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Rice Value Chain Development and Policy Sequencing in Southern Africa

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Rice Value Chain Development and Policy Sequencing in Southern Africa

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Abstract

In the wake of the 2008 food crisis, net food importing countries questioned the reliance on the volatile world market to meet their food demand. Consequently, the necessity to be self-sufficient returned to the forefront of national priorities. In Africa, the Coalition for African Rice Development (CARD) initiative was initiated and aimed to double rice production in the continent by 2018, with the eventual goal of achieving self-sufficiency in rice production. To attain this goal, each of the 23 CARD member countries drafted a comprehensive value chain upgrading strategy called the National Rice Development Strategy (NRDS). This study intends to evaluate through simulations the feasibility of the NRDS goals for four southern African countries, Madagascar, Malawi, Mozambique, and Zambia by looking at past trends and projecting future rice supply and use within each country. The Arkansas Global Rice Model, a non-spatial, partial equilibrium and multi-country econometric framework, is used to estimate baseline projections and simulate self-sufficiency scenarios. The business as usual baseline results indicate that none of the four countries will be able to attain self-sufficiency by 2018. Thus, alternative scenarios estimating the production level requirement for self-sufficiency were simulated — relative to area harvested, yield increase— and compared to the NRDS goals. Additionally, a qualitative analysis of the feasibility of achieving self-sufficiency for each country is provided considering the current national policy framework.

Acknowledgements

First and foremost, I would like to acknowledge my thesis advisor, Dr. Eric Wailes for his unwavering support and patience throughout the thesis research and writing process. His guidance taught me to be an independent researcher despite my shortcomings in the field of agricultural economic studies and research in general. Mr. Eddie Chavez for his willingness to help with the use and understanding of the Arkansas Global Rice Model. His readiness to answer my incessant questions and commuting to campus to help me when needed. Thank you to Dr. Marilyne Huchet-Bourdon, of Agrocampus Ouest, for her keenness to be part of my thesis committee despite the short notice. Dr. Alvaro Durand-Morat for his understanding regarding my work as a teaching assistant and for his constructive comments and advice. Thank you all for the time and energy you put forth in assisting me during this rigorous process.

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This program taught me much more than I bargained for and everything I learned here was definitely not limited to Agricultural Economics but much more. It taught me the virtue of perseverance, commitment, dedication, hard work and the courage to push boundaries. The list is endless.

Dedication

I dedicate this thesis to my family, my father, my mother and my brother, who have been my biggest supporters even from the other side of the world. May this be the first of many Razafinjoelina to pursue graduate studies and be the beginning of a new tradition. To my fiancé, Aldo, for keeping me sane, for encouraging me to go beyond my limits and for having faith in me even when I doubted myself.

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List of Abbreviations

AfDB	African Development Bank
AgGDP	Agricultural Gross Domestic Product
AGRA	African Green Revolution Alliance
AGREP	Arkansas Global Rice Economics Program
AGRM	Arkansas Global Rice Model
ASEAN	Association of Southeast Asian Nations
ASTI	Agricultural Science and Technology Indicators
ASWAp	Agriculture Sector Wide Approach
AU	African Union
CAADP	Comprehensive Africa Agriculture Development Programme
CARD	Coalition for African Rice Development
COMESA	Common Market for Eastern and Southern Africa
CSO	Central Statistics Office
CUTS International	Consumer Unity & Trust Society International
DRC	Domestic Resource Cost
EAC	East African Community
EEAS	European External Action Service
ERP	Economic Rehabilitation Program
EUROCORD	European Cooperative for Rural Development
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
FISP	Fertilizer Input Support Program
FNRSP	Nutrition Security Regional Program
FRA	Food Reserve Agency
FSP	Food Security Pack Program
FTE	full-time equivalent
GDP	Gross Domestic Product
GRiSP	Global Rice Science Partnership
Ha	Hectare
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IOC	Indian Ocean Commission
JICA	Japan International Cooperation Agency
Kg	Kilogram
LCU	Local Currency Unit
MAP	Madagascar Action Plan
MDG	Millennium Development Goals
MGDS II	Malawi Growth and Development Strategy II
MT	Metric Tons

MVAC	Malawi Vulnerable Assessment Committee
NAP	National Agricultural Policy
NEPAD	New Partnership for Africa's Development
NES	National Export Strategy
NPC	Nominal Protection Coefficient
NRA	Nominal Rate of Assistance
NRDP	National Rice Development Platform
NRDS	National Rice Development Strategy
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Square
PARPA	Action Plan for the Reduction of Absolute Poverty
PEDSA	Strategic Plan for Agricultural Sector Development
PND	National Development Plan
PNISA	National Investment Plan for the Agricultural Sector
PPP	Power Purchasing Parity
PSD Online	Production, Supply and Distribution Online
R&D	Research and Development
RGDP	Real Gross Domestic Product
SADC	Southern African Development Community
SADCC	Southern African Development Coordinating Conference
SLC	Standard Local Currency
Sq. Km	Square Kilometers
SRI	System of Rice Intensification
SSA	Sub-Saharan Africa
TICAD IV	Tokyo International Conference on African Development IV
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
UNECA	United Nations Economic Commission for Africa
USAID	United States Agency for International Development
USD	United-States Dollar
USDA-FAS	United States Department of Agriculture Foreign Agricultural Service
WFP	World Food Programme

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Chapter 1: Introduction

1.1 General Background

The 2007-2008 world food crisis caused a substantial rise in food cost, especially staple foods such as rice, wheat, and maize. During this period, the number of undernourished people worldwide increased to nearly one billion, more precisely to 963 million compared to 923 million in 2007 (FAO, 2008). Between 2005 and 2011, world prices for rice, wheat, and maize rose 102%, 115%, and 204% respectively (IFPRI, 2011). Population in the developing world are the most vulnerable to such fluctuations in food price as many of them spend 60% or more of their income on food (WFP, 2009).

A 2015 assessment of Africa's Millennium Development Goals (MDG) performance showed that Sub Saharan Africa, despite the decline of hunger by 8% between 1990 and 2013, remains the most food-deficient of all regions of the world with as much as 25% of its population facing hunger and malnutrition in 2011-2013 (UNECA, AU, AfDB and UNDP, 2015).

Consequently, efforts have been made to remedy the situation. Some strategies focus on specific crops such as rice. During the food crisis, numerous African countries adopted policies that either support domestic production of rice or reduce the cost of imported rice (AfricaRice, 2009).

1.2 Rice in Sub-Saharan Africa

Rice is increasingly becoming an important crop in the continent. It is grown in more than 75% of SSA countries; it is a staple food in ten countries, and per capita consumption in the remaining countries is increasing as rice becomes a preferred staple substitute, mainly due to its ease of storage and preparation (EUROCORD, 2012). This phenomenon is mostly observed in urban areas where imported Asian rice becomes more available at an affordable price (GRiSP, 2013). Moreover, rice production has also increased in the continent as more farmers realize the crop's particulatirty as a cash crop. Unlike other cash crops such as tobacco or coffee, rice can also be consumed within the household making it important for food security since it helps with both food access and farmers income generation (JICA, AGRA, 2008).

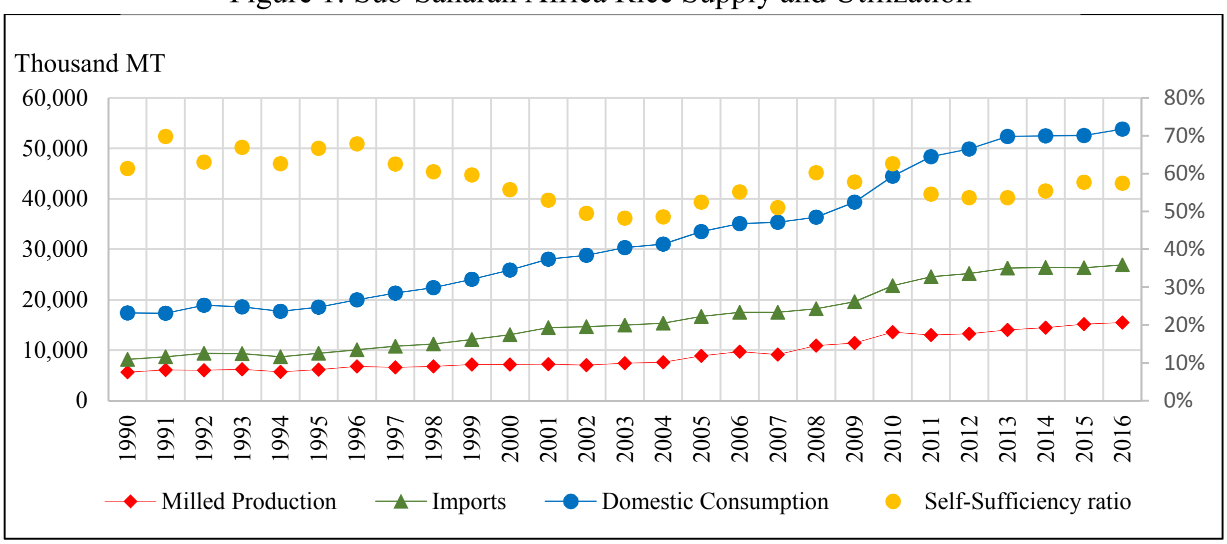
In 2009, SSA imported 9.8 million MT of milled rice, representing one third of the world market imports of rice and 40%[1] of SSA's total rice consumption (EUROCORD, 2012). Such high dependence on imports makes the continent vulnerable to international market shocks, which in turn is a threat to food security and political stability, as observed during the 2008 world food crisis (UNCTAD, 2009; WFP, 2009). Food riots occurred around the world and in Urban West Africa, which became more dependent on imported rice (Moseley, Carney, & Becker, 2010). In Mozambique street protest occurred due to the rise in food and fuel prices in early 2008 (Donovan & Tostão, 2010).

Furthermore, over the past 50 years, rice milled production in SSA has increased from 3.14 million tons to 14.60 million tons. Unlike Asia the expansion in SSA relied on area expansion, which over the past 50 years, increased from 2.5 million hectares to 8.2 million hectares, while milled yield per unit increased only from 1.24MT/Ha to 1.78MT/Ha (JICA, AGRA, 2008). During the same time period, Asian yields increased from 1.86MT/Ha to 4.18MT/Ha while area cultivated only increased moderately, from 107 million hectares to 137 million hectares (JICA, AGRA, 2008). These statistics show SSA's rice sector potential for growth through increasing land productivity with higher yields per hectare if adequate strategies are implemented.

[1] 43 % in 2015.

In terms of consumption, Figure 1 shows that rice consumption in Sub-Saharan Africa has been increasing rapidly between 1990 and 2015. Per capita consumption was 18 kg in 1990 compared to 26 kg in 2015. Total population in SSA increased at an average of 3% per year during the same time period while per capita consumption growth averaged 2% per year. The increasing trend in consumption is expected to continue as population grows. Total domestic consumption level increased from 9.2 million tons in 1990 to 26.2 million tons in 2015, representing a 185% percentage growth. During the same period, milled rice production increased by 168%, from 5.6 million tons to 11.2 million tons. A substantial increase but not enough to meet the domestic demand. In fact, the average self-sufficiency ratio between 1990 and 2015 is 58%. However, if we look at Figure 1, the demand-supply gap was lower between 1990 and 1996, when the average self-sufficiency ratio was 66%, compared to the following years, 1997-2015, when the average self-sufficiency ratio decreased to 55%. Rice consumption in Sub-Sahara Africa (SSA) has been increasing much faster than rice production, causing the sub-continent to be more dependent on imports. Between 1990 and 2015, SSA rice import level increased from 2.5 million tons to 11.2 million tons, reflecting a 342% percentage increase.

Figure 1: Sub-Saharan Africa Rice Supply and Utilization



Source: PSD Online (USDA/FAS, 2015)

1.3 Coalition for African Rice Development (CARD)

As the rice demand-supply gap in SSA continues to expand, increasing domestic rice production becomes an even more important concern so that food security can be improved without depending heavily on imported rice. CARD is a consultative group of bilateral and multilateral donors, African and international institutions who work with African member states with the common goal of doubling 2008 rice production levels by 2018 and attain self-sufficiency. The initiative was launched in the wake of the 2008 food crisis, by the Alliance for a Green Revolution in Africa (AGRA), the New Partnership for African Development (NEPAD) and the Japan International Cooperation Agency (JICA) following the 4th Tokyo International Conference for African Development (TICAD IV) (CARD, 2008).

To achieve their goals, CARD started by assisting African member states in drafting National Rice Development Strategy (NRDS), comprehensive country specific action plan that takes into account all components of the rice value chain, from inputs, production, post-harvest processing, marketing and finance (CARD, 2016).

To date, CARD consists of 23 member countries. This study will focus on four net food importing and Southern African countries (see Figure 2), three of which are CARD members (Madagascar, Mozambique and Zambia) and one non-CARD member (Malawi) but which has elaborated a National Rice Development Strategy.

1.4 Description of the Study

For the aforementioned countries, rice holds a different place at the national level but all four recognize its potential as a lever for food security improvement and extreme poverty reduction. This, among other reasons, motivated the elaboration of country-specific National

Rice Development Strategy (NRDS), developed to serve as a guideline for CARD member countries to reduce dependence on rice imports and eventually to become self-sufficient.

A qualitative analysis of 19 NRDS (Demont, 2013) revealed that in order to achieve these NRDS goals, it is necessary to follow a three-stage policy sequencing strategy, value adding, demand lifting and supply shifting (Section 2.3). In this study, Demont concludes that African countries can be categorized into three groups based on the respective national population's rice preference. Such categorization also showed that sector development strategies should differ across country. For example, in countries where imported rice is favored, self-sufficiency in local rice is inefficient unless strategies to enhance competitiveness of local rice with imports are implemented before domestic production is increased. Alternatively, in countries where local rice is preferred, prioritizing value adding strategies are not as important but should be considered to maintain the comparative advantage of local rice in demand in the long run.

This study proposes a quantitative assessment of the NRDS by evaluating the different changes in production that must occur to attain self-sufficiency, then analyze the feasibility of these goals.

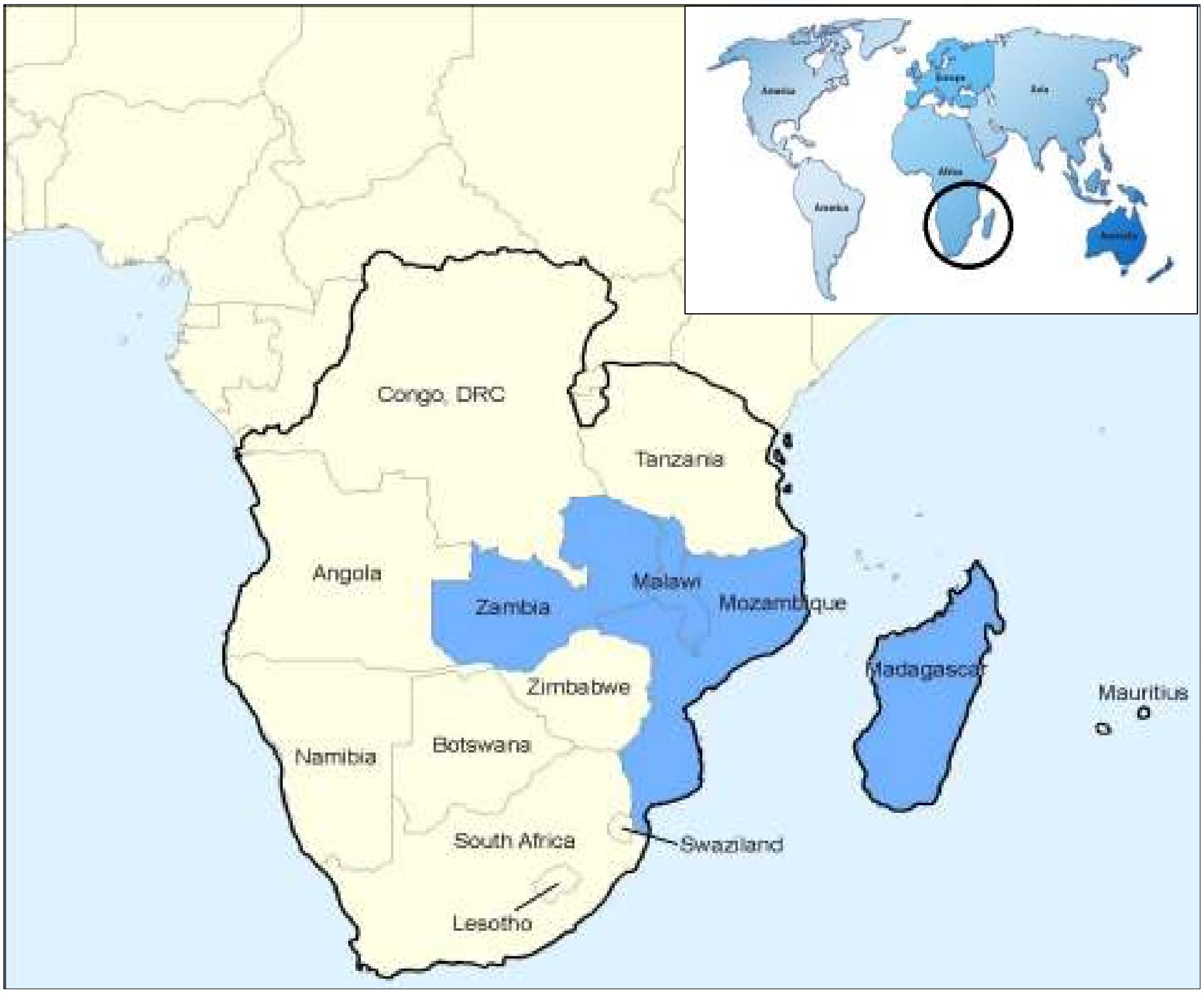
The study will be conducted following these three steps:

- Assess and characterize National Rice Development Strategies (NRDS) for the four selected countries (Madagascar, Mozambique, Malawi, and Zambia).
- Estimate a rice sector model of production, consumption, trade and price and simulate these models in a dynamic baseline for the countries' national rice sector within the global rice economy using the Arkansas Global Rice Model.
- Evaluate through simulations the alternative area and yield increases to meet production requirements to attain self-sufficiency in 2018, for the four countries.

The assessment of these NRDS, as discussed in Chapter 2, consists of reviewing the documents elaborated by the Ministry of Agriculture of each respective country in order to understand the specific focus of their strategies, and their alignment with national and regional agricultural policies and initiatives. Additionally, a business-as-usual rice projection will be generated using the multi-country econometric Arkansas Global Rice model. Then, self-sufficiency scenarios will be simulated using the same model. Comparing the business-as-usual projections against the self-sufficiency scenarios will quantify the changes that must occur in order to attain the goal of achieving rice self-sufficiency. The consequences of achieving self-sufficiency within each of the four countries will be analyzed at the national and international levels.

The remainder of this study is organized as follows. Chapter 1 will end with a general background and current food security situation in the 4 countries. Chapter 2 provides a review of literature relevant to the study, a review of the definition of food security and its components, along with the NRDS assessments. Chapter 3 presents a discussion of the methods of the study, Chapter 4 contains the results, analysis and discussion of the alternative scenarios, and Chapter 5, gives a summary, conclusions, and recommendations of the study.

