00	0	109	0,00	99,09
120,00<x<=140,00	0	109	0,00	99,09
140,00<x<=160,00	1	110	0,91	100,00

Frequency table: Seed quantity per hectare (kg/ha)				
Category	Freq	Cumulative	Percent	Cumul %
80	110	110	100,00	100,00

Frequency table: Labour on soil preparation (number of people)				
Category	Freq	Cumulative	Percent	Cumul %
1	23	23	20,91	20,91
2	40	63	36,36	57,27
3	35	98	31,82	89,09
4	9	107	8,18	97,27
5	2	109	1,82	99,09
6	0	109	0,00	99,09
7	1	110	0,91	100,00

Frequency table: Labour on sowing (number of people)				
Category	Freq	Cumulative	Percent	Cumul %
1	13	13	11,82	11,82
2	52	65	47,27	59,09
3	29	94	26,36	85,45
4	9	103	8,18	93,64
5	4	107	3,64	97,27
6	1	108	0,91	98,18
7	1	109	0,91	99,09
8	1	110	0,91	100,00

Frequency table: Labour on harvest (number of people)				
Category	Freq	Cumulative	Percent	Cumul %
1	11	11	10,00	10,00
2	56	67	50,91	60,91
3	25	92	22,73	83,64
4	11	103	10,00	93,64
5	3	106	2,73	96,36
6	3	109	2,73	99,09
7	0	109	0,00	99,09
8	1	110	0,91	100,00

Frequency table: Type of Payment				
Category	Freq	Cumulative	Percent	Cumul %
Unpaid	86	86	78,18	78,18
Paid in rice	24	110	21,82	100,00

Frequency table: Hoe usage				
Category	Freq	Cumulative	Percent	Cumul %
No	0	0	0,00	0,00
Yes	110	110	100,00	100,00

Frequency table: Rake usage				
Category	Freq	Cumulative	Percent	Cumul %
No	97	97	88,18	88,18
Yes	13	110	11,82	100,00

Frequency table: Catana usage				
Category	Freq	Cumulative	Percent	Cumul %
No	55	55	50,00000	50,0000
Yes	55	110	50,00000	100,0000

Frequency table: Tractor usage				
Category	Freq	Cumulative	Percent	Cumul %
No	61	61	55,45	55,45
Yes	49	110	44,55	100,00

Frequency table: Animal traction usage				
Category	Freq	Cumulative	Percent	Cumul %
No	107	107	97,27	97,27
Yes	3	110	2,73	100,00

Frequency table: Other instruments				
Category	Freq	Cumulative	Percent	Cumul %
Sickle	32	32	29,09	29,09
Knife	78	110	70,91	100,00

Frequency table: Animal traction rent cost (AKZ)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	107	107	97,27	97,27
0,00<x<=200,00	0	107	0,00	97,27
200,00<x<=400,00	0	107	0,00	97,27
400,00<x<=600,00	0	107	0,00	97,27
600,00<x<=800,00	0	107	0,00	97,27
800,00<x<=1000,00	0	107	0,00	97,27
1000,00<x<=1200,00	3	110	2,73	100,00

Frequency table: Tractor rent cost (AKZ)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	67	67	60,91	60,91
0,00<x<=2000,00	16	83	14,55	75,45
2000,00<x<=4000,00	13	96	11,82	87,27
4000,00<x<=6000,00	13	109	11,82	99,09
6000,00<x<=8000,00	0	109	0,00	99,09
8000,00<x<=10000,00	1	110	0,91	100,00

Frequency table: Seeds varieties				
Category	Freq	Cumulative	Percent	Cumul %
Kessongo	26	26	23,64	23,64
Carolino	59	85	53,64	77,27
Kahilahila	16	101	14,55	91,82
Silewa	3	104	2,73	94,55
Certanejo	6	110	5,45	100,00

Frequency table: Varieties origin				
Category	Freq	Cumulative	Percent	Cumul %
Local	19	19	17,27	17,27
Imported	91	110	82,73	100,00

Frequency table: Varieties criterion selection				
Category	Freq	Cumulative	Percent	Cumul %
Yield	34	34	30,91	30,91
Regularity	9	43	8,18	39,09
Flavour	40	83	36,36	75,45
Resistance	27	110	24,55	100,00

Frequency table: Type of sowing				
Category	Freq	Cumulative	Percent	Cumul %
Thread	62	62	56,36	56,36
Line	48	110	43,64	100,00

Frequency table: Fertilizer use				
Category	Freq	Cumulative	Percent	Cumul %
No	60	60	54,55	54,55
Yes	50	110	45,45	100,00

Frequency table: Amount of fertilizer 12-24-12 (kg)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	60	60	54,55	54,55
0,00<x<=50,00	49	109	44,55	99,09
50,00<x<=100,00	0	109	0,00	99,09
100,00<x<=150,00	0	109	0,00	99,09
150,00<x<=200,00	1	110	0,91	100,00

Frequency table: Amount of fertilizer 12-24-12 per hectare (kg/ha)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	60	60	54,55	54,55
0,00<x<=50,00	1	61	0,91	55,45
50,00<x<=100,00	7	68	6,36	61,82
100,00<x<=150,00	3	71	2,73	64,55
150,00<x<=200,00	27	98	24,55	89,09
200,00<x<=250,00	7	105	6,36	95,45
250,00<x<=300,00	1	106	0,91	96,36
300,00<x<=350,00	4	110	3,64	100,00

Frequency table: Total cost of fertilizer 12-24-12 (AKZ)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	60	60	54,55	54,55
0,00<x<=10000,00	49	109	44,55	99,09
10000,00<x<=20000,00	0	109	0,00	99,09
20000,00<x<=30000,00	0	109	0,00	99,09
30000,00<x<=40000,00	0	109	0,00	99,09
40000,00<x<=50000,00	1	110	0,91	100,00

Frequency table: Total cost of fertilizer 12-24-12 per hectare (AKZ/ha)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	60	60	54,55	54,55
0,00<x<=10000,00	1	61	0,91	55,45
10000,00<x<=20000,00	1	62	0,91	56,36
20000,00<x<=30000,00	9	71	8,18	64,55
30000,00<x<=40000,00	27	98	24,55	89,09
40000,00<x<=50000,00	7	105	6,36	95,45
50000,00<x<=60000,00	1	106	0,91	96,36
60000,00<x<=70000,00	4	110	3,64	100,00

Frequency table: Amount of ammonium sulphate (kg)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,000000	61	61	55,45	55,45
0,00<x<=20,00	48	109	43,64	99,09
20,00<x<=40,00	0	109	0,00	99,09
40,00<x<=60,00	0	109	0,00	99,09
60,00<x<=80,00	0	109	0,00	99,09
80,00<x<=100,00	0	109	0,00	99,09
100,00<x<=120,00	0	109	0,00	99,09
120,00<x<=140,00	0	109	0,00	99,09
140,00<x<=160,00	1	110	0,91	100,00

Frequency table: Amount of fertilizer ammonium sulphate per hectare (kg/ha)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	61	61	55,45	55,45
0,00<x<=50,00	1	62	0,91	56,36
50,00<x<=100,00	12	74	10,91	67,27
100,00<x<=150,00	23	97	20,91	88,18
150,00<x<=200,00	10	107	9,09	97,27
200,00<x<=250,00	2	109	1,82	99,09
250,00<x<=300,00	0	109	0,00	99,09
300,00<x<=350,00	1	110	0,91	100,00

Frequency table: Total cost of fertilizer ammonium sulphate (AKZ)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	61	61	55,45	55,45
0,00<x<=5000,00	48	109	43,64	99,09
5000,00<x<=10000,00	0	109	0,00	99,09
10000,00<x<=15000,00	0	109	0,00	99,09
15000,00<x<=20000,00	0	109	0,00	99,09
20000,00<x<=25000,00	0	109	0,00	99,09
25000,00<x<=30000,00	1	110	0,91	100,00

Frequency table: Total cost of fertilizer ammonium sulphate per hectare (AKZ/ha)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	61	61	55,45	55,45
0,00<x<=10000,00	1	62	0,91	56,36
10000,00<x<=20000,00	28	90	25,45	81,82
20000,00<x<=30000,00	17	107	15,45	97,27
30000,00<x<=40000,00	2	109	1,82	99,09
40000,00<x<=50000,00	1	110	0,91	100,00

Frequency table: Total fertilization cost (AKZ)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	60	60	54,55	54,55
0,00<x<=10000,00	46	106	41,82	96,36
10000,00<x<=20000,00	3	109	2,73	99,09
20000,00<x<=30000,00	0	109	0,00	99,09
30000,00<x<=40000,00	0	109	0,00	99,09
40000,00<x<=50000,00	0	109	0,00	99,09
50000,00<x<=60000,00	0	109	0,00	99,09
60000,00<x<=70000,00	0	109	0,00	99,09
70000,00<x<=80000,00	1	110	0,91	100,00

Frequency table: Total fertilization cost per hectare (AKZ/ha)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	60	60	54,55	54,55
0,00<x<=20000,00	2	62	1,82	56,36
20000,00<x<=40000,00	6	68	5,45	61,82
40000,00<x<=60000,00	20	88	18,18	80,00
60000,00<x<=80000,00	18	106	16,36	96,36
80000,00<x<=100000,00	2	108	1,82	98,18
100000,00<x<=120000,00	2	110	1,82	100,00

Frequency table: Origin of fertilizer				
Category	Freq	Cumulative	Percent	Cumul %
Informal Markets	18	18	16,36	16,36
Official Services	32	50	29,09	45,45
Missing	60	110	54,55	100,00

Frequency table: Fertilizer transport				
Category	Freq	Cumulative	Percent	Cumul %
Car	35	35	31,82	31,82
Hand	4	39	3,64	35,45
Hand car	2	41	1,82	37,27
Motor taxi	8	49	7,27	44,55
Manual	1	50	0,91	45,45
Missing	60	110	54,55	100,00