Figure 2: The Four Selected Countries

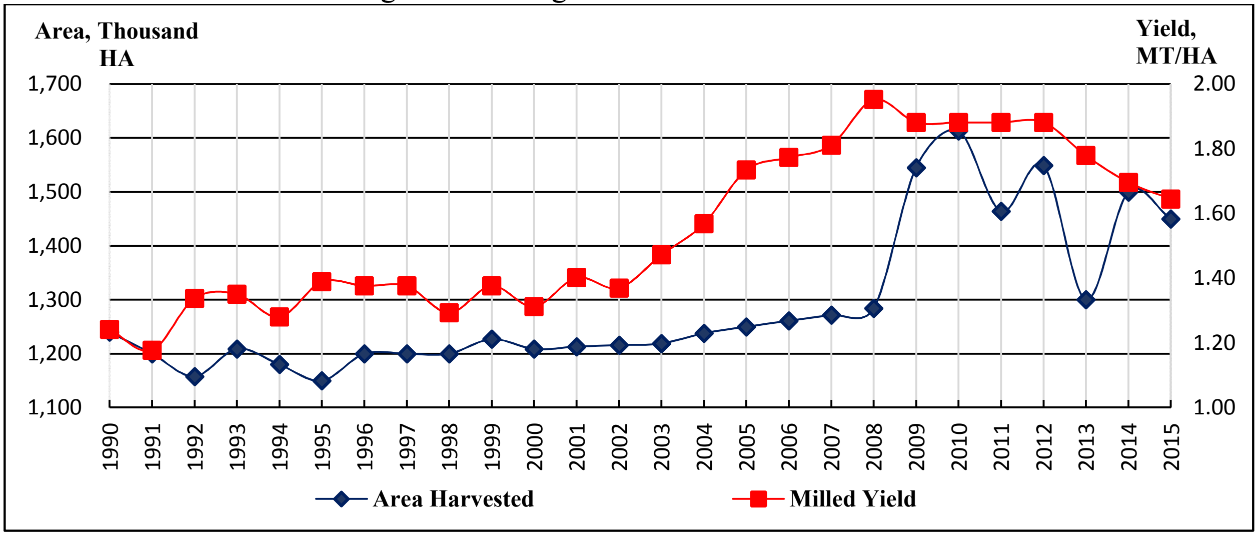


1.5 General Background, Current food security and Rice Situation in the 4 Countries

1.5.1 Madagascar

Located in the Indian Ocean, off the southern coast of Africa, Madagascar is an island country with a total land area of 581,000 Sq. Km of which only 6% are arable lands. Total population in 2015 is estimated at 24.2 million with an annual growth rate of 2.8% over the past 10 years and a GDP of USD 9.98 billion. In 2005-2015, real GDP average growth rate was 3%. The 2009 coup d'état worsened the food security situation in the island, bringing the prevalence of undernourishment from 28% of the national population in 2004-2006 up to 33% in 2010-2012 (FAO, 2013).

Figure 3: Madagascar Rice Area and Yield

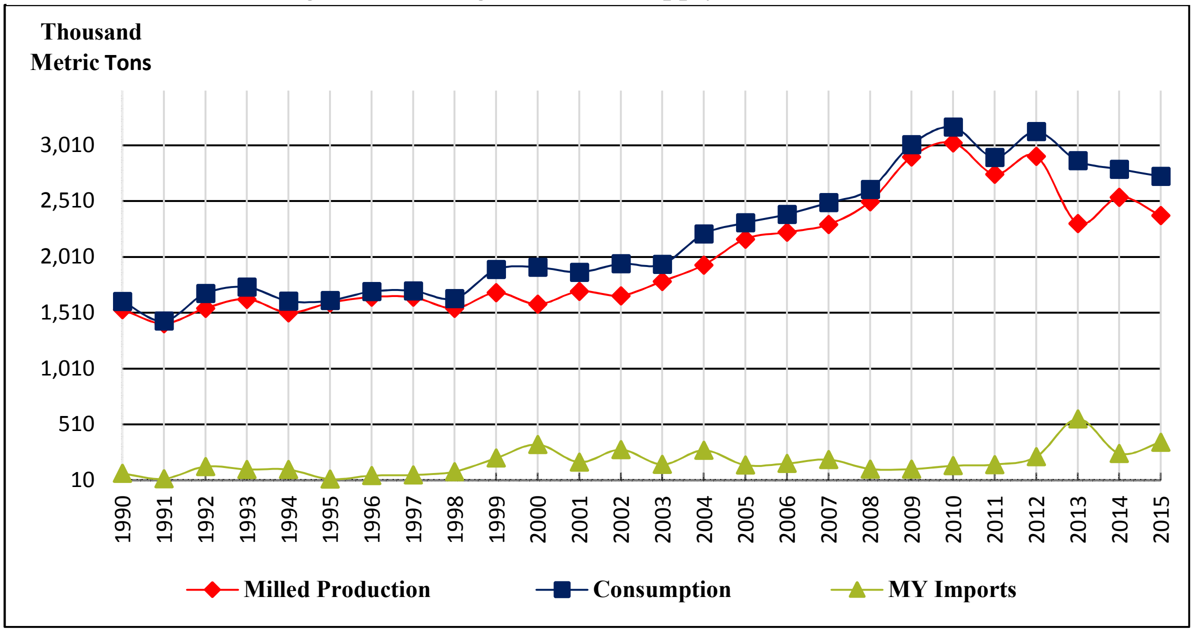


Source: PSD Online (USDA/FAS, 2015)

Between 1990 and 2016, both area harvested and milled yield have been growing at a yearly average of 1%. However, as observed in Figure 3, yield drastically increased starting in 2002 which could be attributed to the initiation of the Madagascar Action Plan (MAP), a comprehensive national program whose vision for agriculture was to double rice production by 2012. This plan was executed through the distribution of improved seeds, promotion of improved production technique such as SRI[2], promotion of the use of machineries, fertilizers, and other mediums (IMF, 2007). Additionally, in 2009, farmers were encouraged to plant more rice incentivized by improved access to irrigation and the dissemination of the high-yielding SRI technologies (FAO, 2009). In the subsequent years, a volatile and downward trend is observed in area harvested however, these are mainly due to weather related incidents.

[2] The System of Rice Intensification is a climate-smart, agro ecological methodology for increasing the productivity of rice and more recently other crops by changing the management of plants, soil, water and nutrients (SRI International Network and Resources Center, 2016).

Figure 4: Madagascar Rice Supply and Utilization



Source: PSD Online (USDA/FAS, 2015)

Generally, erratic weather conditions including cyclones, flooding, droughts and locust infestations have been among the major threats to national food security. In the past 35 years, the country has endured more than 50 natural disasters and the situation is expected to worsen in the future due to the impacts of El Niño related incidents (USAID, 2016a).

Between 2006 and 2010, Madagascar was the second leading producers of paddy rice (4.1 million MT) in Africa after Egypt (6.1 million MT) and ahead of Nigeria (3.9 million MT) (GRiSP, 2013). In the past decade, Madagascar's average self-sufficiency ratio[3] was 92% and since 1960, the country has either attained or been nearly rice self-sufficient. As observed in Figure 3, imports contribute to a relatively small percentage of national rice demand despite the continuous increase in national consumption. The country has the potential to be self-sufficient and even produce rice surplus but historically, imports have been used to stabilize rice price or

[3] Self-sufficiency ratios for the four countries are calculated based on PSD Online data (USDA/FAS) for the 10 most recent years available.

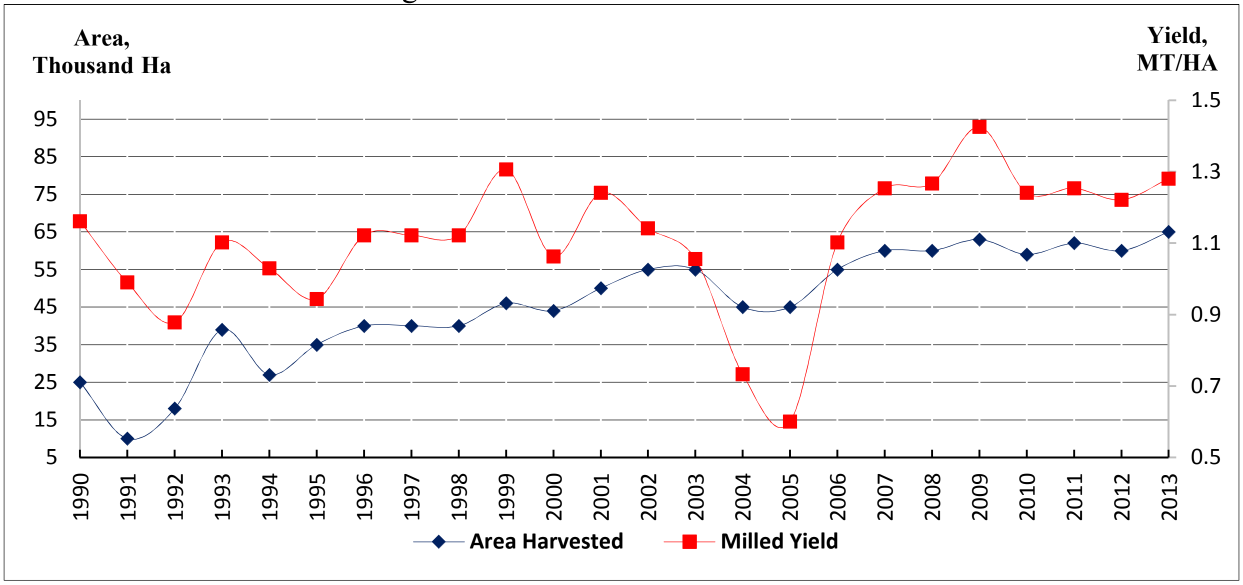
compensate for bad crop seasons (Dorosh & Minten, 2005; Minten, et al., 2006). Rice holds such a crucial importance for Madagascar that ensuring national food security ultimately means a stable rice sector.

1.5.2 Malawi

Bordering Zambia, Tanzania and Mozambique, Malawi is a small landlocked country situated in Southeastern Africa. As of 2015, the country had a total population of 17.22 million with an annual growth rate of 3.1% and a GDP of USD 6.57 billion and an average real GDP growth rate of 5% in 2005-2015. With a land area of 94,280 Sq. Km (40% of arable land), Malawi is one of the most densely populated countries in the Southern Africa region. As of 2008, population density was 139 persons /km^2 which is expected to attain 220 persons /km^2 by 2020 (Murphy, Erickson, & Chima, 2013). The 2015 Malawi Vulnerability Assessment Committee[4] (MVAC) showed that about 2.8 million people were food insecure due to a combination of high food prices, widespread crop failure and reduced income generating opportunities. The underlying issue can often be attributed to weather related disasters. Between 1970 and 2006 Malawi faced 40 weather related disasters of which 16 occurred after 1990 (ActionAid , 2006). In April 2016, Malawi released a disaster declaration as a result of extreme drought aggravated by El- Niño (USAID, 2016b).

[4] The Malawi Vulnerability Assessment Committee comprises Government, inter -government, academic and non-profit member organizations that seek to provide information to inform public action.

Figure 5: Malawi Rice Area and Yield



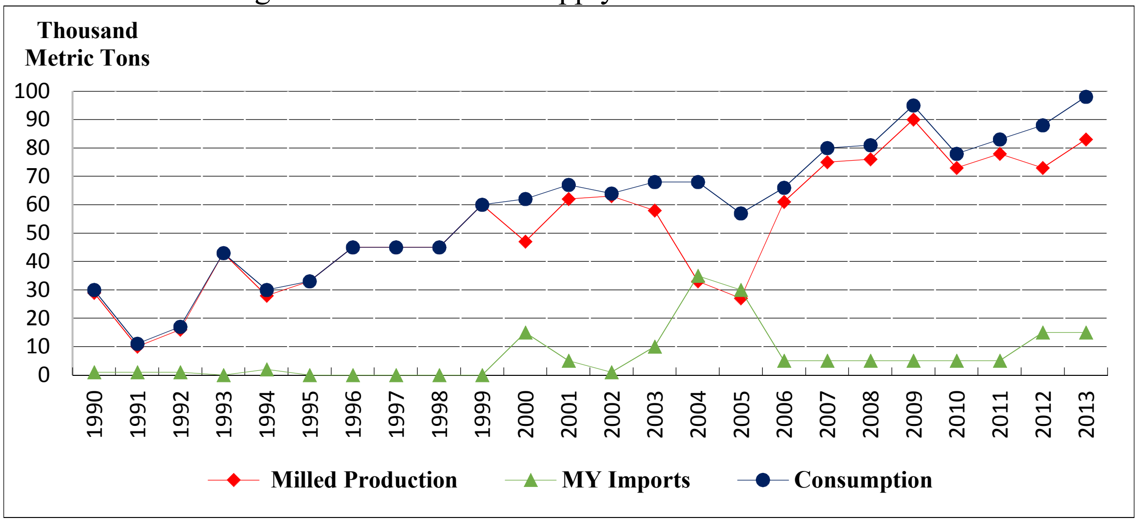
Source: PSD Online (USDA/FAS, 2015)

Historically, maize has been the staple food in Malawi accounting for three quarters of the population's calorie intake in normal years. Rice is the 10th most important crop as far as calorie intake is concerned, contributing with about 2% of the caloric intake (FAO, 2011). In recent years however, the Malawian government started to show interest in the development of the rice sector.

For the past 10 years, average rice self-sufficiency ratio in rice was 91%, production has increased from 29,000 MT in 1990 to 83,000 MT in 2013, mainly due to area expansion. Area under rice cultivation expanded by 160% while yield only increased by 10% at the national level (see Figure 5). Rice is gaining more importance in Malawi as the government plans to make it both an import substitute and an export crop.

With the current trend in rice consumption, the demand-supply gap for rice is still manageable and as observed in Figure 6, the country only resorts to imports during unusually adverse weather seasons but as consumption increases the gap situation might change.

Figure 6: Malawi Rice Supply and Utilization



Source: PSD Online (USDA/FAS, 2015)

1.5.3 Mozambique

Located on the southeastern coast of Africa, Mozambique constitutes of a land area of 786,380 Sq. Km of which 7.2% is arable land. With a growth rate of 2.8%, total population as of 2015 was 27.98 million while current GDP is USD 14.7 billion. Soon after it gained its independence from Portugal in 1975, the country plunged into a civil war that lasted until 1992. Since then, the country has been trying to recover. Over the last 2 decades, the GDP average growth rate was 7.4%, 7.6 % in 2014, then 7.5% and 8.1% in 2015 and 2016 respectively. The steady and high growth has been mainly attributed to recent political stability, and large scale foreign investments in infrastructure and in major sectors (WFP, 2016a).

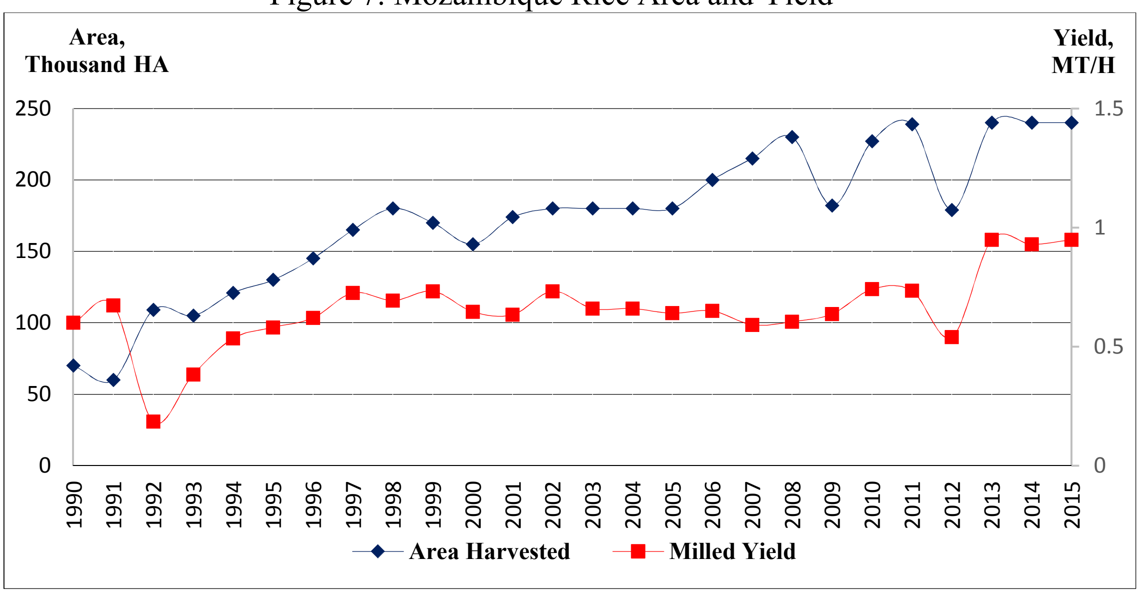
Despite the positive growths, 55% of the population lived under the poverty line in 2014. The agricultural sector is one of the key components of the economy as it contributes to 29% of national GDP. However, the sector is challenged by frequent drought and flooding in various areas of the country. In fact, Mozambique ranks third among the African countries most affected by weather-related hazards (USAID, 2016c). This is particularly an important challenge for rice farmers as 90% of total rice area are rain-fed lowlands and most of the rice produced in

Mozambique come from small landholders who grow rice as subsistence crop (Republique of Mozambique, 2009).

Rice has been present in the country for more than 500 years and comsumption is increasing rapidly, mostly in the urban areas. In 1990, Mozambique's rice self-sufficiency ratio was 49% however, it decreased to an average of only 28% in the most recent 10 years, implying an increasing dependence on imported rice. From 1990 to 2015, rice area harvested expanded from 70,000 Ha to 240,000 Ha and yield increased from 0.91MT/Ha to 1.46 MT/Ha respectively (see Figure 7). Though production increased drastically, total consumption increased even faster, going from 86,000MT in 1990 to 728,000MT in 2015, an amount that is well above the production volume of 350,000MT for 2015 (see Figure 8).

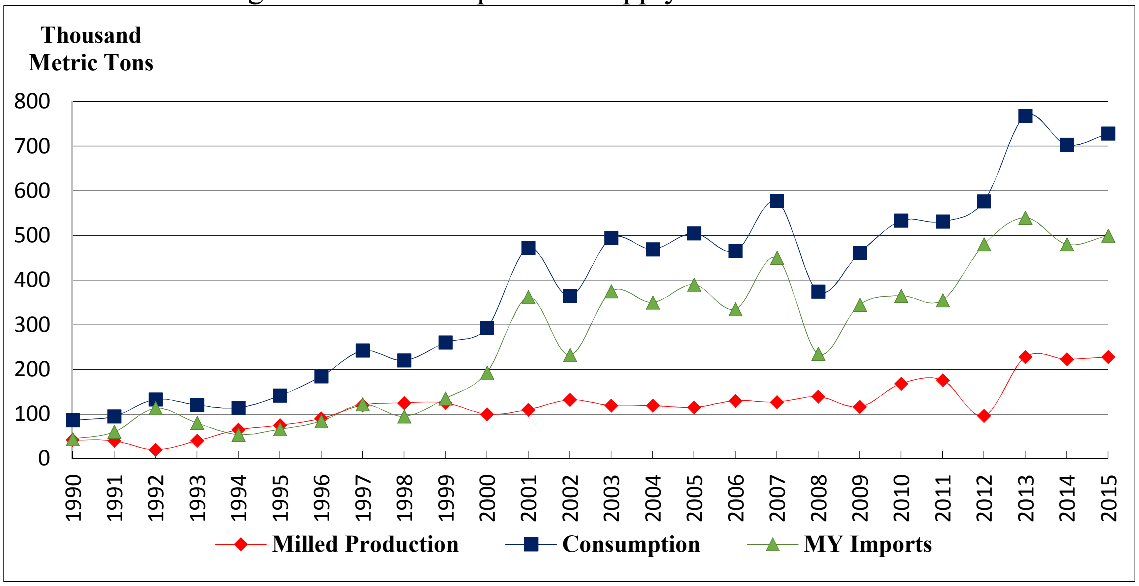
The government intends to alleviate the country's dependence on imported rice through the implementation of the National Rice Development Strategy, which will be discussed further in the next chapter.