Frequency table: Freight cost (AKZ)				
Category	Freq	Cumulative	Percent	Cumul %
x<=0,00	66	66	60,00	60,00
0,00<x<=200,00	15	81	13,64	73,64
200,00<x<=400,00	27	108	24,55	98,18
400,00<x<=600,00	1	109	0,91	99,09
600,00<x<=800,00	0	109	0,00	99,09
800,00<x<=1000,00	1	110	0,91	100,00

Frequency table: Culture control enemy				
Category	Freq	Cumulative	Percent	Cumul %
No any	60	60	54,55	54,55
Manual	50	110	45,45	100,00

Frequency table: Number of controls				
Category	Freq	Cumulative	Percent	Cumul %
0	60	60	54,55	54,55
1	43	103	39,09	93,64
2	7	110	6,36	100,00

Frequency table: Field delimitation				
Category	Freq	Cumulative	Percent	Cumul %
No	45	45	40,91	40,91
Yes	65	110	59,09	100,00

Frequency table: Tree cutting				
Category	Freq	Cumulative	Percent	Cumul %
M	107	107	97,27	97,27
M/W	2	109	1,82	99,09
M/C	1	110	0,91	100,00

Frequency table: Tillage				
Category	Freq	Cumulative	Percent	Cumul %
M	6	6	5,45	5,45
M/W	93	99	84,55	90,00
M/C	3	102	2,73	92,73
M/C/W	8	110	7,27	100,00

Frequency table: Clearing field				
Category	Freq	Cumulative	Percent	Cumul %
M	24	24	21,82	21,82
M/W	34	58	30,91	52,73
M/C	2	60	1,82	54,55
M/W/C	50	110	45,45	100,00

Frequency table: Opening the grooves				
Category	Freq	Cumulative	Percent	Cumul %
M	49	49	44,55	44,55
None	61	110	55,45	100,00

Frequency table: Sowing act				
Category	Freq	Cumulative	Percent	Cumul %
M	7	7	6,36	6,36
W	34	41	30,91	37,27
M/W	69	110	62,73	100,00

Frequency table: Ground cover				
Category	Freq	Cumulative	Percent	Cumul %
M	1	1	0,91	0,91
M/W	68	69	61,82	62,73
C	9	78	8,18	70,91
W/C	3	81	2,73	73,64
M/C	11	92	10,00	83,64
M/W/C	18	110	16,36	100,00

Frequency table: Bird control				
Category	Freq	Cumulative	Percent	Cumul %
M	9	9	8,18	8,18
C	93	102	84,55	92,73
M/C	8	110	7,27	100,00

Frequency table: Rabbits control				
Category	Freq	Cumulative	Percent	Cumul %
None	50	50	45,45	45,45
M	7	57	6,36	51,82
C	21	78	19,09	70,91
M/C	32	110	29,09	100,00

Frequency table: Fertilization act				
Category	Freq	Cumulative	Percent	Cumul %
M	21	21	19,09	19,09
W	9	30	8,18	27,27
M/W	21	51	19,09	46,36
None	59	110	53,64	100,00

Frequency table: Weeding act				
Category	Freq	Cumulative	Percent	Cumul %
M	2	2	1,82	1,82
W	11	13	10,00	11,82
M/W	42	55	38,18	50,00
None	55	110	50,00	100,00

Frequency table: Harvest act				
Category	Freq	Cumulative	Percent	Cumul %
M/W	64	64	58,18	58,18
M/C	4	68	3,64	61,82
M/W/C	42	110	38,18	100,00

Frequency table: Threshing act				
Category	Freq t	Cumulative	Percent	Cumul %
M/C	4	4	3,64	3,64
M/W	102	106	92,73	96,36
W	1	107	0,91	97,27
M/W/C	3	110	2,73	100,00

Frequency table: Processing act				
Category	Freq	Cumulative	Percent	Cumul %
M/C	2	2	1,82	1,82
M/W	92	94	83,64	85,45
W	11	105	10,00	95,45
M/W/C	5	110	4,55	100,00

Frequency table: Storage act				
Category	Freq	Cumulative	Percent	Cumul %
bags	93	93	84,55	84,55
bottle	11	104	10,00	94,55
mat container	6	110	5,45	100,00

Frequency table: Control of Salale prague				
Category	Freq	Cumulative	Percent	Cumul %
No	49	49	44,55	44,55
Yes (ash)	61	110	55,45	100,00

Frequency table: rats prague				
Category	Freq	Cumulative	Percent	Cumul %
Yes	62	62	56,36	56,36
No	45	107	40,91	97,27
Nothing	3	110	2,73	100,00

Frequency table: rats control				
Category	Freq	Cumulative	Percent	Cumul %
Glue	32	32	29,09	29,09
Nothing	50	82	45,45	74,55
Raticide	28	110	25,45	100,00

Frequency table: Production destination				
Category	Freq	Cumulative	Percent	Cumul %
Consumption	40	40	36,36	36,36
Sell	43	83	39,09	75,45
Seed	27	110	24,55	100,00

Frequency table: Place of sale				
Category	Freq	Cumulative	Percent	Cumul %
Do not sell	67	67	60,91	60,91
At home	14	81	12,73	73,64
Local market	29	110	26,36	100,00

Frequency table: Buyers				
Category	Freq	Cumulative	Percent	Cumul %
No buyer	67	67	60,91	60,91
Local population	30	97	27,27	88,18
Other producers	13	110	11,82	100,00

Frequency table: Price of rice in shelt (AKZ/kg)				
Category	Freq	Cumulative	Percent	Cumul %
0	76	76	69,09	69,09
100	31	107	28,18	97,27
150	3	110	2,73	100,00

Frequency table: Price of processed rice (AKZ/kg)				
Category	Freq	Cumulative	Percent	Cumul %
0	91	91	82,73	82,73
120	8	99	7,27	90,00
150	11	110	10,00	100,00

Frequency table: Processing methods				
Category	Freq	Cumulative	Percent	Cumul %
Hand made	95	95	86,36	86,36
Mechanized	15	110	13,64	100,00

Frequency table: Bran fate				
Category	Count	Cumulative	Percent	Cumul %
Animal food	22	22	20,00	20,00
Manure	39	61	35,45	55,45
Others	1	62	0,91	56,36
Underappreciated	48	110	43,64	100,00

A4.3. Analysis of Variance (Municipalities)

Breakdown Table of Descriptive Statistics N=110 (No missing data in dep. var. list)

	Municipality	Age	Years of education	Household number	% of agricultural labor	Rice cultivation experience	Plot size (m2)	Production (kg)	Productivity (kg/hectare)	Total seed quantity (kg)	Seed quantity per hectare (kg/ha)	Labor on soil preparation	Labor on sowing	Labor on harvest	Animal traction rent cost	Tractor rent cost	Amount of fertilizer 12-24-12 (kg)	Amount of fertilizer 12-24-12 per hectare (kg/ha)	Total cost of fertilizer 12-24-12 (AKZ)	Total cost of fertilizer 12-24-12 per hectare (AKZ/ha)	Amount of ammonium sulfate (kg)	Amount of fertilizer ammonium sulfate per hectare (kg/ha)	Total cost of fertilizer ammonium sulfate (AKZ)	Total cost of fertilizer ammonium sulfate per hectare (AKZ/ha)	Total fertilization cost (AKZ)	Total fertilization cost per hectare (AKZ/ha)	Freight cost (AKZ)	Number of controls	Price of rice in shelt (AKZ/kg)	Price of processed rice (AKZ/kg)
	Catabola	44,64000	2,080000	4,500000	0,908000	11,38000	451,680	47,5660	1076,207	3,61344	80,00000	2,320000	2,500000	2,520000	0,00000	2158,800	7,100000	163,7075	1420,000	32741,50	4,952000	117,3643	742,8000	17604,65	2162,800	50346,15	207,0000	0,900000	28,00000	49,20000
	Camacupa	52,48333	1,283333	6,850000	0,971667	10,23333	2117,883	171,2387	742,849	16,94307	80,00000	2,416667	2,600000	2,616667	60,00000	249,167	6,433333	17,4843	1608,333	4371,08	4,600000	11,3825	920,0000	2276,50	2528,333	6647,58	38,3333	0,200000	35,83333	2,50000
	All Grps	48,91818	1,645455	5,781818	0,942727	10,75455	1360,518	115,0238	894,375	10,88415	80,00000	2,372727	2,554545	2,572727	32,72727	1117,182	6,736364	83,9494	1522,727	17266,73	4,760000	59,5561	839,4545	9243,84	2362,182	26510,57	115,0000	0,518182	32,27273	23,72727
significant diferences (p<0,05)		*	*	*	*		*	*	*	*						*		*		*		*	*	*		*	*	*		*