Figure 7: Mozambique Rice Area and Yield



Source: PSD Online (USDA/FAS, 2015)

Figure 5: Mozambique Rice Supply and Utilization



Source: PSD Online (USDA/FAS, 2015)

1.5.4 Zambia

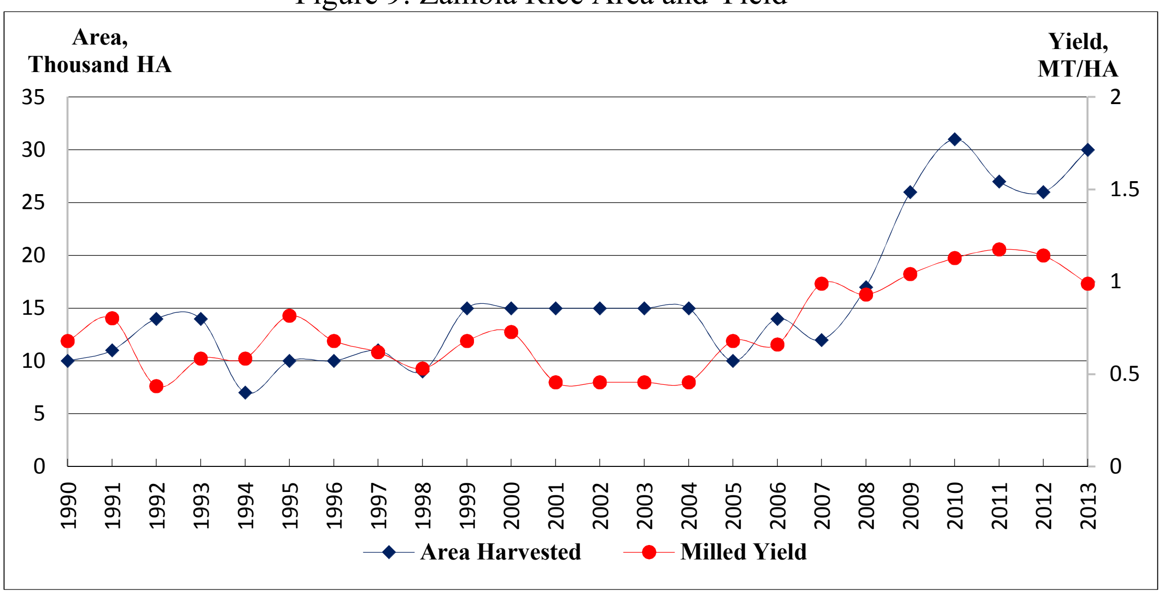
As of 2015, Zambia's total population was 16.2 million with an average growth rate of 3.1%. Land area is 743,390 Sq. Km, with 5% of arable land. In 2011, Zambia graduated from being a low-income country to a lower middle income country (WFP, 2016; USAID, 2016). Between 2010 and 2014, Zambia's economy grew at an average annual rate of 7% but decreased to 3% in 2015 (World Bank, 2016). However, the benefit from the GDP growth was mainly captured by the richer portion of the population living in urban areas and had little to no impact on poverty reduction.

The majority of the Zambian population are young and living in rural areas with 67% of the labor force employed in agriculture. This shows the importance of the sector as a tool to alleviate poverty and improve the food security situation at the national level, which is challenged by many factors and exacerbated by the dependence on rainfed agriculture (USAID, 2016d).

Rice is a minor but important food and cash crop in Zambia. Milled production increased from 7,000MT in 1990 to 30,000MT in 2013 (Figure 10) and total consumption per year also increased accordingly, from 7,000MT to 40,000MT (Figure 10). The average self-sufficiency ratio for 2005-2015 was 71%.

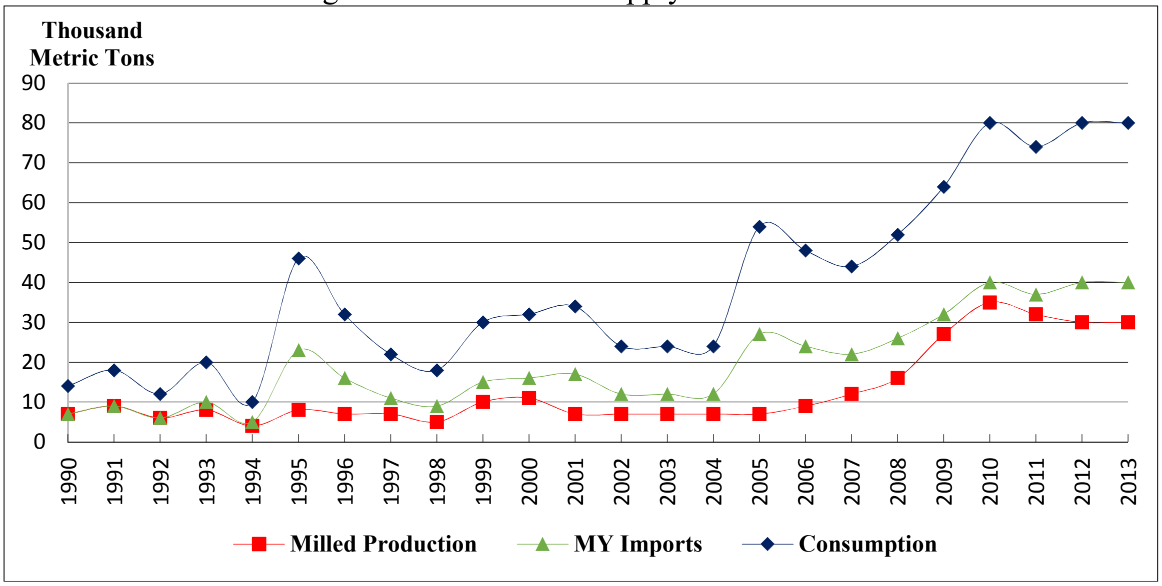
According to the FAO country profile, rice is the 9th most important crop in the Zambian national diet. However, in the National Rice Development Strategy, the government recognizes rice as one of the major food crops (along with, maize, cassava and wheat), imperative for food security and suggests that increasing national rice production is of paramount importance (Republic of Zambia, 2011).

Figure 9: Zambia Rice Area and Yield



Source: PSD Online (USDA/FAS, 2015)

Figure 6: Zambia Rice Supply and Utilization



Source: PSD Online (USDA/FAS, 2015)

Chapter 2: Literature Review

2.1 Food Security

The 2008 food crisis raised questions about the reliance on imports to meet food demand. It stimulated national, regional and international discussions, initiatives and policy developments that promoted programs to achieve food self-sufficiency (CARD, 2008; EUROCORD, 2012; Minot, 2011). Among these was the CARD initiative whose specific objective is to double national rice production of various African nations in order to close the demand-supply gap in the rice sector. Additionally, this dynamic action plan intends to tackle a larger issue, to improve food security in the African member states.

The term "food security" was coined in the mid-1970s and has since been defined and redefined[5] until the 1996 World Food Summit where global leaders agreed upon a definition, which consists of four main constituents: physical availability, economic access, utilization and

[5] Official concepts of food security along with the historical context and explanations of definition changes can be found in FAO's (2003) extensive report on Trade and Food Security.

stability. “Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.” (World Food Summit, 1996).

Generally, countries attempting to achieve an adequate level of food security have followed one of two broad strategies: food self-sufficiency and food self-reliance (FAO, 2003). The difference between the two lies in the respective approaches, self-sufficiency wants to focus on meeting local food demand solely through domestic production while food self-reliance intends to do so through a combination of domestic production, stock holding and trade (Jayne & Rukuni, 1993). Both approach have their merits and disadvantages; however, it has been suggested that there is no single optimal approach for all nations to the problem of food security. Rather, programs should be tailored to meet the needs of each country and emphasize the evaluation of cost-effectiveness of each alternative (World Bank, 1986). In order to identify such a strategy, it is important to first understand the principal causes of food insecurity.

2.1.1 Food Security and Poverty

Since food security implies access to food, it is easy to conclude that increasing food supply is the solution to fight food insecurity[6]. However, it has been argued that the root cause of food insecurity, inter alia, is the inability to acquire food due to low or limited purchasing power, resulting from poverty (World Bank, 1986; United Nations, 2011). The events of the 2007-2008 food crisis validated this argument. Several studies have concluded that there is a strong relationship between increasing food prices and poverty and consequently food insecurity due to declining purchasing power. A study by Tiwari and Zaman (2010) estimated that, in 2009, an

[6] There are two kinds of food insecurity: transitional (temporary) and chronic (continuous). For the purpose of this thesis, food security refers to chronic food security unless otherwise specified.

additional 41.3 million people or 4.4 % of the world's population became undernourished as a result of the global crisis. At the national level, countries that are net exporters of food will likely benefit from food price inflation while the opposite effect is expected for net importers. At the same time, within both exporter and importer nations there are winners (producers) and losers (consumers). The same is true at the household level. In many Sub-Saharan African countries however, even though a real food price increase raises gross income for farmers, food producers tend to be net buyers of food and spend more than half of their income on food purchases, in which case food price increase will result in a decline in welfare rather than the expected positive effect (Barrett & Dorosh, 1996; Wodon & Zaman, 2008; WFP, 2012). Such a decline will lead to increased food insecurity as individuals have less income to spend on food.

These arguments would suggest that in order to efficiently mitigate food insecurity, it is necessary to develop and implement policies that result in economic growth and equitable improvement in income. As Clover (2003, p. 09) stated, "Tackling hunger cannot be solved by simply producing more food". Smith et al. (2000, p. 10) add further that "In most settings, policies that improve people's access to food by reducing poverty are likely to have the greatest gain in food security improvements" and the World Bank (1986, p. 06) suggests that "a careful balancing of measures for trade, production, and poverty alleviation are required in most countries". The latter suggestion identifies three major factors of food security improvement. The importance of poverty alleviation as a lever for food security enhancement has been discussed. Two other major factors are trade and production.

2.1.2 Achieving Food Security

As expected, expanding food production is also an important factor pertaining to food security and it has been a controversial topic. It was previously mentioned that generally, countries attempting to enhance their food security situation, tend to adopt one of two broad strategies: food self-sufficiency or food self-reliance. The former is a concept that is widely supported by the food sovereignty movement and asserts that in the long run, food security can only be achieved through reliance on domestic production, with enough barriers to shield from price fluctuations and unfair trading, rather than food imports (Dupraz & Postolle, 2013). On the other hand, there is also the argument that such strategy is only worth pursuing if the country has a comparative advantage in the production of the given crop (World Bank, 1986). But more importantly, if a country has a comparative advantage in an export crop, it might be more beneficial for this country to prioritize allocation of resources towards the production of such export crop instead of trying to be self-sufficient in food crop (Thomson & Metz, 1998). In the latter situation, it is intended that the concerned country would be able to earn enough foreign exchange to then acquire the required food from the global market, through imports. This does not imply that all food requirements should be met through imports but rather, it proposes the strategy of finding an efficient combination of: domestic production, trade, stocks management and food aid.

An argument that supports the self-sufficiency strategy is that not only the country in question would have more sovereign control over their food supply instead of relying on a volatile world market but at times, focusing on domestic production alone can be the least-cost alternative, particularly for land locked countries where transportation cost, among other things, is an additional challenge. Faye, McArthur, and Sachs (2004) suggest that the challenges faced by landlocked countries can be categorized into four dimensions: 1) dependence on transit infrastructure; 2) dependence on political relations with neighbors; 3) dependence on peace and stability within transit neighbors; and 4) dependence on administrative processes in transit. These dimensions would suggest that even if landlocked countries are able to invest in national infrastructure, the substantial reliance on factors outside of national control are still impediments to improved food access. This could suggest that food self-sufficiency is a more favorable option. The same study also suggests these issues can be addressed first by investing in their internal transportation infrastructure, and then by capitalizing on regional integration strategies (e.g., Common Market for Eastern and Southern Africa (COMESA) and the Southern African Development Community (SADC)).

Furthermore, Jayne & Rukuni (1993) looked at the distributional effects of maize (national staple) self-sufficiency in Zimbabwe, a landlocked country in southern Africa. Their study suggested that even if the expected producer price needed to achieve self-sufficiency is below the cif cost of imports, there is an important trade-off between food self-sufficiency and food affordability due to the high costs associated with domestic production to achieve self-sufficiency. They concluded that 1) the pursuit of maize self-sufficiency in Zimbabwe does not necessarily contribute to broad-based rural income growth and could eventually erode purchasing power and food security in grain-deficit rural areas as well as urban areas and 2) reliance on moderate levels of maize imports does not necessarily constitute an agricultural policy failure.

These arguments intend to show that although pursuit of self-sufficiency might be an intuitive option, it might not necessarily be the most efficient one in all cases.

2.1.3 Food Security and Trade

The relationship between trade and food security is a complex matter as its effects span through several channels. Diaz-Bonilla (2014) proposes a framework exploring these effects through the different levels of food security, global to individual, and the four dimensions as previously discussed in section 2.1 (access, availability, utilization and stability).

As shown in Figure 10 below, this framework suggests that first, trade influences global and consequently national food availability by enabling products to flow from surplus to deficit areas (Brooks & Matthews, 2015). Then, access by generating government revenue and economic growth, is known to have a positive effect on food security since it affects household incomes, which in turn will influence individual food security (Diaz-Bonilla, 2014; Brooks & Matthews, 2015; World Bank, 1986). Lastly, stability is a major concern for proponents of food self-sufficiency due to the volatility of the world market, as discussed in the previous section. The world rice market in particular is highly volatile due to a combination of several factors, such as, high levels of domestic protection, geographic concentration of rice production and consumption, relatively thinly traded volumes, and erratic weather (Wailes E. J., 2002; 2005).

However, studies suggest that food price volatility seems larger in domestic markets than in international markets but more importantly, measures can be put in place to mitigate these undesirable effects (Minot, 2011; Fouad & Gillson, 2014). For instance, international and regional food trade could be an excellent buffer to counter domestic fluctuations in food supply and used as a catalyst for economic growth (Minot, 2012; Fouad & Gillson, 2014; Pannhausen & Untied, 2010).

For the four countries in this study, regional trade could be a useful instrument as all four are members of the Southern African Development Community (SADC)[7] and the Common Market for Eastern and Southern Africa (COMESA)[8], except for Mozambique, which is only a SADC member.

Trade has the potential to improve food security and reduce the food demand and supply gap. However, there is an ongoing debate on the relative effectiveness of trade in these capacities particularly in developing countries where net sellers of food could also be net buyers. The challenge for policy makers remains on the ability to capitalize on the benefits of trade while minimizing the risks and negative effects (Brooks & Matthews, 2015).

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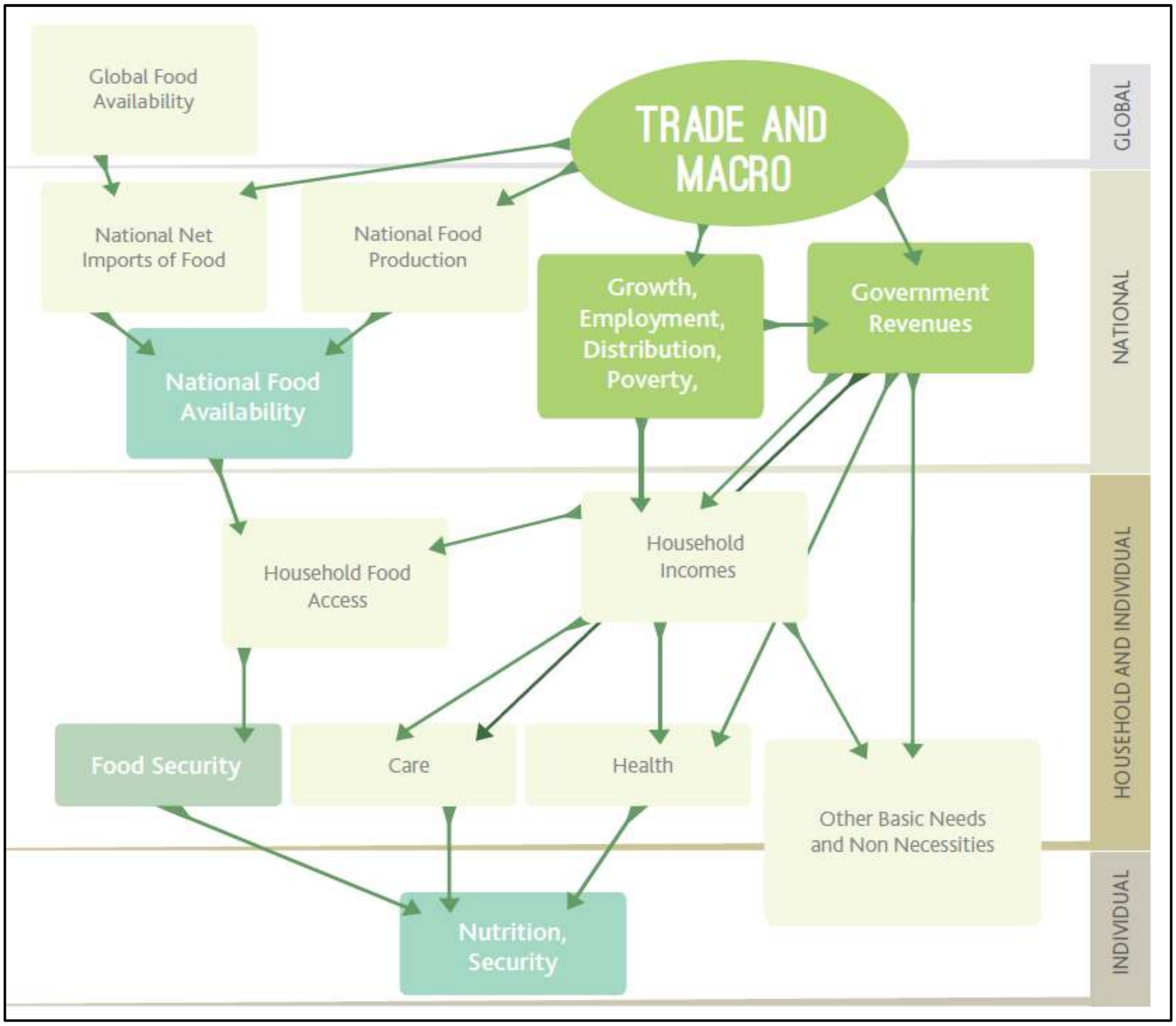
[7] SADC is the result of the transformation of the Southern African Development Coordinating Conference (SADCC) via the SADC Treaty in 1992, which redefined the basis of cooperation among Member States from a loose association into a legally binding arrangement. Members are: Angola, Botswana, DR Congo, Lesotho, **Madagascar**, **Malawi**, Mauritius, **Mozambique**, Namibia, Seychelles, South Africa, Swaziland, Tanzania, **Zambia** and Zimbabwe.

[8] COMESA was formed in 1994 to replace the Preferential Trade Area (PTA) via the COMESA Treaty. Members are: Burundi, Comoros, D.R. Congo, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, **Madagascar**, **Malawi**, Mauritius, Rwanda, Seychelles, Sudan, Swaziland, Uganda, **Zambia**, and Zimbabwe

Figure 11: Channels through which Trade Affects Food Security



Source: (Diaz-Bonilla, 2014)[9]

[9] Diaz-Bonilla's chart was adapted from a conceptual framework for food security by Smith (1998) and later revised by Laroche Dupraz and Huchet Bourdon (2014) to bring out the links between food security, national food policies and food security indicators.

2.2 Strategies for Food Security Improvement

Previous research has hypothesized that improving the food security situation in Africa requires a value chain approach. For the case of rice in West-Africa, for example, improving farm-level productivity would be insufficient to improve food security since in some countries domestic rice is perceived as inferior compared to imported rice (Wailes, Durand-Morat, & Diagne, 2015; Demont & Ndour, 2014). The NRDS were developed and geared towards improving different aspects of the rice value chains in each respective country. However, this value chain approach lends itself to the application of a set of three-stage policy sequencing namely, value-adding, supply shifting and demand lifting (Demont & Rizzotto, 2012). Value adding refers to any type of investment or policy that has the potential to enhance the value and or quality of locally produced rice, particularly in comparison to imported rice. Supply shifting are any direct or indirect investments or policy actions that would increase the supply of local rice in local markets. Demand lifting are all direct or indirect investments or policies that would ensure (increase or sustain) demand for local rice once the effect of supply shifting investments are observed (Demont, 2013). These stages are continuous and overlapping phases as opposed to a sequence of separate actions, although, priorities might differ across countries (Demont & Rizzotto, 2012).

Demont (2013) categorizes African countries into three groups according to consumers' rice preference for local compared to imported rice and countries' geographical locations:

- Group 1: coastal countries with dominant consumer preferences for imported rice
- Group 2: coastal countries with dominant consumer preferences for local rice
- Group3: landlocked countries with dominant consumer preferences for local rice.

These grouping influence priority actions across country. Group 1 countries are the only ones with dominant preference for imported rice, an attribute that is partly due to the countries' vulnerability to urban biased[10] policies, but also probably because local rice is of significantly lower quality or without preferred characteristics such as fragrance or aroma. It is suggested that in these countries, large urban consumption centers were made possible by imports as opposed to productivity growth, which in turn influences consumers' tendency to favor imported food products or in this case, imported rice (Fox, 2012; Demont, 2013). This preference would suggest that value-adding and demand lifting strategies should be prioritized over supply lifting.

Group 2 countries, despite their costal location have retained their preference for local rice due to the historical importance that the crop holds in the population's diet. In Madagascar, for example, even in the country's major seaport, the population still has a preference for local rice (Hume, 2009). These countries have a comparative advantage in demand albeit are vulnerable due to their costal location and susceptibility to urban bias. Thus, supply lifting can be prioritized but value adding should follow in order to maintain this advantage in the long run.

Lastly, group 3 countries, are landlocked and less susceptible to 'urban bias' thus prefer local rice since local markets are not flooded by imported products. Nevertheless, Demont (2013) warns that despite this natural shield from 'urban bias', group 3 countries might still be vulnerable to the same obstacles faced by group 2 countries. Burkina Faso is used as an example. The country imports 60% of its national rice consumption from the major Asian rice exporting countries, an operation that is enabled by the existing infrastructures in neighboring countries

[10] Urban bias refers to the inefficient and systemic bias against agriculture and the rural economy in the allocation of developmental resources (Bezemer & Headey, 2008; Demont, Rutsaert, Ndour, & Verbeke, 2013)

such as Côted'Ivoire, Ghana and Togo. Such a situation might suggest that policy sequencing similar to group 2 might be effective also with the possibility to capitalize on a regional value chain approach (Demont, 2013).

Following the abovementioned categorization, two of the four countries of interest are classified under group 2 (Madagascar and Mozambique) and one under group 3 (Zambia). Malawi, was not included in the Demont (2013) study, thus was not classified under any of the 3 groups. However, certain characteristics may suggest that the Malawi should be a group 3 country. Similar to Zambia, Malawi is also a landlocked country and time series data suggests that national rice demand has been met, predominantly by local production. Moreover, imports have been particularly difficult in the country due to the persistence of civil wars in neighboring countries (Faye et al., 2004) which might imply that local markets were inadvertently protected and not flooded by imported rice. Following these characterizations, the consumers in all 4 countries included in this study have a preference for local rice, which would indicate that these countries have a comparative advantage in demand in the development of their rice sector relative to group 1 countries (Demont & Ndour, 2014). Thus the primary focus of their rice value chain investments and policies should be supply lifting.

This study will explore first through projections if, with the baseline projections of exogenous variables such as population and income growth and modeled trends in per capita consumption and yield growth and production area expansion, the 4 countries will achieve their NRDS goals by 2018 and second analyze, with different scenarios, what changes need to occur to reach these goals. To do so, it is necessary to first assess the NRDS of each country.

2.3 NRDS Assessments

The NRDS are direct reflections of national institutions and rice stakeholders' perception on priority areas for achieving the national goals to double rice production or attain rice self-sufficiency. The two goals are generally different since rice holds a unique position in each country. An attribute that can also be observed in the per capita consumption levels for each country (Figure 12). As discussed in previous sections, in Madagascar rice is the number one staple food crop and Figure 12 shows that with an average per capita consumption level of 127 kg/ year in 1990-2013, the country has the highest per capita consumption level among the four countries. Second is Mozambique with an average of 17 kg/year, where rice is not the number one staple food but figures among the top three. Then in both Malawi and Zambia, rice is a substitute staple or cash crop and average per capita consumption in 1990-2013 was 5 and 2 kg/year respectively.

Figure 7: Average Per Capita Consumption of Rice in the Four Countries (kg/year) During 1990-2013

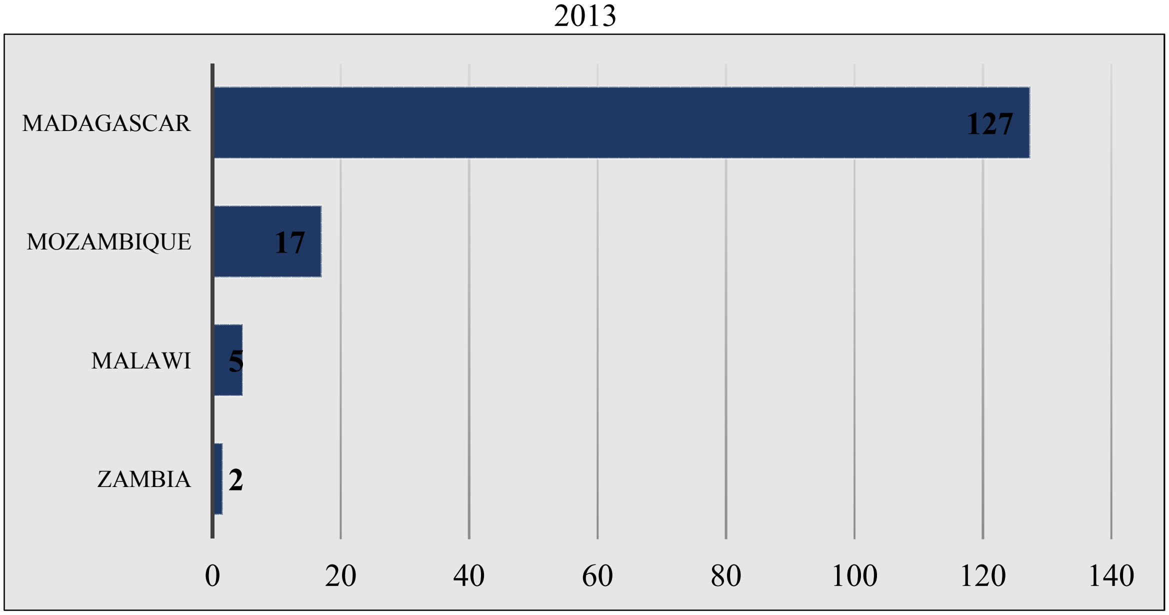


Table 1 provides a summary of the production objectives for the four countries, comparing 2013-2015 average (base years) with the NRDS goals for 2018. Then, Table 2 provides a summary of specific areas of priority, categorized following the three stage policy sequencing discussed in the previous section. The following four subsections will consist of detailed country-by-country discussion of NRDS production goals, identification of priority sub-sectors and the coherence of each country's NRDS with national and regional policies.

2.3.1 Madagascar

For Madagascar, the general objectives of the NRDS can be summarized into three main components: 1) Contribute to food security in all regions of the country; 2) Improve economic growth and 3) Improve the livelihood of the actors of the rice sector (Republique of Madagascar, 2010; Republique of Madagascar, 2016)[11].

Madagascar's strategy relies heavily on boosting production, through area expansion, facilitation of access to improved seeds, inputs and machinery. More specifically, the goal is to increase production by 45% by expanding area harvested by 43% and yield by 1% (Table1). The NRDS goal Figures for Madagascar are averages for four different zones of production which explains the low yield goal. Weak irrigation management characterizes one of the four zones of interests where the yield target for 2018 is only 0.95MT/Ha compared to the 2018 average yield increase goal of 1.73MT/Ha. Additionally, Table 2 also shows the lack of emphasis on demand lifting strategies where the only investment plan is for market infrastructure upgrading and linkages.

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[11] For Madagascar, two NRDS versions are used in this study. The 2010 official version posted on CARD's website and an unpublished draft dated January 2016. The figures in Table 1 reflects the NRDS goals as presented in the 2016 version. The main differences between the two versions lay on the project timeline and the NRDS' integration within the national policy framework. In the 2010 version, the program ends in 2018 whereas in the 2016 version, the program timeline is extended to 2020. Additionally, the 2010 version was in line with the Madagascar Action Plan (MAP) a program of the previous regime which was discontinued following the 2009 coup d'état. The 2016 NRDS version is aligned with the new regimes' policy frameworks.

Studies have shown that Madagascar has a comparative advantage in rice production (Razafimandimby, 1998; Minten, et al., 2006), which justifies the interest for self-sufficiency achievement. The country goal for area expansion will require incentives for producers. This is particularly important since the current structure seems to be doing the opposite. In his study, Razafimandimby (1998) showed that Nominal Protection Coefficient (NPC)[12] favors imported over locally produced rice (the estimated NPC average value was 0.7). Additionally, in 2005, the Malagasy government removed all import taxes levied on imported rice (Dorosh & Minten, 2005; Dabat, Jenn-Treyer, Razafimandimby, & Bockel, 2008). Initially, this policy change was intended to offset a bad production year, in 2004, and stabilize rice price. However, the policy remained unchanged long after the rice crisis. This is particularly important if the goal is to incentivize rice producers to expand area harvested. Bourdon and Dupraz (2014) suggest that although an open market (low or zero tariff) is positive for urban consumers, it can have an adverse effect on domestic producers, as it may discourage them from developing their supply if they cannot compete with international competition.

As mentioned, the NRDS low yield goal is explained by low yield level in one of the zone of interest for rice production handicapped by poor irrigation structures. Several irrigation projects are underway including those listed on CARD's website (CARD, 2016), which are mostly aimed at developing and rehabilitating irrigation structures in major rice growing areas. Additionally, Madagascar officially became an AfricaRice member state in 2010 (AfricaRice, 2010). Since then, efforts promoting the use of improved seeds have been initiated. Such

[12] The Producer Nominal Protection Coefficient (NPC) is an indicator of the nominal rate of protection for producers measuring the ratio between the average price received by producers (at farm gate), including payments per ton of current output, and the border price (measured at farm gate level). (OECD, 2002)

strategies would imply that Madagascar has the potential to go above the yield goal increase of 1%, alleviating some of the pressure to increase area which as previously discussed would be difficult if the current structures remain the same.

In terms of NRDS inclusion within national policies, the Indian Ocean Island is still recovering from a political crisis which started in 2008. In doing so, the government put in place the National Development Plan (PND) a comprehensive multi-sector plan which takes into account the development of the rice sector given its national importance (Republique of Madagascar, 2015). Prior to this political crisis, the development of the rice sector was governed under the Madagascar Action Plan, a project of the pre-crisis regime (Republique of Madagascar, 2010).

On the regional level, the country aims to be the "Indian Ocean's rice basket" which entails to not only produce enough for domestic consumption but also have a large surplus to supply neighboring countries (Republique of Madagascar, 2010). This is in line with the Indian Ocean Commission[13]'s Nutrition Security Regional Program (FNRSP) where one of the main implementation concept is to make Madagascar the "breadbasket of the Indian Ocean" (FAO, 2016). Among the IOC 5 country members, Madagascar represents 99% of IOC's total land area and 98% of currently cultivated land (FAO, 2016). This emphasizes further the need for the country to increase food production in general and rice production in particular. Madagascar's NRDS also recognizes the potential offered by regional markets such as COMESA and SADC.

[13] The Indian Ocean Commission (IOC) is an intergovernmental organization created in 1982 in Port-Louis Mauritius and comprises five countries: Reunion which is considered a French department, Mauritius, an Upper Middle Income Country, Seychelles a High Income Country, Madagascar and Union of the Comoros which are both least developed countries (EEAS, 2015).

2.3.2 Malawi

Malawi's strategic objectives consist of four pillars: create a strong institutional framework, strengthen farmers' organizations, support increased production, and develop streamlined rice processing and marketing. The four pillars target specific challenges along the value chain and intend to remedy issues such as the lack of coordination among actors of the rice sector, limited access to input, financial capital, output markets for smallholder rice farmers, low productivity and poor storage facilities (National Rice Development Platform, 2014)[14].

In Malawi's NRDS document, target goals are expressed as projections of production potentials if resources are fully exploited for area and yield increases. Comparing the base year (2015) data used for the projection and actual data from USDA's Production Supply and Distribution Online Database, the NRDS projections seem to be extremely overstated, thus for consistency, percentage differences were used to calculate the NRDS goal in Table 1 rather than the actual Figures in the NRDS document.

According to the listed Figures (Table 1), Malawi intends to increase area by 11% and yield by 67%. Between 1990 and 2013, the average per capita consumption of rice in Malawi is 4.74 Kg/MT and as previously stated in the introduction, rice is only the 10th most important crop in the Malawian diet. However, the government has recently showed interest in the crop and optimistically mentioned in the NRDS document that export revenue earned from rice can rival that of the current major export earner, tobacco. No study on the comparative advantage of rice production in Malawi has been found during the course of this study. However, a few studies

[14] The National Rice Development Platform (NRDP) is the coordinating body of Malawi's rice value chain. The NRDP drafted the country's NRDS and aims to enhance collaboration of stakeholders along the value chain in order to advance and promote the development of a competitive rice value chain. It is facilitated by the African Institute of Corporate Citizenship

recognize that Malawi has a strong comparative advantage in tobacco production and other crops such as cotton, paprika, macadamia, and groundnuts (Nakhumwa, Hassan, Kirsten, & Ng'ong'ola, 1999; Nakhumwa, Ng'ong'ola, Minde, Lungu, & Mapemba, 1999). Although the study is dated, it is important to notice that there is an existing comparative advantage in tobacco production, a crop that is highly important in terms of export revenue. Thus, the investment in a different crop to compete or replace tobacco is a consequential decision that needs to be thoroughly reviewed, but is reflected in the NRDS document (National Rice Development Platform, 2014, p. 09).

At the same time, some factors favors the decision to invest in rice production. In terms of policy integration, at the national level, the Malawi Growth and Development Strategy II (MGDS II) recognizes agriculture to be of paramount importance for economic growth, wealth creation and food security (Government of Malawi, 2011; National Rice Development Platform, 2014). The Agriculture Sector Wide Approach (ASWAp) is the realization of MGDS II for achieving agricultural growth and poverty reduction (Republic of Malawi, 2011). ASWAp prioritizes maize and tobacco, the country's most prominent food and export crops, respectively. However, it also recognizes that in order to attain the 6% agricultural growth per annum, additional growth in other high value crop such as rice is necessary (Benin, Diao, McCool, Simtowe, & Thurlow, 2008). Thus, this provides a basis to explain the government's novel interest in rice sector development (National Rice Development Platform, 2014). The government intends to increase rice production and make it both an import substitute and an export crop.

The 6% agricultural growth objective is consistent with the Comprehensive Agricultural Development Program (CAADP)[15]. Additionally, under the National Export Strategy (NES) the government also recognizes Malawi as a regional hub in the center of the Tripartite region's fast growing markets (SADC, COMESA, and EAC) and therefore Malawi must take advantage of its strategic location (Government of Malawi, 2013).

[15] CAADP is Africa's policy framework for agricultural transformation, wealth creation, food security and nutrition, economic growth and prosperity for all. It is a program of the African Union under the New Partnership for Africa's Development (NEPAD) (CAADP, 2016)

Table 1: NRDS Production Increase Goals for the Four Countries[16]

Variable	**Benchmark**	**NRDS Scenario**		
	2013-2015 Avg.	2018 Goal	Level Δ from Base	% Δ from Base
Madagascar				
Area Harvested (1000 Ha)	1,417	2,023	606	43%
Yield (MT/Ha)	1.71	1.73	0.02	1%
Production (1000 MT)	2,413	3,496	1,083	45%
Malawi				
Area Harvested (1000 Ha)	65	72	7	11%
Yield (MT/Ha)	1.28	2.13	0.86	67%
Production (1000 MT)	83	154	43	85%
Mozambique				
Area Harvested (1000 Ha)	240	389	149	62%
Yield (MT/Ha)	0.94	2.28	1.33	141%
Production (1000 MT)	226	885	659	291%
Zambia				
Area Harvested (1000 Ha)	30	42	12	40%
Yield (MT/Ha)	1	1.98	0.98	98%
Production (1000 MT)	30	83.16	53	177%

Source: PSD Online (USDA-FAS, 2016); NRDS Documents

[16] Figures in Table 1 are in milled basis. NRDS 2018 goals listed as rough were converted into milled using PSD online milling rates.

Table 2: NRDS Subsector Strategies [Adapted from Demont *(2013)*]

Country	Supply-shifting investments				Demand-lifting investments			
	Value-adding investments							
	Area expansion, irrigation and infrastructure	R&D, extension, innovation, capacity building	Intensification, land access, seed, credit, inputs, mechanization	Processing and storage capacity	Quality upgrading, capacity building, governance	Branding, labeling	Market infrastructure, linkages	Promotion, advertising
Madagascar	X	X	X				X	
Malawi	X	X	X	X			X	
Mozambique	X	X	X	X	X	X	X	X
Zambia	X	X	X	X	X		X	X

Source: NRDS documents

2.3.3 Mozambique

As discussed in section 1.4.3, even though rice is important in the national diet, the country is highly dependent on imported rice. As such, through the development of the rice sector, the main goal is to reverse this dependence and eventually generate exportable surplus to supply the Southern African Region (Republique of Mozambique, 2009).