Analysis of Variance. Marked effects (in red) are significant at p < 0,05

	SS	df	MS	SS	df	MS	F	p
Age	1,677760E+03	1	1,677760E+03	1,083650E+04	108	100	16,7211	0,000084
Years of education	1,730939E+01	1	1,730939E+01	2,398633E+02	108	2	7,7937	0,006202
Household number	1,506136E+02	1	1,506136E+02	3,841500E+02	108	4	42,3435	0,000000
% of agricultural labor	1,105485E-01	1	1,105485E-01	1,278633E+00	108	0	9,3375	0,002829
Rice cultivation experience	3,585939E+01	1	3,585939E+01	7,566513E+03	108	70	0,5118	0,475889
Plot size (m2)	7,571546E+07	1	7,571546E+07	3,853566E+08	108	3568117	21,2200	0,000011
Production (kg)	4,171344E+05	1	4,171344E+05	5,512231E+06	108	51039	8,1728	0,005104
Productivity (kg/hectare)	3,030752E+06	1	3,030752E+06	6,597738E+06	108	61090	49,6111	0,000000
Total seed quantity (kg)	4,845789E+03	1	4,845789E+03	2,466282E+04	108	228	21,2200	0,000011
Seed quantity per hectare (kg/ha)	0,000000E+00	1	0,000000E+00	3,029226E-27	108	0	0,0000	1,000000
Labor on soil preparation	2,548485E-01	1	2,548485E-01	1,214633E+02	108	1	0,2266	0,635018
Labor on sowing	2,727273E-01	1	2,727273E-01	1,569000E+02	108	1	0,1877	0,665678
Labor on harvest	2,548485E-01	1	2,548485E-01	1,546633E+02	108	1	0,1780	0,673972
Animal traction rent cost	9,818182E+04	1	9,818182E+04	4,104000E+06	108	38000	2,5837	0,110887
Tractor rent cost	9,945544E+07	1	9,945544E+07	2,798322E+08	108	2591039	38,3844	0,000000
Amount of fertilizer 12-24-12 (kg)	1,212121E+01	1	1,212121E+01	4,386723E+04	108	406	0,0298	0,863172
Amount of fertilizer 12-24-12 per he	5,831242E+05	1	5,831242E+05	5,636929E+05	108	5219	111,7229	0,000000
Total cost of fertilizer 12-24-12 (AKZ	9,673485E+05	1	9,673485E+05	2,694846E+09	108	24952276	0,0388	0,844279
Total cost of fertilizer 12-24-12 per h	2,195129E+10	1	2,195129E+10	2,460378E+10	108	227812778	96,3567	0,000000
Amount of ammonium sulfate (kg)	3,379200E+00	1	3,379200E+00	2,442628E+04	108	226	0,0149	0,902941
Amount of fertilizer ammonium sulfa	3,063315E+05	1	3,063315E+05	3,209945E+05	108	2972	103,0666	0,000000
Total cost of fertilizer ammonium su	8,563593E+05	1	8,563593E+05	9,571734E+08	108	8862717	0,0966	0,756517
Total cost of fertilizer ammonium su	6,407791E+09	1	6,407791E+09	7,956590E+09	108	73672131	86,9771	0,000000
Total fertilization cost (AKZ)	3,644035E+06	1	3,644035E+06	6,853890E+09	108	63461941	0,0574	0,811074
Total fertilization cost per hectare (A	5,207906E+10	1	5,207906E+10	5,692373E+10	108	527071572	98,8083	0,000000
Freight cost (AKZ)	7,758667E+05	1	7,758667E+05	1,971883E+06	108	18258	42,4942	0,000000
Number of controls	1,336364E+01	1	1,336364E+01	2,810000E+01	108	0	51,3620	0,000000
Price of rice in shelt (AKZ/kg)	1,673485E+03	1	1,673485E+03	2,612583E+05	108	2419	0,6918	0,407391
Price of processed rice (AKZ/kg)	5,947882E+04	1	5,947882E+04	2,412930E+05	108	2234	26,6220	0,000001

A4.4. Analysis of Variance (Villages)

Breakdown Table of Descriptive Statistics N=110 (No missing data in dep. var. list)

	Vilage	Age	Years of education	Household number	% of agricultural labor	Rice cultivation experience	Plot size (m2)	Production (kg)	Productivity (kg/hectare)	Total seed quantity (kg)	Seed quantity per hectare (kg/ha)	Labor on soil preparation	Labor on sowing	Labor on harvest	Animal traction rent cost
	Ndembei	45,50000	1,400000	4,700000	0,840000	12,40000	410,300	40,7000	1001,349	3,28240	80,00000	2,800000	3,100000	2,800000	0,0000
	Kalila	47,20000	2,100000	4,600000	0,970000	11,10000	390,300	38,9800	1006,053	3,12240	80,00000	2,000000	1,600000	1,800000	0,0000
	Kalohuma	41,30000	2,100000	4,000000	0,940000	9,60000	468,200	45,2000	988,898	3,74560	80,00000	3,000000	2,400000	2,400000	0,0000
	Sawimbo	43,40000	2,000000	4,400000	0,860000	13,00000	540,000	67,4000	1358,929	4,32000	80,00000	2,500000	3,400000	3,600000	0,0000
	Tchacucuta	45,80000	2,800000	4,800000	0,930000	10,80000	449,600	45,5500	1025,805	3,59680	80,00000	1,300000	2,000000	2,000000	0,0000
	Kwemba2	56,00000	2,000000	6,800000	0,900000	16,10000	4105,000	377,1000	703,738	32,84000	80,00000	3,000000	3,500000	3,800000	0,0000
	Salumbinja	52,40000	1,400000	6,400000	1,000000	9,50000	1505,000	96,4000	645,104	12,04000	80,00000	2,900000	2,900000	2,800000	0,0000
	Cateia	49,60000	0,600000	6,100000	1,000000	8,50000	1720,000	101,3000	604,667	13,76000	80,00000	2,700000	2,700000	2,700000	0,0000
	Muinha	54,20000	2,100000	7,200000	0,930000	12,30000	1560,000	132,2000	875,556	12,48000	80,00000	1,900000	2,000000	1,900000	0,0000
	Chingui	52,00000	1,000000	8,300000	1,000000	6,80000	2334,500	224,0500	978,029	18,67600	80,00000	2,400000	2,700000	2,700000	0,0000
	Ringoma	50,70000	0,600000	6,300000	1,000000	8,20000	1482,800	96,3820	650,000	11,86240	80,00000	1,600000	1,800000	1,800000	360,0000
	All Grps	48,91818	1,645455	5,781818	0,942727	10,75455	1360,518	115,0238	894,375	10,88415	80,00000	2,372727	2,554545	2,572727	32,7273
significant diferences (p<0,05)		*	*	*	*		*	*	*	*		*	*	*	*