As seen on Table 2, Mozambique's NRDS is balanced between the three policy sequencing categories but the major priorities remain in increasing production and productivity, sustaining competitiveness of local rice varieties and encouraging capacity building and coordination. The production goal is highly ambitious and foresees an increase of 291%, driven by yield improvement, with a 141% increase and a 62% expansion of land area (Table 1). In the past 10 years, average rice consumption in Mozambique has been 434 thousand MT against an average milled production of 170 thousand MT, showing a high dependence in rice imports to meet domestic consumption requirements and thus justifying the need to reduce this dependency by increasing domestic production.

A study analyzing the comparative advantage and agricultural trade in Mozambique recognizes that rice is an important crop in the area near the Zambezi River. However, there is no evidence to conclude whether the country has a comparative advantage in rice production or not since rice was not considered as one of the main crop of interest in the study. Nonetheless, it was concluded that comparative advantage exists for the nine (9) crops considered (maize, sorghum, sunflower, beans, cowpea, potatoes, onions, cotton and cassava) at various degrees across regions (Mucavele, 2000).

Mozambique intends to go from importing more than half of their rice demand to becoming self-sufficient. However, the average yield level for 2013-2015 is only 0.94 MT/Ha, the lowest for the four countries being analyzed. This could imply that the country has a large potential to increase their production through yield improvement, but alternatively it may reflect a limited resource base by which yields can be improved. However, area harvested would also need to expand drastically suggesting that current areas dedicated to other crops might need to be reallocated for rice production. As such, the strategy for production increase must be carefully analyzed to avoid shifting of resources away from more profitable crops.

In terms of policy inclusion, the development of the rice sector is supported by a national policy framework such as the Strategic Plan for Agricultural Sector Development (PEDSA)[17] and the National Investment Plan for the Agricultural Sector (PNISA)[18], the investment plan that has been developed to operationalize actions to achieve PEDSA's objectives. PEDSA lays out the vision for development in the agricultural sector, in terms of how the government will prioritize its allocation of resources to that end. Additionally, the Action Plan for the Reduction of Absolute Poverty (PARPA)[19] recognizes the important role of agriculture for poverty reduction and identifies six priority crops: maize, cassava, beans, rice, cashew, nuts, and cotton (Republique of Mozambique, 2009). These programs among others are all in line with the CAADP, which for Mozambique was launched in late 2010 (NEPAD, 2014).

[17] http://fsg.afre.msu.edu/mozambique/caadp/pedsa_final-english_22_nov.pdf

[18] http://www.resakss.org/sites/default/files/pdfs/Final%20PNISA%20Revised%20Version_0.pdf

[19] https://www.imf.org/external/pubs/ft/scr/2011/cr11132.pdf

2.3.4 Zambia

Through the NRDS, Zambia intends to increase rice production by 177% by 2018. A strategy driven by yield improvement, aiming for a 98% increase, and a 40% area expansion (Table1). These goals will be achieved by strategically choosing areas of intervention for increased production, promoting research, technology dissemination and capacity building, strengthening market linkages and developing a strong governance structure to effectively implement the NRDS (Republic of Zambia, 2011).

A study on the comparative advantage of several crops in Zambia showed that the country does not hold a comparative advantage in rice production primarily due to the remoteness of rice production location and other issues (Saasa, Chiwele, Mwape, & Keyser, 1999). The study suggests further that at average level of output, domestic resource cost (DRC) is higher than 1 and even with potential management, rice remains one of the least efficient activities analyzed. Such findings question the viability of investing in increasing rice production. However, as discussed above, the NRDS proposes to attain the production growth mainly through yield improvement, which would imply that it might be possible to attain the production goals using the current area harvested avoiding the need to forgo land dedicated to other crops for rice production.

Rice consumption in Zambia is the lowest among the four countries of interest in this study with an average of 30 thousand MT between 2004 and 2013. Nonetheless, even though rice is a minor crop in Zambia, it is an important food and cash crop in certain regions. In recent years, production has increased significantly, a phenomenon that is attributed to crop diversification response by smallholder farmers who have been converting to commodities which offers them higher net income. This increased interest in the rice crop is also reflected in the national policy (Republic of Zambia, 2011). The National Agricultural Policy (NAP) is the overarching framework for all agriculture related programs in the country and is implemented through the Zambia Comprehensive Africa Agriculture Development Program compact (CAADP). The Government of the Republic of Zambia has realigned the rice subsector to CAADP principles pillar III and IV which deal with food supply and hunger along with agricultural research and technology dissemination, respectively (Republic of Zambia, 2011).

Chapter 3: Methods

As observed in previous sections, rice holds different places across the four countries national diets, some rice sector development goals are more ambitious than others but more importantly, comparative advantage in rice production also differ.

Previous studies (EUROCORD, 2012; Demont, 2013) have attempted to assess the various NRDS and give recommendations for implementation; however, they are qualitative in nature. This study proposes a quantitative analysis of the NRDS and self-sufficiency implication at the national and international level, for Madagascar, Malawi, Mozambique and Zambia.

In doing so, it is necessary to first determine if each country will attain rice self-sufficiency by 2018, with the current conditions (baseline scenario). If not, what changes in production must occur in order to attain self-sufficiency?

Different scenarios of production changes, for self-sufficiency, will be simulated along with the NRDS scenarios. Then, the impacts of the production changes in each scenario will be analyzed at the national and global levels.

The Arkansas Global Rice Model (AGRM) will be used to generate the baseline projections and simulate the different scenarios.

3.1 The Arkansas Global Rice Model (AGRM)

AGRM (Wailes & Chavez, 2011) is a multi-country econometric framework, which allows for the generation of deterministic and stochastic simulations. It provides projections of the world rice economy for a ten-year period, which serve as a benchmark for impact analysis on policies, markets and environment. AGRM has been utilized in conducting research such as:

- The assessment of the regional and national approaches to improving food security for rice consumption in West Africa (Wailes, Durand-Morat, & Diagne, 2015),
- The documentation of current and projected status of the rice economies of member states of the Association of Southeast Asian Nations (ASEAN) (Wailes & Chavez, 2012),
- The analysis of the impact of major trade policies on the global rice economy (Wailes E. J., 2004; Wailes E. J., 2005) and
- The provision of yearly international rice outlook through the Arkansas Global Rice Economics Program[20].

To date, the AGRM covers 61 individual countries within five world regions: Africa, the Americas, Asia, Europe and Oceania (Wailes & Chavez, 2016). All countries not modeled individually are aggregated in the five regions rest-of-the-region models. In addition to the country detail, the AGRM is particularly important in its ability to differentiate between long and medium grain markets, which is an important feature given the large differences in prices, trade and policy interventions (FAO, 2004).

[20] http://www.uark.edu/ua/ricersch/

3.1.1 AGRM and Four Countries' Equation Specifications

The major component of a country or regional model include a supply sector, a demand sector, trade, stocks and price linkage equations.

Supply Sector

The model assumes that the supply side is determined by profit maximizing rice producers and consists of two main variables: area harvested and yield. Area harvested is expressed as:

$$AH_t = f(AH_{t-1}, P_t^e, W_t^e, e_t)$$

where AH_t is harvested area, P_t^e is expected price received by producers, W_t^e is expected input price and e_{1t} is the error term where positive coefficients are anticipated for lagged area and expected price of rice and negative coefficient for input price.

Yield is specified as a function of output, input prices, and technological change.

$$Y_t = f(P_t^e, W_t^e, e_t)$$

In this study, the area harvested equations for the four countries use lagged area and lagged producer prices as independent variables, since it is assumed that the current year's area harvested is influenced by the producers' expectations based on information from the previous year. Price of input is not included due to lack of data availability and the relatively low level of input use in these four countries. The yield equations are modeled as a function of trend for simplicity and because of unavailability of data.

Demand Sector

The model assumes that the demand side is determined by utility-maximizing consumers and is expressed as:

$$D_t = f(M_t, RP_t, WP_t, e_t)$$

where D_t represent total rice demand on a per capita basis, M_t is per capita income in real terms, RP_t is retail price, and WP_t is wheat or maize price.

AGRM's demand sector also includes an export demand equation, which was not estimated in this study given that none of the four countries exports rice (according to PSD data). Also, wheat price or other substitute prices were not included.

Price Linkages

Price linkage equations include three different prices: farm price, which is a function of retail price, which in turn is a function of the international reference price, which is generally modeled as a function of Thai price (5% broken).

In this study:

Producer and retail prices are linked to the international reference price (Thai long grain 100%B price) via price transmission equations. When used, the international reference price is adjusted to reflect the import tariffs levied for each country.

In some specifications, dummy variables are used in order to indicate natural disaster or other unexplainable shocks.

3.2 Modeling Method and Evaluative Statistics

Of the four countries of interest in this study, only Mozambique was already incorporated in AGRM. The other three countries were modeled separately in excel via ordinary least square (OLS), then added into AGRM. For each estimated dependent variable, several regression results were obtained and the best models were chosen based on the goodness of fit (adjusted R^2), coefficients' expected signs, and significance of coefficients (t and p values).

Adjusted R^2: R^2 measures the proportion of total variation in the dependent variable explained by the collective independent variable, so generally, the higher the R^2, the more statistically significant the model. However, R^2 tends to increase as independent variables are added due to the decrease in the degrees of freedom. As such, adjusted $R^2$is the better indicator for measuring goodness of fit.

t-value: t-statistics are used to test the null hypothesis ($\beta = 0$) associated with the coefficients in a regression equation. Coefficients' significance was determined based on their t-value, which varies according to the degrees of freedom, which depend on the number of observation of each regression at a given level of significance (10, 5 or 1 percent level).

p-value: For a given coefficient, a p-value under the significance level, usually 0.05, would indicate that it is significant.

3.3 Data Source

For each of the estimated variables, time series data ranging from 1990 to 2015 were used but varied depending on availability. Dependent variable data were obtained from the U.S. Department of Agriculture Foreign Agricultural Service (USDA-FAS) Production, Supply and Distribution Online (PSD). These variables include area harvested, yield, production (rough and milled), consumption, stocks, and import quantities at the national level. Price data were gathered from FAO GIEWS for retail prices and from FAOSTAT for producer prices. The FAOSTAT producer prices can be retrieved as local currency unit per metric ton (LCU/MT) or standard local currency per ton (SLC/MT) which accounts for currency changes or rebasing. The latter was used to account for such changes in the countries of interest. The international reference price (Thai long grain 100%B) were retrieved from the U.S. Department of Agriculture, Economic Research Service, *Rice Situation and Outlook reports.* Macroeconomic data were retrieved from AGRM based on the Global Insight database, for the required period.

3.2 Scenario Simulations

Table 1 presented the 2018 NRDS production goals for each country, including the area harvested expansion and the yield improvement goals. As such, two basic scenarios were simulated in AGRM, one that is driven by area expansion (Scenario 1) and another that is driven by yield improvement (Scenario 2). Additionally, the NRDS goals were also simulated as a third scenario (combination of area and yield increase).

These scenarios are compared to the baseline projections with a business-as-usual projection with regard to AGRM projections of market outcomes without forcing a self-sufficiency goal. The scenarios result in either the specific area or yield quantities required to attain self-sufficiency by 2018. These simulations take into account the dynamic baseline changes in consumption overtime. Consumption changes endogenously because as these countries eliminate imports, there is a negative impact on the world reference price which is then transmitted to the respective country's retail and producer prices thus increasing domestic consumption and a second round impact on production. The AGRM iterates until an equilibrium is obtained.

Scenario 1 is an area expansion driven strategy. Here yield is held at the baseline projection level for 2018 while different values for area harvested is iterated until 2018 consumption equals 2018 production, the point where the country is at the self-sufficiency level.

Scenario 2 is a yield improvement driven strategy. Here area harvested is held at baseline projection level for 2018 while different values for yield is imposed until 2018 consumption equals 2018 production levels.

The resulting output for all scenarios (including the NRDS goals) were then analyzed and the impact of achieving self-sufficiency and the NRDS goals in each country were examined at the national and international levels.

These simulations were limited in nature as the yield equation did not take into account changes in area harvested and vice versa. Typically, significant increases in rice area harvested would imply that either marginal land not in production or land dedicated for the production of another crop would be reallocated to rice production, suggesting that yield would likely decrease as the land used for expansion would not necessary be the most suitable for rice production.

Chapter 4: Empirical Results and Interpretation

This chapter presents the empirical estimates of sub models for the four countries, which are detailed in Appendix 1. The resulting estimated equations are used to implement the country sub models into AGRM and to calculate projections.

4.1 Country Sub models: Equations Specifications

4.1.1 Madagascar Sub model

Area Harvested

For the sample period (1990-2015), area harvested (MGAH) was stable until 2009 when it increased by 20% from the previous year was (from 1,284 thousand ha in 2008 it increased to 1,545 Ha in 2009), then reached a record high[21] in 2010 (1,613 thousand ha) and subsequently declined the following years. For the years 1990-2007, the year-to-year average area increase was less than 1%.

MGAH was specified as a function of lagged producer price, to reflect the price effect on MGAH, and two dummy variables. The first dummy is used to capture the abnormal increase between 2009 and 2015 ($D_{09\text{-}15}$) and the second one (D_{13}) to reflect a decrease in 2013 due to a weather related cause. Lagged producer price was not statistically significant but gave an estimated elasticity of 0.025. A study on Madagascar's agricultural sector showed that due to weak infrastructures or lack thereof, producers are unable to respond to market signals (Razafimandimby, 1998). This supports the finding of this study and explain why producer price was not statistically significant. The lagged dependent variable ($MGAH_{t-1}$) was also included in the original specification but was not statistically significant and thus omitted.

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[21] These record growths resulted from the implementation of the Madagascar Action Plan which targeted to double national rice production by 2012. To achieve this goal, the government promoted area expansion by distributing seeds, machineries, fertilizers, and encouraging land titling (FAO, 2008). The Madagascar Action Plan was initiated by the President who was ousted in 2009 and continuation of the program with the new regime is uncertain.

Yield

Rice yield is characterized by two distinct trends during the sample period of 1990-2015. The period before and after 2003. The yield equation is specified as a function of trend and a shift trend. The shift trend extends from 2003 to 2008, a period during which yield was relatively higher than in the years before and after[22]. The shift trend variable is statistically significant at the 1% significance level, and the trend variable at the 5% significance level. The resulting coefficients were 0.302 and 0.023 for trend and shift trend respectively, indicating that during the sample period, yield increased by 0.3% per annum and during the shift trend period an additional average of 23 kg per annum (trend was estimated in log form but not the shift trend variable).

Per Capita Consumption

Madagascar's per capita consumption was modeled as a function of retail price, per capita GDP (proxy for income) and milled production. Using a conditional regression, an own price elasticity of -0.050 was imposed under the assumption that if retail price increases, rice consumption would decrease but rather inelastic given that it is the staple food in Madagascar. The income elasticity is 0.185 but the income variable was not statistically significant, which suggests that the income effect on rice consumption is marginal. However, the production variable is statistically significant (1% level) and resulted in an elasticity of 0.591, implying that if supply increases, consumption would also increase at a proportionate rate.

[22] See previous footnote.

Producer Price

Producer price was modeled as a function of the international reference price (Thai 100%B, long grain) which is significant at the 1 % level of significance. The price transmission elasticity is estimated to be 0.700, implying that a 10%increase in the international reference price would lead to a 7% increase in producer price.

Retail Price

Similar to the producer price, retail price was also modeled as a function of the international reference price and is statistically significant at the 5% level of significance. The resulting price transmission elasticity is 0.427 implying that a 10%increase in the international reference price would lead to a 4% increase in producer price.

4.1.2 Malawi Sub model

Area Harvested

From 1990 to 2013, area harvested has been stable with an average growth of 9% per annum, admittedly from a low base. For Malawi, the sample period for the area harvested estimation was 1997 to 2013 due to lack of producer price data. The area harvested equation was specified as a function of the lagged dependent variable, lagged producer price and a binary variable to account for a drought in 2004 and 2005 (Phiri, 2005; Pauw, Thurlow, & Van Seventer, 2010). The lagged dependent variable is significant at the 1% level of significance. Lagged producer price is not significant but is a reasonable inelastic estimate of 0.140. These results indicate that producers decide more heavily on their rice area harvested for the year based on the previous year’s area rather than responding to the previous year’s market information.

This is explained by several causes, among those, the lack of market information or market coordination, which could suggest the need for greater investment in market infrastructure.

Yield

The yield equation is specified as a function of trend and, similar to area harvested, a binary variable to account for the 2004-2005 drought. All variables are significant at the 5% level of significance. The resulting yield elasticity is 0.21 relative to the trend variable suggesting that yield increased by 0.2% annually. The dummy variable coefficient is -0.605.

Per Capita Consumption

For the 1990-2013 sample period, total consumption has been increasing steadily, rising from 30 thousand metric tons in 1990 to 98 thousand metric tons in 2013. Correspondingly, even though it is fairly small compared to countries where rice is a dominant crop, per capita consumption also increased, going from 3 kg per person in 1990 to 6 kg per person in 2013. The per capita consumption equation was modeled as a function of per capita GDP, used as a proxy for income, the international reference price used as a proxy for retail price because of unavailable retail price data, and milled production. The estimated model is able to explain 90% of the variation in per capita consumption. However, both income and the international reference price are not statistically significant. The income elasticity was 0.260 and the own price elasticity, -0.108. In contrast, milled production was statistically significant and resulted in an elasticity of 0.470.

Producer Price

Producer price is modeled as a function of the international reference price and is statistically significant at the 1% level of significance. The resulting price transmission elasticity is 0.857.

4.1.3 Mozambique Sub model

Area Harvested

The sample period for Mozambique's area harvested estimation was 1994 to 2008 due to lack of price data. However, the estimated model is able to explain more than 95% of the variation in area harvested. During this period, area harvested is steady with the exception of 1999 and 2000, a period of flooding, which was captured in the estimation using a binary variable. Additionally, the lagged dependent variable, lagged price ratio of rice relative to maize were also used. Lagged area and the dummy variable are statistically significant at the 1% level of significance while the lagged price ratio is at the 5% level. The price ratio elasticity is 0.099.

Yield

The sample period for yield estimation is 1990 to 2015, during which yield growth has been stable with the exception of a few years. Yield is modeled as a function of trend and a binary variable for 1992, 1993 and 2012. Years characterized by drought (1992 and 1993) and flood (2012) (Suit & Choudhary, 2015). All variables are statistically significant and the trend coefficient suggests that on average, yield increased by 15.5kg annually over the sample period. Trend explains about 85% of the yield variation.

Per Capita Consumption

During the sample period of 2000 to 2014, per capita consumption has been highly variable, with a minimum of 16 kg per person in 2000 and a maximum of 29 kg per person in 2013. In 2014, per capita consumption was approximately 26 kg per person. Mozambique's per capita consumption is modeled as a function of retail price and per capita GDP as a proxy for income. Both variables are statistically significant, retail price at the 5% and per capita GDP at the 1% level of significance. The resulting own price elasticity is -0.894 and the income elasticity is 1.012.

Producer Price

Producer price was estimated as a function of the international reference price, resulting in a price transmission elasticity of 0.861 and is significant at the 1% level of significance.

Retail Price

Retail price was modeled as a function of the international reference price, significant at the 1% level of significance and resulted in a price transmission elasticity of 0.935.

4.1.4 Zambia Sub model

Area Harvested

From 1990 to 2013, area harvested has been unstable with a minimum of 7 thousand metric tons in 1994 and a maximum of 31 in 2010. Due to lack of price data, the sample period for the area model estimation was 2006 to 2014. The Zambian area harvested was modeled as a function of lagged area, and lagged producer price. Lagged area was significant at the 5% level of significance whereas the producer price coefficient was not significant. The estimated price elasticity was 0.135.

Yield

Similar to area, yield has also been variable between 1990 and 2013, with a minimum paddy yield of 0.64 Mt per Ha and a maximum of 1.78 Mt per Ha. Yield (milled) was modeled as a function of a shift trend capturing a high yield increase that began in 2007. It is significant at the 1 % level of significance and the resulting coefficient was 0.116. A trend variable was also included in the original model but was statistically insignificant and thus removed.

Per Capita Consumption

Zambia's per capita consumption was modeled as a function of retail price and per capita GDP, as a proxy for income. A conditional regression price elasticity of -0.1 was imposed, under the assumption that consumers are more responsive to rice price changes given that it is not the staple food and other substitute crops are available. The income elasticity is 2.199, which suggests that rice is a novel food staple. The income variable (RGDP) is statistically significant at the 1% level.

Producer Price

The producer price equation was estimated as a function of the international reference price and resulted in a price transmission elasticity of 0.862. The variable is statistically significant at the 5% level of significance.

Retail Price

For Zambia, the retail price was modeled as a function of the international reference price, which was statistically significant at the 1% level of significance. The resulting price transmission elasticity was 1.011. Typically, price transmission elasticities are expected to be less than one. This unexpected price transmission elasticity could be the result of high market distortions due to the high involvement of the Food Reserve Agency (FRA). [23]

4.2 AGRM Baseline Projections

The projections reveal that with a business as usual environment, none of the four countries will attain self-sufficiency by 2018. The baseline projections for each country are shown in Appendix Table 3 and the figures for the benchmark analysis along with the scenario analysis results (discussed in the next section) are summarized in Table 3.

For Madagascar, the rice self-sufficiency ratio is relatively the same in the 2013-2015 base year (88%) compared to 2018 (89%), and by 2025 the self-sufficiency ratio is projected to decrease to 87%. From the 2013-2015 base year to 2018, domestic production is expected to increase by 5%. Looking at the production level change, in 2013-2015 production is 2,413 thousand MT increasing to 2,526 thousand MT in 2018. Consumption level increases from 2,733

[23] It was created in 1995 to buy strategic commodity reserves for use as relief in terms of production shortage however, since 2005, FRA became a state controlled marketing board setting floor prices and buying large grain production surpluses (CUTS International, 2016)… Historically, FRA has bought maize, rice and cassava but involvement is relatively higher in the maize sector. The sample period for the estimation of the retail price transmission equations was 2007-2015 suggesting that the resulting negative coefficient might be a consequence of government's direct involvement in the rice sector or spillover effect from the maize market distortion.

thousand MT in the base year to 2,846 thousand MT in 2018 resulting in the same production deficit figure of -320 for both the base year and 2018.

For Malawi, the rice self-sufficiency is expected to improve from 85% in the 2013-2015 base year up to 90% in 2018. The production deficit changes from -15 thousand MT in 2013-2015 to -12 thousand MT in 2018. During this time period, domestic consumption is expected to increase by 20% (98 thousand MT to 118 thousand MT) while production is expected to increase by 27% (83 thousand MT to 106 thousand MT). The AGRM projection (Appendix Table 3) indicate that with business as usual environments, Malawi will be nearly self-sufficient in 2020 and fully self-sufficient by 2021 (self-sufficiency ratios are 98% and 102% respectively for those years)

For Mozambique, the demand-supply gap is relatively large with a self-sufficiency ratio of only 29% in 2013-2015 and 37% in 2018. By 2025, the self-sufficiency ratio is expected to increase to 58%. Consumption is expected to decrease from 790 thousand MT in 2013-2015 to 686 thousand MT in 2018. However, this downward trend is not expected to last and in fact the next year, consumption is expected to increase again. The production level decreases starting in 2015 but starts to increase gradually in the following years. Production is expected to rise by 12%, from 226 thousand MT in 2013-2015 to 253 thousand MT in 2018.

For Zambia, rice self-sufficiency ratio in 2013-2015 was 75% and expected to increase to 86% in 2018. During the same time period, consumption is expected to decrease from 40 thousand MT in 2013-2015 to 38 thousand MT in 2018. However, this decreasing trend is not expected to continue as consumption increases marginally in the following years and reaching 50 thousand MT in 2025. Production is expected to increase by 8% between 2013-2015 and 2018, increasing from 30 thousand MT to 32 thousand MT respectively.

These baseline projections show the current supply and demand situation for each country along with how the situation will evolve by 2018 in a business as usual environment. Mozambique have the lowest self-sufficiency ratio and thus expected to have a higher level of production increase requirements in order to attain the rice self-sufficiency goals by 2018. The next section presents the scenario simulation results, which quantifies the production requirements following three scenarios (scenario 1: area driven, scenario 2: yield driven and scenario 3: the NRDS scenario).

4.3 Scenario Results

Besides presenting the production requirements for each country, this section also provide an analysis of the simulation results at the national (Table 3) and global level (Table 4).

4.3.1 Madagascar

The resulting simulation suggests that in order to be self-sufficient in 2018, holding yield at baseline level, area harvested needs to expand by 42%, going from 1,417 thousand ha in the 2013-2015 base year to 2,016 thousand ha in 2018. This will enable production to reach 3,383 thousand MT in 2018, the same level as total consumption for the same year. In contrast, if area harvested is held at baseline level and yield improvement is imposed, the 2018 self-sufficiency level requirement to attain the same production level is 2.25 MT/Ha, a 32% level increase from the 2013-2015 base year average of 1.71. The self-sufficiency production level is 3% below the NRDS production goal of 3,496 thousand MT which is a combination of 43% increase in area harvested and 1% increase in yield from the 2013-2015base year. The NRDS scenario would bring Madagascar a little above self-sufficiency level with a relatively small production surplus of 47 thousand MT and a self-sufficiency ratio of 101%.

At the international level, the international reference price (Thai 100%B, Long grain) will decrease by US$/Mt 4.33 in scenario 1, decrease by US$/Mt6.81 in scenario 2 and decrease by US$/Mt7.44 in the NRDS scenario. In terms of world rice supply and utilization, self-sufficiency in Madagascar would increase world production by 857 thousand MT, 730 thousand MT and 842 thousand MT in scenario 1, 2 and NRDS respectively. Total world consumption would increase by 872 thousand MT, 860 thousand MT and 974 thousand MT respectively in the three scenarios. In scenario 1, world rice area harvested would increase by 510 thousand Ha while yield would decrease by 4kg/Ha. In scenario 2, yield would increase by 5 kg/ha while area harvested would decrease by 8 thousand Ha. Then, in the NRDS scenario, world rice area harvested would increase by 510 thousand Ha, the same level increase as in scenario 1, while yield would decrease by 4 kg/ha. This would lead to an increase in world total consumption by 974 thousand MT.

4.3.2 Malawi

For Scenario 1, holding yield at baseline level, in order to attain self-sufficiency by 2018, Malawi area harvested needs to expand to 100 thousand ha, which represents a 53% increase from the base year level of 65 thousand ha. In Scenario 2 (holding area harvested at baseline level), yield would need to increase by 26%, going from 1.28 Mt/Ha in 2013-2015 to 1.60 Mt/Ha in 2018. Both scenario would enable the country to reach a self-sufficient level of production of 130 thousand MT, a target that is 8% below the NRDS goals. The NRDS production goal is a combination of 11% increase in area harvested and 67% increase in yield, which will enable Malawi to have a rice production surplus of 13 thousand MT.

At the international level, the international reference price would decrease by US$/Mt 2.64, US$/Mt, 2.64 and US$/Mt 2.82 in scenario 1, 2 and NRDS respectively. In Scenario 1, world rice area harvested would increase by 10 thousand Ha while yield would decrease by 0.8 kg/ha. In scenario 2, area would decrease by 8 thousand MT while yield would decrease by 0.5 kg/ha. In scenario 1 and 2, total production would decrease by 104 thousand MT and decrease by 80 thousand MT in the NRDS scenario while total consumption would increase by 11 thousand MT in scenario 1 and 2, and increase by 36 thousand MT in the NRDS scenario.

4.3.3 Mozambique

Over the past 10 years, Mozambique has only been able to meet 39% of their total rice demand through domestic production. Consequently, any efforts to become self-sufficient in rice production would require drastic changes in area harvested, yield productivity or both. The scenario simulation results show that with Scenario 1, Mozambique would have to increase the area dedicated to rice production by 192% to be self-sufficient by 2018. This would increase area from 240 thousand ha in the base year average (2013-2015) to 700 thousand ha in 2018. In the yield improvement driven strategy, yield must increase by 185%, going from 0.94 Mt/Ha in 2013-2015 to 2.69 Mt/Ha in 2018. These strategies would bring the production level up by 207%, increasing from 226 thousand MT in 2013-2015 to 694 thousand MT in 2018, which is 22% below the NRDS production target of 885 thousand MT. This target consists of a combination of 62% increase in rice area harvested and 141% increase in yield, which would enable Mozambique to have a production surplus of 188 thousand MT.

At the international level, given Mozambique's high import quantity, achieving self-sufficiency would decrease the international reference price by US$/Mt 8.61 in scenario 1 and 2 and decrease by US$/Mt 11.25 in the NRDS scenario. In terms of supply and utilization, Scenario 1 would increase world rice area harvested by 441 thousand ha, production by 313 thousand MT, and total consumption by 464 thousand MT. In scenario 2, the changes in the supply and use quantity are the same as in scenario 1. In the NRDS scenario however, world rice area harvested would increase by 123 thousand ha, production would increase by 504 thousand MT and total consumption would increase by 670 thousand MT.

4.3.4 Zambia

In Scenario 1, to be self-sufficient in 2018, Zambia will need to increase area by 21% increasing the rice area harvested level from 30 thousand ha to 36 thousand ha. Under Scenario 2, yield must increase by 21% going from an average level of 1 Mt/Ha to 1.21 Mt/Ha. Both of these scenarios will bring the production level up to 38 thousand MT, a change that is 55% below the NRDS production goal of 83 thousand MT. This production goal consists of a combination of 40% increase in rice area harvested and 98% increase in yield.

At the international level, the changes in scenario 1 and 2 would reduce the international reference price by US$/Mt 2.55, and a reduction of US$/Mt 3.19 in the NRDS scenario. Scenario 1 would decrease world rice area harvested by 3 thousand ha, and a decrease of 8 thousand Ha in scenario 2. Change in production and consumption levels are the same in scenarios 1 and 2 with a 123 thousand MT decrease in production and 8 thousand MT decrease in world total consumption. With the NRDS scenario, world rice area harvested would increase by 2 thousand ha, production would decrease by 77 thousand MT while total consumption would decrease by 95 thousand MT.

Table 3: Scenario Simulation Results[24]

Variable	Benchmark			Scenario 1 (Area)			Scenario 2 (Yield)			NRDS Scenario		
	2013-2015 Avg.	2018 AGRM	% Δ from Base	2018 Goal	% Δ from Base	% Δ from NRDS	2018 Level	% Δ from Base	% Δ from NRDS	2018 Goal	Level Δ from Base	% Δ from Base
Madagascar												
Area Harvested (1000 Ha)	1,417	1,505	6%	2,016	42%	-0.4%	1,505	6%	-26%	2,023	606	43%
Yield (MT/Ha)	1.71	1.68	-2%	1.68	-2%	-3%	2.25	32%	30%	1.73	0.02	1%
Production (1000 MT)	2,413	2,526	5%	3,383	40%	30%	3,383	40%	30%	3,496	197	8%
Consumption (1000 MT)	2,733	2,846	4%	3,383	24%	15%	3,383	24%	15%	3,449	202	7%
Self-sufficiency Ratio	88%	89%		100%			100%			101%		
Deficit/Surplus (1000 MT)	-320	-320	0%	0			0			47		
Malawi												
Area Harvested (1000 Ha)	65	81	25%	100	53%	38%	81	25%	12%	72	7	11%
Yield (MT/Ha)	1.28	1.31	2%	1.31	3%	-39%	1.60	26%	-25%	2.13	0.86	67%
Production (1000 MT)	83	106	27%	130	56%	-15%	130	57%	-15%	154	71	85%
Consumption (1000 MT)	98	118	20%	130	33%	-8%	130	33%	-8%	141	43	43%
Self-sufficiency Ratio	85%	90%		100%			100%			109%		
Deficit/Surplus (1000 MT)	-15	-12	-19%	0			0			13		
Mozambique												
Area Harvested (1000 Ha)	240	258	8%	700	192%	80%	258	8%	-34%	389	149	62%
Yield (MT/Ha)	0.94	0.98	4%	0.98	4%	-57%	2.69	185%	18%	2.28	1.33	141%
Production (1000 MT)	226	253	12%	694	207%	-22%	694	207%	-22%	885	659	291%
Consumption (1000 MT)	790	686	-13%	694	-12%	-1%	694	-12%	-1%	697	-93	-12%
Self-sufficiency Ratio	29%	37%		100%			100%			127%		
Deficit/Surplus (1000 MT)	-564	-432	-23%	0			0			188		
Zambia												
Area Harvested (1000 Ha)	30	31	4%	36	21%	-14%	31	4%	-26%	42	12	40%
Yield (MT/Ha)	1.00	1.04	4%	1.04	4%	-47%	1.21	21%	-39%	1.98	0.98	98%
Production (1000 MT)	30	32	8%	38	26%	-55%	38	26%	-55%	83	53	177%
Consumption (1000 MT)	40	38	-6%	38	-6%	0%	38	-6%	0%	38	-2	-6%
Self-sufficiency Ratio	75%	86%		100%			100%			221%		
Deficit/Surplus (1000 MT)	-10	-5	-48%	0			0			45		

Source: AGRM, NRDS documents, PSD Online

[24] Scenario1: Area driven strategy, Scenario 2: Yield driven strategy

Table 4: Self-sufficiency Implication on the International Rice Market

Variable	Madagascar			Malawi			Mozambique			Zambia		
	Scenario1	Scenario2	NRDS	Scenario1	Scenario2	NRDS	Scenario1	Scenario2	NRDS	Scenario1	Scenario2	NRDS
Area Harvested (1000 Ha)	510	-8	510	10	-8	-17	441	-8	123	-3	-8	2
Yield (MT/Ha)	-0.004	0.005	-0.004	-0.0008	-0.0005	-0.0002	-0.006	0.002	0.001	-0.0007	-0.0006	-0.0005
Production (1000MT)	857	730	842	-104	-104	-80	313	313	504	-123	-123	-77
Per Capita Use	0.115	0.113	0.128	0.002	0.002	0.005	0.061	0.061	0.088	-0.001	-0.001	0
Total Consumption (1000MT)	872	860	974	11	11	36	464	464	670	-8	-8	42
Exports (1000MT)	-123	-198	-216	-80	-80	-85	-250	-250	-326	-77	-77	-95
Imports (1000MT)	-123	-198	-216	-80	-80	-85	-250	-250	-326	-77	-77	-95
Ending Stocks (1000MT)	468	181	239	-277	-277	-269	-323	-323	-338	-288	-288	-292
Change in International Reference Price (US$/MT) Long Grain	-4.33	-6.81	-7.44	-2.64	-2.64	-2.82	-8.61	-8.61	-11.25	-2.55	-2.55	-3.19

Source: AGRM simulation results

4.4 Result Synthesis and Mechanism of Achieving Self-sufficiency

Table 3 outlines the quantity of production required for each country to achieve self-sufficiency by 2018. This section will discuss, country by country, the feasibility of these requirements by looking at historical trend and taking into account the existing agricultural frameworks.

4.4.1 Madagascar

To achieve self-sufficiency by 2018, Madagascar need to increase production by 10% annually in the coming three years. However, between 1990 and 2016, average production change is 2% (USDA-FAS, 2016). In terms of area and yield changes, the averages during the same time period has been 1 and 2% respectively, while the goal for self-sufficiency is 42% in the area driven strategy and 32% increase in the yield driven strategy. Such estimates suggest that, taking historical trends into account, the self-sufficiency goals are highly ambitious. In fact, the AGRM projections (Appendix Table 3) indicate that with business as usual, even by 2025, Madagascar's production will not catch up with total consumption (Appendix Table 3, Madagascar).

As observed in Table 2 in the NRDS assessment section, Madagascar's NRDS is heavily oriented towards boosting supply through area expansion, intensification and increased focus on R&D along with extension services. However, the NRDS mentions that 34% of rice producers are small-scale farmers whose land allocated for rice production is below 1Ha. These farmers are characterized by their limited resources of capital, financial, market access, production equipment and even labor. The rest of the farmers are producers who are self-sufficient in rice and have alternative crops for income generation (43%) and lastly are producers who are semi-specialized in rice production (23%) who are common in major producing regions.

With the current condition, only the last category of rice farmers have the potential to play a significant role in the NRDS intensification strategy since they are the ones who have the operating capital necessary to acquire the inputs and tools needed to achieve the production goals. Small-scale producers would not be able to compete and essentially be forced to stop production without improved access to credit or subsidies. This would be detrimental to food security as these small-scale farmers are subsistence farmers who without rice production would have no income but more importantly, no access to food.

Furthermore, as discussed in the previous section, achieving rice self-sufficiency in Madagascar would reduce the rice international reference price by US$/Mt 7.44 in the NRDS scenario. Given that Madagascar is a price taker, this would result in a decrease of local rice price implying an income drop for the 85% of Malagasy farmers who are involved in rice farming, which represents 60% of total population. At the same time, this would also make rice more affordable to consumers. Although the economic welfare effect of achieving rice self-sufficiency is outside of the scope of this study, this dynamic is an important factor to consider mostly for a country where net buyers of rice are also net sellers.

Another important tradeoff to consider is the reorganization of agricultural land areas. Area expansion requires the reallocation of large surface of land currently dedicated for the production of other crops to rice production. After rice, the other two most important crops in Madagascar are cassava and maize. The two are essential substitutes for households who cannot afford to purchase rice, mostly during the lean season (November to mid-March) and for the southern region where access to rice is limited (Fintrac Inc., 2013). This is once again an important factor to consider in terms of food security. If land currently under maize and cassava production were reallocated to rice production then supply of the two substitute crops would decrease leading to an increase in their prices. Such a situation would be unfavorable for the households who turn to the two substitute crops due to their affordability but even more for the southern region, which is already suffering from persistent drought and famine (FEWS NET, 2016).