	Vilage	Tractor rent cost	Amount of fertilizer 12-24-12 (kg)	Amount of fertilizer 12-24-12 per hectare (kg/ha)	Total cost of fertilizer 12-24-12 (AKZ)	Total cost of fertilizer 12-24-12 per hectare (AKZ/ha)	Amount of ammonium sulfate (kg)	Amount of fertilizer ammonium sulfate per hectare (kg/ha)	Total cost of fertilizer ammonium sulfate (AKZ)	Total cost of fertilizer ammonium sulfate per hectare (AKZ/ha)	Total fertilization cost (AKZ)	Total fertilization cost per hectare (AKZ/ha)	Freight cost (AKZ)	Number of controls	Price of rice in shelt (AKZ/kg)	Price of processed rice (AKZ/kg)
	Ndembei	2490,000	9,00000	227,9762	1800,000	45595,24	6,34000	173,0317	951,000	25954,76	2751,000	71550,00	270,0000	1,200000	50,00000	60,0000
	Kalila	1684,000	6,40000	197,2133	1280,000	39442,67	3,92000	116,9304	588,000	17539,55	1868,000	56982,22	260,0000	0,900000	20,00000	24,0000
	Kalohuma	1020,000	5,20000	105,9347	1040,000	21186,93	3,30000	72,5061	495,000	10875,91	1535,000	32062,85	100,0000	0,400000	20,00000	12,0000
	Sawimbo	3810,000	10,20000	192,5000	2040,000	38500,00	7,50000	149,9802	1125,000	22497,02	3165,000	60997,02	255,0000	1,200000	0,00000	150,0000
	Tchacucuta	1790,000	4,70000	94,9134	940,000	18982,68	3,70000	74,3734	555,000	11156,01	1495,000	30138,68	150,0000	0,800000	50,00000	0,0000
	Kwemba2	900,000	20,00000	10,0000	5000,000	2500,00	15,00000	7,5000	3000,000	1500,00	8000,000	4000,00	90,0000	0,200000	55,00000	15,0000
	Salumbinja	0,000	0,00000	0,0000	0,000	0,00	0,00000	0,0000	0,000	0,00	0,000	0,00	0,0000	0,000000	20,00000	0,0000
	Cateia	0,000	0,00000	0,0000	0,000	0,00	0,00000	0,0000	0,000	0,00	0,000	0,00	0,0000	0,000000	40,00000	0,0000
	Muinha	0,000	8,50000	49,0769	2125,000	12269,23	5,60000	32,0513	1120,000	6410,26	3245,000	18679,49	80,0000	0,400000	40,00000	0,0000
	Chingui	595,000	10,10000	45,8290	2525,000	11457,26	7,00000	28,7436	1400,000	5748,73	3925,000	17205,99	60,0000	0,600000	50,00000	0,0000
	Ringoma	0,000	0,00000	0,0000	0,000	0,00	0,00000	0,0000	0,000	0,00	0,000	0,00	0,0000	0,000000	10,00000	0,0000
	All Grps	1117,182	6,73636	83,9494	1522,727	17266,73	4,76000	59,5561	839,455	9243,84	2362,182	26510,57	115,0000	0,518182	32,27273	23,7273
significant diferences (p<0,05)		*		*		*		*		*		*	*	*		*