Moreover, infrastructure is also an important factor to consider for achieving self-sufficiency. Previous research shows there is a correlation between isolation and poverty (Paternostro, Razafindravonona, & Stifel, 2001; Stifel, Minten, & Dorosh, 2003). Specifically, these researchers show that that 1) poverty increases with remoteness; 2) yields of major crops (rice, maize and cassava) fall significantly, as one gets further away from major markets; and 3) use of agricultural inputs decrease with isolation. Additionally, it was previously mentioned that rice production in Madagascar is highly competitive, mainly due to low cost of productions and low labor costs. However, this competitiveness is lost along the value chain due to high marketing cost caused by remoteness of producing areas, which essentially leads to high transportation costs (Minten, et al., 2006). Although distance between rural and urban areas cannot be changed, the state of the infrastructures such as roads can be. Simulation results by Stifel, Minten and Dorosh (2003) suggests that halving travel time per kilometer on major highways can increase rice production by 1.3 %. Infrastructure improvements and market linkages are discussed in the NRDS but without mention of detailed budgets.

Another important infrastructure to consider is storage facilities which is hardly mentioned in the NRDS. An extensive study looking at local markets and food security programs in Madagascar (Fintrac Inc., 2013) found that adequate storage is almost nonexistent with the exception of large-scale wholesalers who own their storage facilities and some small-scale wholesalers who either rent spaces or store rice in their households. The benefits of storage facilities include the possibility to have access to rice all year round. This is a particularly challenging situation, first for the southern region where the population is suffering from major supply reductions due to locust invasion and weather related incidents, and second, for low-income households who have to turn to imports during the lean season.

4.4.2 Malawi

To be self-sufficient by 2018, Malawi will need to increase production by 40%. Looking at historical data, between 1990 and 2013, the average production increase was only 9%. This signals that the self-sufficiency goals could not be attained unless initiatives are undertaken to increase either area or yield or both, which averaged at 9% and 2% respectively between 1990 and 2013. Moreover, as observed in the AGRM baseline projections in Appendix Table 3, Malawi's rice production will only increase by 27% between the 2013-2015 and 2018.

The NRDS goal is to achieve rice self-sufficiency mainly driven through yield increase rather than area expansion (67% yield improvement and an 11% area increase). This would imply that farmers would not need to reallocate much of their land production to rice. This is particularly important since rice is not among the national staple crops but more importantly, comparative advantage exists in the production of other dominant crops such as tobacco and hybrid maize, which currently occupy large cultivated land areas (Nakhumwa, Ng'ong'ola, Minde, Lungu, & Mapemba, 1999). However, since area expansion would be minimal, yield improvement would need to be drastic.

In the 2005/06 growing season, Malawi launched the Farmer Input Subsidy Program (FISP), which had a remarkable impact on national maize production, increasing maize production from 1,225 thousand MT in 2005 to 2,611 thousand MT in 2006 and to 3,226 thousand MT the following year (USDA-FAS, 2016). Given the significant impact of the FISP on Malawi's national maize production, the government could begin a similar program for rice production while learning and adapting from the drawbacks encountered in the FISP implementation (Dorward & Chirwa, 2011; Lunduka, Ricker-Gilbert, & Fisher, 2013). However, FISP has been widely criticized for its inability to benefit small scale farmers but more importantly, it is a costly program accounting for 10% of national government expenditure in 2012, and representing 4% of national GDP (Hourticq, Phiri, & Phiri, 2013). Once again, this exposes the tradeoff between investing in a minor crop versus staple crops.

A recent study on the economic efficiency of rice production in smallholder irrigation schemes in Malawi revealed that there is a 35% potential for rice yield improvement or a 47% potential increase in production if adequate policies and strategies addressing input and output markets are implemented (Magreta, Edriss, Mapemba, & Zingore, 2013). More specifically, adjustment in access to input use and credit must occur along with the ability to lever the capacity of farmer groups or associations to facilitate communications between farmers for technical advices and knowledge sharing.

Additionally, as previously mentioned, Malawi is a landlocked country, an attribute that is both a strength and weakness. Under the National Export Strategy (NES), Malawi wants to take advantage of its geographic location to be an export hub for neighboring countries. However, this requires investment in the national road infrastructure whether the goal is to capitalize on regional trade or to facilitate national transportations. An assessment of Malawi's infrastructure suggests that Malawi has been spending heavily on its road network. However, in recent years road preservation expenditures have fallen short (Foster & Shkaratan, 2011).

In terms of the national policies, the Agriculture Sector Wide Approach (ASWAp) is the national framework encompassing all agricultural related initiatives and is aligned with the

CAADP goals. A technical review was conducted after the implementation of ASWAp, which revealed that the national initiative is heavily oriented towards maize and tobacco, the major staple and export crops, respectively. Improving maize production and productivity through input subsidies account for 37% of the agricultural expenditure whereas technology generation and dissemination along with agricultural support services only account for 6.2% of the total agricultural budget (NEPAD, 2010).

This lopsided budget allocation might be justified given that maize is the staple crop accounting for three quarters of the population's calorie intake in normal years (FAO, 2011). However, Malawi often suffers from erratic weather conditions. In 2015, maize production decline by 29% then again by 15 % the following year (USDA-FAS, 2016). With such conditions, it would be advisable to diversify investment into different crops to offset adverse maize growing seasons. The ASWAp recognizes the importance of diversification. However, it does not specifically consider rice but rather attempts to assess the potential in livestock, fishery, legumes and horticultural food production.

In sum, Malawi intends to be self-sufficient in rice production in the coming three years however, the crop does not seem to be among the priority crops in the main agricultural policy framework. Potential to increase rice production exist but to achieve the 2018 production targets, a strong focus on yield improvement must occur, which is difficult to envision with the existing policy priorities.

4.4.3 Mozambique

Rice is an important crop in Mozambique and has been part of the national diet for 500 years. However, the country is highly dependent on imports. The government intends to reverse the situation by ambitiously raising national production by 291% by 2018. This goal is 22% above the necessary production requirement for self-sufficiency compared to scenario 1 and 2 figures. This production goal consists of a 93% annual increase, a rather high mark compared to an average change of 13% annually if we look at historical data since 1990. The NRDS intends to achieve the production goals mainly through yield improvement with a projected increase of 141%. However, given the low self-sufficiency ratio (a 28% annual average for the 10 most recent years), the area expansion requirement is also high (62%). Looking at historical data between 1990 and 2013, the average area and yield changes for Mozambique are 7% and 8% respectively.

The average milled yield for 2013-2015 is 0.94 MT/Ha, the lowest among the four countries of interest. Such a low yield level could indicate potential for a high percentage increase for 2018. The National Agriculture Investment Plan (PNISA) proposes a detailed yield increase following three distinct technology packages. Technology package 1 (use of improved seed), technology package 2 (improved seeds, fertilizers and herbicides) and technology package 3 (technology package 2 under irrigation conditions) with an expected average yield of 1.6 MT/Ha, 2 Mt/Ha and 2.7MT/Ha respectively (Government of the Republic of Mozambique). This translates to an average yield goal of 2.1MT/Ha. When simulated in AGRM[25], achieving this yield goal reduces Mozambique's import requirements for 2018 by more than half the quantity needed in the business as usual scenario, an import level of 150 thousand MT compared

[25] Baseline in Appendix

to 433 thousand MT in the business as usual scenario. As for area expansion, there is no mention of a specific plan in the PNISA. However, a specific budget requirement is outlined, not just for rice area expansion but an overall expansion of agricultural land.

Looking at the international rice market, it was previously discussed that Mozambique's achievement of rice self-sufficiency would reduce the international rice reference price by an average of US$/Mt 9.49 between scenario 1, 2 and NRDS. In the PNISA yield goal scenario, international rice price would only be reduced by US$/Mt 6.51. Similar to Madagascar's case this dynamic needs to be considered since it would make rice more affordable to consumers while at the same time decreasing rice farmer's revenue.

Overall, the PNISA is a comprehensive plan that encompasses key priorities in Mozambique's agricultural sector, including rice. However, there is a growing concern on how the program would be financed. It is mentioned in the PNISA document that cooperation partners meet only 22% of the total PNISA budget requirements and the rest will have to come from tax revenues earned from exploration of natural resources and other sources of government revenues. With the uncertainty from these revenue sources, the coverage and feasibility of the PNISA program and consequently rice production improvement depends heavily on two basic assumptions: 1) the government's ability to plan and coordinate investments and 2) the sufficient and timely commitment of partners to financially and continuously support the PNISA.

In sum, due to the large gap between national production and domestic consumption, the government of Mozambique would only be able to reduce the rice import requirement by half rather than fully achieve self-sufficiency, if we look at the current national framework. Thus, if Mozambique wants to achieve the NRDS or self-sufficiency goals, priorities need to be revised, as it would imply a budget and potentially production area reallocation to rice production. The difference in Mozambique's strategy is that rather than focusing on one specific crop, the national program[26] intends to invest in national structures that would result in improvement across sectors and subsectors (food crop, cash crops, fisheries, livestock etc.)

4.4.4 Zambia

To attain its self-sufficiency goal by 2018, Zambia need to increase production by 26% by 2018 (scenario 1 and 2). Unlike the other countries, Zambia's NRDS document does not stipulate achieving self-sufficiency or producing surplus for export. Rather it simply plans to double rice production within five years (2011-2015), which according to actual PSD online data was not achieved. The 2018 NRDS goals are based on projections and according to AGRM baseline projections (Appendix Table 3), the country would still be a net importer of rice by 2018.

Based on scenario simulations, the NRDS goals are well above the production requirements necessary to be self-sufficient in 2018, which imply the possibility for a production surplus. Zambia's production strategy relies mainly on yield improvement, a 98% increase, and a 40% area increase. Looking at historical data (1990-2013), the average annual yield change is 4% and area 8%.

Rice production is predominantly undertaken by small-scale producers in the northern part where 50% of domestic rice production occurred as of 2009 (Chemonics International Inc., 2009). The following year, a survey by the Central Statistics Office (CSO) confirmed that rice was still grown by small-scale producers, 30% of which are women and the average farm size

[26] The PNISA focuses on five major components: 1) Production and Productivity; 2) Market Access; 3) Food and Nutritional Security; 4) Natural resources and 5) Institutional Reform Program to Enhance Implementation, for all the priority subsectors of interest including rice.

range from 0.25 to 1.8 Ha (Republic of Zambia, 2011). Increasing yield by almost 100% will require the use of improved technologies: seeds, irrigation systems, and fertilizers among other things. Such changes would drastically increase total production costs, which these smallholder farmers might not be able to afford.

The government of Zambia operates three subsidy programs, although biased towards maize production: The Food Security Pack Program (FSP), the Food Reserve Agency (FRA) and the Fertilizer Input Support Program (FISP). The Food Security Pack Program targets vulnerable small-scale farming households providing them with material and technical assistance in the form of low-interest loans (International Labour Organization, 2013). The Food Reserve Agency and the Fertilizer Input Support Program go hand in hand as the FRA is the FISP's implementing agency (The African Centre for Biodiversity, 2016).

Generally, the FRA engages in market facilitation, development and management. For example, during the years when Zambia produces bumper crops, FRA acts as a price stabilizer by procuring the maize surplus at above market rates (Government of the Republic of Zambia, 2013). The FISP provide select farmers with fertilizers and maize seeds. Together the two programs, FRA and FISP, make up 60% of the expenditure on agriculture (Government of the Republic of Zambia, 2013). However, there has been concerns on the program's inability to benefit small-scale farmers. To be eligible for FISP, farmers must be registered with farmers' group, be able to cultivate 1 to 5 hectares of maize and be able to pay towards the cost of the inputs (World Bank, 2010). Moreover, research on Zambian farmers access to maize market suggests that the probability that the FRA buys maize from a farmer diminishes as the household's location becomes further away from the district town (Chapoto & Jayne, 2011).

With an average area harvested of 30 thousand hectares, yield of 1Mt/Ha and a per capita consumption of less than 3 kg per year, rice is a minor crop in Zambia. The estimated per capita consumption equation in this study suggests that rice is a luxury good (section 4.1.4) in the country and recent statistics revealed that it is mainly grown by small-scale farmers. However, Zambian rice is popular even in foreign countries where rice has long been a staple food which could indicate an opportunity for the export market (Chemonics International Inc., 2009). Furthermore, the government recognizes the crop's potential as both a food and cash crop, making it important for food security and poverty alleviation (Republic of Zambia, 2011).

These factors rationalize the need for investment in rice production given its potentials. However, as discussed in section 2.3.4, Zambia does not hold a comparative advatage in rice production at the average level of output and even with potential improved management, rice production remains inefficient compared to other crops (Saasa, Chiwele, Mwape, & Keyser, 1999). Moreover, the current policy framework does not seem to favor rice production and is heavily oriented towards maize production. This questions the ability of the country to attain self-sufficiency by 2018 and much less the NRDS production goal which is 42% higher than the self-sufficiency requirement for 2018.

4.4.5 Shared priority investment areas

Besides Zambia, the NRDS goals for each country aim to attain self-sufficiency by 2018 with a combination of yield improvement and area expansion. Moreover, besides Madagascar, none of the countries have a comparative advantage in rice production. For Zambia and Malawi, rice does not rank among the major crops nationally, so investment in a minor crop where comparative advantage is nonexistent would be an injudicious use of domestic resources.

However, if investment in rice production are implemented despite these arguments then it is desirable for these countries to regain a comparative advantage in the sector. One way to achieve this would be through reduction of rice production costs and improvement of the quality of rice produced. Such strategies will be difficult to achieve unless some basic infrastructures and government funds are available to farmers.

For instance, the lack of input market is among one of the major issues observed in these four countries. As of 2010, only 4% of producers use fertilizers in Mozambique and only 7% use any pesticides (Government of the Republic of Mozambique). In Madagascar, despite the significant rice demand, 98% of farmers still use traditional seed varieties (Republique of Madagascar, 2016). However, facilitating access to inputs would be meaningless unless farmers have the financial mean to purchase them. All four countries discuss the development of schemes facilitating access to credit. In addition to that, Malawi, Mozambique and Zambia each have their own Fertilizer Input Support Program (FISP), intended to enable farmers to have access to inputs. However, these programs have been widely criticized for the fact that they marginalize small-scale producers but more importantly, they are costly programs and for all three countries the subsidy mainly aims to improve maize production and not any other crops. Similar programs could be introduced for rice or the same program could expand its focus to rice. However, given the absence of a comparative advantage in rice production in the three countries (Malawi, Mozambique, Zambia) a study on the effects of such a policy is necessary before action for implementation is advised.

Another important aspect to consider is infrastructure investments including irrigations, processing facilities, storage, roads, and other market infrastructures. Irrigation has great potential to improve rice production mostly in these countries where rice production is mainly rainfed. In Mozambique for example, 90% of the total rice area are rain-fed lowlands (Republique of Mozambique, 2009). Moreover, as previously mentioned, the agricultural sectors in these four countries are often challenged by erratic weather conditions which have worsened in recent years due to El Niño. Thus, the existence of irrigation infrastructures would reduce the dependence on rain. Processing (milling and drying) facilities are important to mitigate post-harvest losses and the improvement of milled rice quality during the milling process.

Furthermore, storages facilities are important as they allow farmers to store their rice harvest and sell later to earn higher prices than the low harvest period price. In addition, storage facilities also enable farmers to keep surpluses to use later during the lean season, a particularly important aspect for Madagascar where poor households have to turn to imported rice during the lean season when local rice is scarce. Additionally, road infrastructures are of the utmost importance. The main benefit is that improved roads enable market linkages allowing production to flow from surplus to deficit areas. Also, they connect remote areas to urban markets, enabling market access.

Lastly, all of these important sectors need to be supported by research, which is necessary to 1) have a better understanding of the situation in order to efficiently implement necessary changes; 2) facilitate adoption of new technologies as some farmers might be reluctant to change; and 3) ensure maintenance, training and promotion of new technologies. To understand the current research climate in each country, Agricultural Science and Technology Indicators (ASTI)[27] data are reviewed. In Madagascar, major crop research[28] account for 37% of research

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[27] Facilitated by the International Food Policy Research Institute (IFPRI), ASTI data are sets of Open-access data and analysis on agricultural research investment and capacity in low- and middle-income countries (IFPRI, n.d.).

[28] Major crops include those that are the focus of at least 5 percent of all crop researchers.

focus and rice research account for 35% of the 37%. As of 2011, the country spent 0.16% of its agricultural GDP on agricultural R&D, a level that is six times lower than the 1% target recommended by NEPAD (Stads, Randriamanamisa, & Domgho, 2013). In Malawi, agricultural R&D spending more than doubled between 2008 and 2011 due to growth in government and donor funding which translates to a 1.03% R&D investment, as a share of agricultural GDP, meeting the NEPAD recommended level. Major crop research account for 57% of total research focus and rice reasearch account for 9% of the 57% (Flaherty & Kamangira, 2014). In Mozambique, major crop research account for 40% of research focus of which 16% is focused on rice research. Public spending on agricultural R&D increased by 14% between 2008 and 2011 in Mozambique, but was primarily driven by the increased cost associated with salaries and capital investments (Flaherty & Nhamusso, 2014). In Zambia, historical trends indicate a serious decline in agricultural R&D investment as public research spending decreased from 22 million purchase-parity-price (PPP) dollars on average in the 1990s to 7 million PPP dollars in 2005, accounting for less than 0.5% of agricultural GDP. This was the result of a government-sector hiring freeze along with a lack of training opportunities (Flaherty & Mwala, 2010). It is observed here that budget dedicated to agricultural research varies across country. If we look at the number of full-time equivalent (FTE) researchers per 100,000 farmers for 2008, Zambia leads with 6.8 FTE researchers per 100,000 farmers followed by Mozambique 3.08, Madagascar 2.8 and Malawi 2.49. Such statistics indicate the need for increased human capital investment and capacity building for research.

Chapter 5: Conclusion

5.1 Summary of Findings

The 2008 food crisis renewed the interest of net food importing countries to invest in national self-sufficiency instead of relying on volatile international markets. The CARD initiative originated following this event and aimed to double rice production in Africa by 2018, so that the African member countries would become self-sufficient. To do so, CARD assisted 23 African countries in drafting a country specific and comprehensive national strategy that would enable the attainment of the said production goal by upgrading their respective rice value chains. This national strategic framework is the National Rice Development Strategy (NRDS). Each NRDS presented a specific production goal for each country driven by a combination of yield improvement and area expansion.

This study focused on four southern African countries, Madagascar, Malawi, Mozambique and Zambia, and aimed to quantify the production requirements needed to be self-sufficient in 2018 while taking into account the change in consumption requirements for that year. The Arkansas Global Rice Model (AGRM), a partial equilibrium and multi-country econometric framework, was used to estimate baseline projections. The estimated business-as-usual projections revealed that although production would increase, none of the four countries would be self-sufficient by 2018. Consequently, different scenarios to find the quantity of area harvested and yield increase required for self-sufficiency level in 2018 were simulated in AGRM. The simulations results (Table 3), suggests that with the exception of Zambia, the NRDS production goals would enable the countries to attain self-sufficiency.

The AGRM model also allows for the observation of the impact of achieving self-sufficiency within the world rice market, in terms of world rice supply and utilization along with the potential impact on the world rice prices. Since Madagascar and Mozambique's supply and use are moderately significant within the world rice market, Madagascar with the high consumption and Mozambique with the high level of imports, the effect of achieving rice self-sufficiency in the two countries are relatively significant at the international price level. As summarized in Table 4, rice self-sufficiency in Madagascar and Mozambique would reduce the rice international reference price (Thai 100%B, Long grain) by an average of US$/Mt 6.19 and US$/Mt 9.49 respectively between the three scenarios (area driven, yield driven and NRDS), while increasing world total consumption by 902 thousand MT and 533 thousand MT respectively[29]. The impact of achieving self-sufficiency for Malawi and Zambia are minimal at the world level and are summarized in Table 4.