Analysis of Variance. Marked effects (in red) are significant at p < 0,05

	SS	df	MS	SS	df	MS	F	p
Age	2,161564E+03	10	2,161564E+02	1,035270E+04	99	105	2,06704	0,034225
Years of education	4,927273E+01	10	4,927273E+00	2,079000E+02	99	2	2,34632	0,015708
Household number	1,875636E+02	10	1,875636E+01	3,472000E+02	99	4	5,34816	0,000003
% of agricultural labor	3,341818E-01	10	3,341818E-02	1,055000E+00	99	0	3,13592	0,001612
Rice cultivation experience	6,898727E+02	10	6,898727E+01	6,912500E+03	99	70	0,98803	0,458965
Plot size (m2)	1,282916E+08	10	1,282916E+07	3,327805E+08	99	3361419	3,81659	0,000221
Production (kg)	1,050251E+06	10	1,050251E+05	4,879115E+06	99	49284	2,13102	0,028691
Productivity (kg/hectare)	5,154146E+06	10	5,154146E+05	4,474344E+06	99	45195	11,40414	0,000000
Total seed quantity (kg)	8,210663E+03	10	8,210663E+02	2,129795E+04	99	215	3,81659	0,000221
Seed quantity per hectare (kg/ha)	0,000000E+00	10	0,000000E+00	2,827277E-27	99	0	0,00000	1,000000
Labor on soil preparation	3,481818E+01	10	3,481818E+00	8,690000E+01	99	1	3,96663	0,000143
Labor on sowing	4,187273E+01	10	4,187273E+00	1,153000E+02	99	1	3,59532	0,000422
Labor on harvest	4,701818E+01	10	4,701818E+00	1,079000E+02	99	1	4,31399	0,000052
Animal traction rent cost	1,178182E+06	10	1,178182E+05	3,024000E+06	99	30545	3,85714	0,000197
Tractor rent cost	1,523153E+08	10	1,523153E+07	2,269723E+08	99	2292649	6,64364	0,000000
Amount of fertilizer 12-24-12 (kg)	3,502255E+03	10	3,502255E+02	4,037710E+04	99	408	0,85871	0,574101
Amount of fertilizer 12-24-12 per hectare (kg/ha)	7,523950E+05	10	7,523950E+04	3,944221E+05	99	3984	18,88512	0,000000
Total cost of fertilizer 12-24-12 (AKZ)	2,139077E+08	10	2,139077E+07	2,481906E+09	99	25069753	0,85325	0,579163
Total cost of fertilizer 12-24-12 per hectare (AKZ/ha)	2,934642E+10	10	2,934642E+09	1,720866E+10	99	173824804	16,88276	0,000000
Amount of ammonium sulfate (kg)	1,925184E+03	10	1,925184E+02	2,250448E+04	99	227	0,84691	0,585048
Amount of fertilizer ammonium sulfate per hectare (kg/ha)	3,978884E+05	10	3,978884E+04	2,294376E+05	99	2318	17,16848	0,000000
Total cost of fertilizer ammonium sulfate (AKZ)	7,531697E+07	10	7,531697E+06	8,827128E+08	99	8916291	0,84471	0,587095
Total cost of fertilizer ammonium sulfate per hectare (AKZ	8,665985E+09	10	8,665985E+08	5,698396E+09	99	57559553	15,05568	0,000000
Total fertilization cost (AKZ)	5,422262E+08	10	5,422262E+07	6,315308E+09	99	63790985	0,85000	0,582175
Total fertilization cost per hectare (AKZ/ha)	6,953436E+10	10	6,953436E+09	3,946843E+10	99	398671003	17,44154	0,000000
Freight cost (AKZ)	1,106500E+06	10	1,106500E+05	1,641250E+06	99	16578	6,67439	0,000000
Number of controls	2,096364E+01	10	2,096364E+00	2,050000E+01	99	0	10,12390	0,000000
Price of rice in shelt (AKZ/kg)	3,568182E+04	10	3,568182E+03	2,272500E+05	99	2295	1,55446	0,131728
Price of processed rice (AKZ/kg)	2,085218E+05	10	2,085218E+04	9,225000E+04	99	932	22,37795	0,000000

Marked correlations are significant at p < ,05000 N=101 (Casewise deletion of missing data)

A4.5. Correlations Analysis (dependent variable Productivity)

Variable	Productivity (kg/hectare)
Municipality	-0,529630
Vilage	-0,329861
Gender	0,008988
Civil status	-0,012554
Age	-0,279742
Years of education	0,204840
Household number	-0,133186
% of agricultural labor	-0,128918
Rice cultivation experience	-0,106283
Reason for growing the crop	0,118786
Standstill	-0,015534
Plot size (m2)	-0,112649
Land tenure system	-0,056127
Month soil preparation	0,185690
Sowing month	0,204935
Harvest month	-0,114508
Total seed quantity (kg)	-0,112649
Seed quantity per hectare (kg/ha)	-0,032342
Tractor usage	0,493386
Seeds varieties	-0,178565
Amount of fertilizer 12-24-12 per hectare (kg/ha	0,557567
Amount of fertilizer ammonium sulfate per hec	0,575979
Total fertilization cost per hectare (AKZ/ha)	0,589286
Number of controls	0,659371
Salale prague	-0,115369
Production destination	0,043986
Place of sale	0,381875
Buyers	0,247558
Price of rice in shelt (AKZ/kg)	0,031781
Price of processed rice (AKZ/kg)	0,484644
Tractor rent cost	0,026434
Seeds varieties	0,154718
Varieties origin	0,044125
Varieties criterium selection	-0,008763
Type of sowing	0,104301
Fertilizer use	
Amount of fertilizer 12-24-12 (kg)	-0,007105
Amount of fertilizer 12-24-12 per hectare (kg/ha	-0,122350
Total cost of fertilizer 12-24-12 (AKZ)	0,001739
Total cost of fertilizer 12-24-12 per hectare (AK	-0,129997
Amount of ammonium sulfate (kg)	0,005935
Amount of fertilizer ammonium sulfate per hec	0,042155
Total cost of fertilizer ammonium sulfate (AKZ)	0,014336
Total cost of fertilizer ammonium sulfate per he	0,048472
Total fertilization cost (AKZ)	0,006476
Total fertilization cost per hectare (AKZ/ha)	-0,065451
Origin of fertilizer	0,156436
Fertilizer transport	-0,258591
Freight cost (AKZ)	-0,172762
Culture control enemy	
Number of controls	0,238529
Field delimitation	
Tree cutting	-0,044178
Tillage	-0,092066
Clearing field	0,234221
Opening the grooves	-0,159584
Sowing act	-0,010458
Ground cover	0,305833
Bird control	0,085194
Rabbits control	0,033398
Fretilization act	0,058893
Weeding act	-0,263036
Harvest act	0,037733
Threshing act	0,204089
Processing act	0,121638
Storage act	0,005719
Salale prague	-0,102043
Salale control	-0,102043
rats prague	-0,114257
rats control	0,005233
Production destination	-0,049432
Place of sale	0,335937
Buyers	0,275271
Price of rice in shelt (AKZ/kg)	-0,094561
Price of processed rice (AKZ/kg)	0,332464
Processing methods	0,317724
Bran fate	0,087663