After the identification of the self-sufficiency production level requirements for each country, it is necessary to observe whether the existing policy framework would enable each country to achieve their goals. For Madagascar, the NRDS is oriented towards supply shifting by upgrading the production system through increased use of improved seeds, chemical fertilizers etc. However, such strategy might only benefit medium to large-scale farmers who have the financial assets to adopt such technologies. This would be problematic as 34% of Malagasy rice producers are small-scale farmers whose land for rice production is below 1Ha.Thus, programs for increased access to credits, land expansion and input subsidies would be necessary to ensure that this demographic of producers are not marginalized.

For Mozambique, the NRDS goals are highly ambitious but given the current low yield level (the lowest among the four countries of interest) potentials do exist. Currently, rice

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[29] figures are average between the 3 scenarios

production is predominantly rain-fed lowland which would imply a potential in irrigation investment and the exploitation of upland production. However, development of the rice sector is budgeted in the National Agriculture Investment Plan 2014-2018 (PNISA). The PNISA planned budget for three distinct technology packages, which lead to an average yield goal of 2.1 Mt/Ha. When simulated in AGRM, this only reduced Mozambique's import requirement for 2018 by half, ringing the import level down to 320 thousand MT compared to 622 thousand MT in the business-as-usual scenario. No specific area harvested expansion goal was mentioned however, assuming the current framework and maintaining area at baseline level, Mozambique will not be self-sufficient in 2018. As a result, there is a need to align national agricultural frameworks.

For Malawi and Zambia, rice is not a major crop, and consequently is minimized within the national agricultural policies. For both countries, the majority of the budget for agriculture go towards improving maize production, the staple food crop, through the Farmer Input Subsidy Program (FISP). Despite the raising concern on the program's inability to benefit small-scale farmers, FISP has had positive effect in both countries. However, knowing that the program is costly and comparative advantage in rice production does not exist in either country, further studies must be undertaken before it is advisable to recommend the development of such scheme for rice production or the expansion of the same program to include rice.

Lastly, some shared priority investment areas were suggested following the common challenges observed in each country. Among these are the establishment of input markets, which should be supported by an initiative to enable access to financial assets so that small-scale farmers are not marginalized. Then, infrastructure investment that would increase production, improve rice quality and ease market access are also necessary. Finally, to ensure the efficiency and sustainability of the investment in these different areas, support through increased investment in agricultural research must be prioritized.

5.2 Limitations of the Study and Future Research

One of the main challenges encountered during the course of this study was data availability for the country model estimations. The area and yield equations are limited, as they do not take into account any production cost. This is because data on input use, transportation costs, and other costs associated with production are scarce or nonexistent for these countries. The limited literature contains some data but it is either a snapshot for just one year, outdated or does not encompass the reality at the national level. Similarly, some price data were also unpublished, which reduced the time series observed (especially for Zambia).

Furthermore, the literature on rice production within the four countries is limited with the exception of Madagascar. Most literature on African rice concerns West Africa. This was particularly challenging when trying to determine whether the four countries have a comparative advantage in rice production or not. The studies used to draw the conclusions for each country on this matter were outdated but it was assumed that they still had some validity.

In terms of the scenario simulations, the yield equations do not take into account changes in area harvested and vice versa. However, typically, if area harvested increases, yield would generally decrease since area is expanded on land that is not normally suitable for rice production. In addition, the self-sufficiency scenarios were analyzed separately for each country which does not allow one to observe the possible impact if all four countries were to reach self-sufficiency.

Moreover, this study also intended to estimate the cost of achieving self-sufficiency, meaning, the cost associated with area expansion and yield improvement among other things. However, due to lack of data on production costs, this section was replaced with the qualitative assessment on key priority areas for investment.

Then, all four of these countries express some interest on capitalizing their membership within regional markets (SADC and COMESA). However, this study did not observe such relationship. Thus, a potential future study would be to observe the effect of achieving national self-sufficiency at the regional level along with the potential impact of changes in rice import policies.

Lastly, this study did not investigate the welfare effect of achieving rice self-sufficiency, which is especially important for Mozambique and Madagascar where achieving self-sufficiency would have a noticeable impact on international rice price, and thus affecting both net consumers and net producers of rice.

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Appendix

Appendix Table 1: Submodel Equations

Madagascar Submodel equations – Appendix Table 1 continued [30]

Dependent Variables	Explanatory Variables	Parameters	Elasticity	Std. Error	t-value		Units
$LnRIAHH_{MG}$		6.792		0.469	14.478	***	1000 Ha
Adj. $R^2 = 0.897$	$LnrRIPPP_{MGt-1}$	0.025	0.025	0.038	0.662		Ariary per MT
Est. period = 1991-2015	D_{09-15}	0.224	0.224	0.015	14.584	***	
F = 70.974	D_{13}	-0.154	-0.154	0.035	-4.397	***	
Std. error = 0.032							
$LnRIYPH_{MG}$		-0.038		0.105	-0.357		MT per Ha
Adj R^2: 0.793	LnTrend	0.302		0.036	8.367	***	
Est. period = 1990-2015	Shift Trend	0.023		0.009	2.675	**	
F = 49.131							
Std. error = 0.072							
$LnRIUPC_{MG}$		-2.389		4.821	-0.496		Kg per person
Adj $R^2 = 0.764$	$LnRIPRE_{MG}$	-0.050[31]	-0.050				Ariary per Kg
Est. period = 2005-2014	$LnNADRL_{MG}$	0.186	0.186	0.361	0.514		Ariary per person
F = 15.588	$LnRISPR_{MG}$	0.591	0.591	0.107	5.550	***	1000 MT
Sdt. error = 0.038							

[30] All variables are estimated in log forms so the resulting coefficients are directly elasticity values.
[31] Imposed elasticity for conditional regression.

$LnRIPPP_{MG}$		1.307		0.654651	1.997988	*	USD per MT
Adj R^2= 0.599	LnRGPOB1TH	0.700	0.700	0.112977	6.198936	***	USD per MT
Est. period = 1990-2015							
F= 38.427							
Std. error = 0.189							
$LnrRIPRE_{MG}$ =		7.516		2.349	3.199	***	Ariary per Kg
Adj R^2= 0.306	LnrRGPOB1TH	0.427	0.427	0.183	2.330	**	Ariary per Kg
Est. period = 2005-2015							
F= 5.426							
Std. error = 0.119							

Malawi submodel equations– Appendix Table 1 continued

Dependent Variables	Explanatory Variables	Parameters	Elasticity	Std. Error	t-value		Units
$LnRIAHH_{MW}$		-0.310		1.018	-0.304		1000 Ha
Adj. R^2 = 0.781	$LnRIAHH_{MWt-1}$	0.711		0.141	5.047	***	1000 Ha
Est. period = 1997-2013	$LnrRIPPP_{MWt-1}$	0.140	0.140	0.115	1.213		MKwacha per MT
F = 20.125	D_{04-05}	-0.114		0.065	-1.749	*	
Std. error = 0.076							
$LnRIYPH_{MW}$		-0.462		0.070	-6.619	***	MT per Ha
Adj R^2: 0.742	LnTrend	0.211		0.026	8.111	***	Year - 1982
Est. period = 1983-2015	D_{04-05}	-0.605		0.092	-6.567	***	
F = 47.095							
Std. error = 0.124							

LnRIUPC$_{MW}$		-5.572		3.242	-1.719	*	Kg per person
Adj R^2 = 0.903	LnNADRL$_{MW}$	0.260	0.260	0.435	0.598		
Est. period = 1990-2013	LnrRGPOB1TH*(1+RIGTM$_{MW}$)	-0.109	-0.109	0.104	-1.045		MKwacha per Kg
F = 54.693	LnRISPR$_{MW}$	0.471	0.471	0.102	4.595	***	1000 MT
Sdt. error = 0.127	D_{91-92}	-0.600		0.150	-4.004	***	
LnRIPPP$_{MW}$		2.354		0.464	5.077	***	MKwacha per MT
Adj R^2= 0.958	LnRGPOB1TH	0.857	0.857	0.045	19.114	***	MKwacha per MT
Est. period = 1996-2013							
F= 365.33							
Std. error = 0.201							

Mozambique submodel equations – Appendix Table 1 continued

Dependent Variables	Explanatory Variables	Parameters	Elasticity	Std. Error	t-value		Units
LnRIAHH$_{MZ}$		0.350		0.313	1.119		1000 Ha
Adj. R^2 = 0.955	LnRIAHH$_{MZt-1}$	0.941		0.060	15.555	***	1000 Ha
Est. period = 1994-2008	LnrRIPPP$_{MZt1}$/LnrMAPP$_{MZt-1}$	0.099	0.099	0.044	2.270	**	Metical per MT
F = 100.673	D_{99-00}	-0.141		0.028	-5.028	***	
Std. error= 0.036							

$LnRIYPH_{MZ}$		-0.279		0.074	-3.781	***	MT per Ha
Adj R^2: 0.849	Trend	0.016		0.003	4.734	***	Year - 1982
Est. period = 1990-2015	$D_{92-93;2012}$	-0.518		0.054	-9.572	***	
F = 71.759							
Std. error = 0.122							
$LnRIUPC_{MZ}$		-17.895		6.496	-2.755	**	Kg per person
Adj R^2 = 0.385	$LnrRIPRE_{MZ}$	-0.895	-0.895	0.313	-2.863	**	Metical per kg
Est. period = 2000-2014	$LnNADRL_{Mz}$	1.012	1.012	0.310	3.260	***	Metical per person
F = 5.399							
Sdt. error = 0.132							
$LnRIPPP_{MZ}$		0.483		0.685	0.705		Metical per MT
Adj R^2= 0.885	LnRGPOB1TH	0.861	0.861	0.082	10.465	***	Metical per MT
Est. period = 1993-2007							
F= 109.521							
Std. error = 0.189							
$LnRIPRP_{MZ}$		1.138		0.874	1.302		Metical per MT
Adj R^2= 0.309	LnRGPOB1TH	0.935	0.935	0.096	9.762	***	Metical per MT
Est. period = 2000-2015							
F= 95.305							
Std. error = 0.210							

Zambia submodel equations– Appendix Table 1 continued

Dependent Variables	Explanatory Variables	Parameters	Elasticity	Std. Error	t-value		Units
$LnRIAHH_{ZM}$		-0.399		1.848	-0.216		1000 Ha
Adj. $R^2 = 0.699$	$LnRIAHH_{ZMt-1}$	0.814		0.189	4.314	**	1000 Ha
Est. period = 2006-2014	$LnrRIPPP_{ZMt-1}$	0.135	0.135	0.188	0.717		ZKwacha per MT
F = 10.327							
Std. error=0.203							
$LnRIYPH_{ZM}$		-0.094		0.052	-1.792	*	MT per Ha
Adj R^2: 0.545	Shift trend	0.116		0.022	5.351	***	
Est. period = 1990-2013							
F = 28.628							
Std. error = 0.224							
$LnRIUPC_{ZM}$		-15.413		3.195	-4.824	**	Kg per person
Adj $R^2 = 0.859$	$LnrRIPRE_{ZM}$	-0.100	-0.100				ZKwacha per Kg
Est. period = 2007-2011	$LnNADRL_{ZM}$	2.199	2.199	0.435	5.053	***	Zkwacha per person
F = 25.535							
Sdt. error = 0.073							
$LnrRIPPP_{ZM}$		2.201		1.972	1.115		USD per MT
Adj $R^2 = 0.450$	$LnrRGPOB1TH*(1+RIGTM_{ZM})$	0.862	0.862	0.297	2.894	**	USD per MT
Est. period = 2005-2014							
F= 8.379							
Std. error = 0.272							

$RIPRP_{ZM}$		0.667		9.585	0.070		ZKwacha per MT
Adj R^2= 0.999	$RIPPP_{ZM}$	1.011	1.022	0.001	816.71	***	ZKwacha per MT
Est. period = 2007-2015							
F= 667024.6							
Std. error = 4.704							

Appendix Table 2: Variable Nomenclature, Units and Data Source[32]

Variable	Name	Units	Data source
		Supply&Use	
RIAHH	Area harvested	1000 Ha	PSD
RICIT	Beginning Stock	1000 MT	PSD
RICOT	Ending Stock	1000 MT	PSD
RISMN	Net Imports	1000 MT	PSD
RISMT	Imports	1000 MT	PSD
RISPR	Milled Production	1000 MT	PSD
RISPT	Rough Production	1000 MT	PSD
RIUDC	Domestic Consumption	1000 MT	PSD
RIUPC	Per Capita consumption	Kg/person	Calculated
RIUXN	Net Exports	1000 MT	PSD
RIUXT	Exports	1000 MT	PSD
RIYPH	Yield milled	Mt/Ha	Calculated
RIYPHR	Rough Yield	Mt/Ha	PSD
		Prices	
RIPPP	Producer price		FAOSTAT
RIPRE	Retail price		FAO GIEWS
RGPOB1TH	International reference price (Thai 100%B long grain)		AGRM
MAPP	Maize Producer Price		FAOSTAT
		Macro	
DEPTL	Population	Millions	AGRM
NADDL	GDP Deflator (2000=100)	Index Number	AGRM
NADNL	Nominal GDP	Billions of LC	AGRM
NADRL	Real GDP at 2000 Prices	Billions of LC	Calculated
NIMEL	Exchange Rate	LC/$	AGRM
NIPCL	Consumer Price Index (2000=100)	Index Number	AGRM
		Policy	
RIGTM	Import Tax	Percent	WTO

[32] These variable name abbreviations are consistent with AGRM notations.

Appendix Table 3: AGRM Baseline Projection Results[33]

Madagascar Rice Supply and Utilization- Appendix Table 3 continued

	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26
				(Thousand Hectares)									
Area Harvested	1,300	1,500	1,450	1,450	1,479	1,505	1,535	1,565	1,594	1,624	1,653	1,683	1,713
				(Metric Tons per Hectare)									
Yield	1.78	1.70	1.64	1.63	1.66	1.68	1.70	1.72	1.75	1.77	1.79	1.81	1.83
				(Thousand Metric Tons)									
Production	2,311	2,546	2,382	2,368	2,448	2,526	2,611	2,696	2,782	2,870	2,958	3,049	3,142
Beginning Stocks	0	0	0	0	2	2	2	1	1	1	1	2	2
Domestic Supply	2,311	2,546	2,382	2,368	2,450	2,528	2,612	2,698	2,784	2,871	2,960	3,051	3,144
Consumption	2,871	2,746	2,582	2,658	2,761	2,846	2,935	3,031	3,132	3,241	3,355	3,472	3,591
Ending Stocks	0	0	0	2	2	2	1	1	1	1	2	2	2
Domestic Use	2,871	2,746	2,582	2,660	2,763	2,847	2,937	3,032	3,134	3,242	3,356	3,474	3,593
Net Trade	-560	-200	-200	-292	-313	-319	-324	-335	-350	-371	-397	-423	-449

[33] Base year = 2013-15; AGRM historical data goes back to 1983, the time period for the baseline estimations go from 1990 to 2013/2015 depending on data availability and the projections go all the way to 2037.

Malawi Rice Supply and Utilization- Appendix Table 3 continued

	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26
				(Thousand Hectares)									
Area Harvested	65	65	65	65	74	81	93	107	121	137	152	169	187
				(Metric Tons per Hectare)									
Yield	1.28	1.28	1.28	1.28	1.29	1.31	1.32	1.33	1.35	1.36	1.38	1.39	1.40
				(Thousand Metric Tons)									
Production	83	83	83	83	95	106	123	142	163	186	209	235	263
Beginning Stocks	0	0	0	0	1	1	1	2	2	2	2	3	3
Domestic Supply	83	83	83	83	96	107	124	144	165	188	212	237	266
Consumption	98	98	98	100	109	118	131	145	160	176	193	211	230
Ending Stocks	0	0	0	1	1	1	2	2	2	2	3	3	3
Domestic Use	98	98	98	101	110	119	132	147	162	179	196	214	234
Net Trade	-15	-15	-15	-18	-14	-12	-8	-3	3	9	16	23	32

Mozambique Rice Supply and Utilization- Appendix Table 3 continued

	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26
(Thousand Hectares)													
Area Harvested	240	240	240	240	248	258	272	285	303	322	346	372	398
(Metric Tons per Hectare)													
Yield	0.95	0.93	0.95	0.93	0.95	0.98	1.00	1.02	1.04	1.05	1.07	1.09	1.10
(Thousand Metric Tons)													
Production	228	223	228	223	235	253	271	292	314	340	371	405	440
Beginning Stocks	0	0	0	0	-4	-1	-1	0	0	0	0	0	0
Domestic Supply	228	223	228	223	231	252	270	292	314	340	371	405	440
Consumption	768	823	778	528	659	686	716	718	725	736	744	750	760
Ending Stocks	0	0	0	-4	-1	-1	0	0	0	0	0	0	1
Domestic Use	768	823	778	524	658	685	715	718	725	736	744	750	760
Net Trade	-540	-600	-550	-302	-427	-433	-445	-426	-411	-396	-373	-345	-320

Mozambique Rice Supply and Utilization in PNISA Yield scenario- Appendix Table 3 continued

	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27
(Thousand Hectares)														
Area Harvested	240	240	240	240	248	258	272	285	302	322	346	372	398	422
(Metric Tons per Hectare)														
Yield	0.95	0.93	0.95	0.93	0.95	2.10	1.00	1.02	1.04	1.05	1.07	1.09	1.10	1.12
(Thousand Metric Tons)														
Production	228	223	228	223	235	542	271	292	314	340	371	405	440	474
Beginning Stocks	0	0	0	0	-4	-1	-1	0	0	0	0	0	0	1
Domestic Supply	228	223	228	223	231	541	270	291	314	340	371	405	440	474
Consumption	768	823	778	528	659	691	715	717	725	736	743	750	760	763
Ending Stocks	0	0	0	-4	-1	-1	0	0	0	0	0	0	1	1
Domestic Use	768	823	778	524	658	690	714	717	725	736	744	750	760	764
Net Trade	-540	-600	-550	-302	-427	-150	-444	-426	-411	-396	-373	-345	-320	-290

Zambia Rice Supply and Utilization- Appendix Table 3 continued

	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26
				(Thousand Hectares)									
Area Harvested	30	30	30	30	31	31	32	33	34	35	36	37	38
				(Metric Tons per Hectare)									
Yield	1.00	1.00	1.00	1.00	1.02	1.04	1.06	1.08	1.11	1.13	1.15	1.17	1.20
				(Thousand Metric Tons)									
Production	30	30	30	30	31	32	34	35	37	39	41	43	45
Beginning Stocks	0	0	0	0	1	1	1	1	1	1	1	1	1
Domestic Supply	30	30	30	30	32	33	35	36	38	40	42	44	46
Consumption	40	40	40	33	34	38	40	41	42	44	46	48	50
Ending Stocks	0	0	0	1	1	1	1	1	1	1	1	1	1
Domestic Use	40	40	40	33	35	38	41	41	43	44	46	49	51
Net Trade	-10	-10	-10	-3	-3	-5	-6	-5	-5	-5	-5	-5	-5