A4.6. Multiple Regression Analysis (dependent variable Productivity)

Method step by step forward, dependent variable Productivity

Multiple Regression Results (Step 0)

Dependent: Productivity (Multiple R = 0,00000000; F = 0,000000; R^2= 0,00000000; df = 0,100; No. of cases: 101; adjusted R^2= 0,00000000; p = -0,00000; Standard error of estimate:300,71786424)

Step 0: No variables in the regression equation

Multiple Regression Results (Step 1)

Dependent: Productivity (Multiple R = = ,65937075; F = 76,14987; R^2= ,43476978; df = 1,990; No. of cases: 101; adjusted R^2= ,42906039; p = -0,00000; Standard error of estimate: 227,22406082)

Intercept: 736,57479319 Std.Error: 30,57241; t(99) = 24,093; p = 0,0000

Number of controls b*= ,659

(significant b* are highlighted in red)

Multiple Regression Results (Step 2)

Dependent: Productivity (Multiple R = = ,70385724; F = 48,10951; R^2= ,49541501; df =2,980; No. of cases: 101; adjusted R^2= ,48511736; p = -0,00000; Standard error of estimate: 215,78107629)

Intercept: 1071,9611408 Std.Error: 101,9455; t(98) = 10,515; p = ,0000

Number of controls b*= ,647 Age b*= -,25

(significant b* are highlighted in red)

Multiple Regression Results (Step 3)

Dependent: Productivity (Multiple R = = ,73114223; F = 37,13632; R^2= ,53456896; df = 3,970; No. of cases: 101; adjusted R^2= ,52017419; p = -0,00000; Standard error of estimate: 208,30564107)

Intercept: -17157,25123; Std.Error: 6382,246; t(97) = -2,688; p = ,0085

Number of controls b*= ,565 Age b*= -,24 Processing methods b*= ,214

(significant b* are highlighted in red)

Multiple Regression Results (Step 4)

Dependent: Productivity (Multiple R = = ,75880221; F = 32,57452; R^2= ,57578080; df = 4,960; No. of cases: 101; adjusted R^2= ,55810500; p = -0,00000; Standard error of estimate: 199,90275128)

Intercept: -34071,15925; Std.Error: 8257,608; t(96) = -4,126; p = ,0001

Number of con b*= ,557 Age b*= -,23 Processing methods b*= ,234 Sowing month b*= ,204

(significant b* are highlighted in red)

Multiple Regression Results (Step 5)

Dependent: Productivity (Multiple R = ,76351077; F = 26,55794; R^2= ,58294870; df = 5,950; No. of cases: 101; adjusted R^2= ,56099863; p = ,000000; Standard error of estimate: 199,24717251)

Intercept: -25844,48664; Std.Error: 10449,47; t(95) = -2,473; p = ,0152

Number of con b*= ,506 Age b*= -,19 Processing me b*= ,214 Sowing month b*= ,208

Municipality b*= -,11 (significant b* are highlighted in red)

Regression Summary for Dependent Variable: Productivity (kg/hectare) (Pascoal1.sta)

R= ,76351077 R^2= ,58294870 Adjusted R^2= ,56099863 F(5,95)=26,558 p<,00000 Std.Error of estimate: 199,25

	b*	Std.Err.	b	Std.Err.	t(95)	p-value
Intercept			-25844,487	10449,469	-2,473	0,015
Number of controls	0,506	0,082	244,127	39,678	6,153	0,000
Age	-0,186	0,073	-5,125	2,026	-2,529	0,013
Processing methods	0,214	0,074	180,225	61,983	2,908	0,005
Sowing month	0,208	0,067	153,340	49,204	3,116	0,002
Municipality	-0,113	0,089	-67,737	53,010	-1,278	0,204