

DETERMINANTS OF RICE SUPPLY IN TANZANIA

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**A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE
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ABSTRACT

Rice is among the most important crops in Tanzania, being both a commercial and major staple food crop for the majority of population. Furthermore, the rice industry contributes substantially to employment, foreign exchange and food security. The importance of rice in contributing to national growth is critical; this makes it meaningful to investigate the nature of rice farmers' production decisions. Despite the government's pursuit of pricing policies, Tanzanian rice production has not kept speed with consumption. This study was conducted to explore the nature in which rice producers respond to price and non-price factors. Specifically the study aimed at assessing the response of rice farmers to price and non-price factors in terms of area under production. Using time series data, the present study employed a Nerlovian expectation adjustment model to assess the farmer's responsiveness to price and non-price variables. The study was based on the secondary time series data covering the period of (1999-2008) obtained from the Ministry of Agriculture, Food and Cooperatives, Tanzania Meteorological Agency (TMA), and National Bureau of Statistics (NBS). The findings of the present study show that the important factors affecting farmers' decision to allocate land to rice include, the own price, price of substitute crop (maize), rainfall and fertilizer whose specific elasticities are 0.19, 0.17, 0.42 and 0.21 respectively. Price incentives on their own are inadequate to influence smallholder farmers' decision to allocate land to rice. The empirical results show that non price variables are more sensitive to rice supply than the price variables. Therefore policy needs to go beyond price interventions as a means to motivate and influence smallholder farmers' rice production decisions. Thus, the policy implications suggest that there should be a huge emphasis on non-price factors such as irrigation.

DECLARATION

I, Antony Nyerere, do hereby declare to the Senate of Sokoine University of Agriculture that, this dissertation is my own work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

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Above declaration is confirmed

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DEDICATION

Dedication to my dear beloved wife WinnieHauleand family.

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LIST OF ABBREVIATIONS AND SYMBOLS

AfDB	African Development Bank
ASDP	Agricultural Sector Development Programme
ASDS	Agricultural Sector Development Strategy
ATOT	Agriculture and Trade Opportunities for Tanzania
CC	Central Corridor
CRMP	Cooperative Reform and Modernization Programme
FAO	Food and Agriculture Organization
MAFC	Ministry Agriculture Food Security and Cooperatives
NBS	National Bureau of Statistics
NRDS	National Rice Development Strategy
REPOA	Research on Poverty Alleviation
RLDC	Rural Livelihood Development Company
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
TFC	Tanzania Fertilizer Company
TFRA	Tanzania Fertilizer Regulatory Authority
URT	United Republic of Tanzania
USDA	United States Department of Agriculture

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania is the largest producer of rice in East Africa, with much of the best land for rice growing (REPOA, 2012). An estimated 18% of farming households grow rice, and the economic activity in the rice sector contributes about 2.7% of the national GDP. The rice sector is among the major sources of employment, income and food security for Tanzanian farming households (USDA World Rice Statistics, 2009).

Tanzania is the second largest producer of rice in Southern Africa after Madagascar with production level of 818000 tons (USDA world rice statistics, 2009). The cultivated area is 681 000 ha; this represents about 18% of Tanzania's cultivated land. About 71% of the rice grown in Tanzania is produced under rain fed conditions; irrigated land presents only 29% of the total area with most of it in small village level traditional irrigations (URT, 2009).

Rice is the second most important food and commercial crop in Tanzania after maize. About 80% of the work force is employed in agriculture and rice is consumed by 60% of the Tanzanian population (FAO, 2008).

Rice production in Tanzania is largely dominated by smallholder farmers under rain fed conditions (ACT, 2010). In recent years, with the rapid growth of cities and towns propelled by rapid population growth, the country has experienced enormous increase in rice demand. The NRDS of 2009 reported that the demand and supply situation of the rice

market in Tanzania shows that there is high demand that cannot be sufficiently supplied by the local production. For example in 1998 the recorded production (in thousand tons) was 530, consumption was 644 thousand tons and in 2007, production was only 818 thousand tons while consumption was 968 thousand tons (FAOSTAT, 2014). These data show that rice supply is increasing at low rate compared to demand.

However, there are opportunities for rice sector development in the country. These are: i) Availability of land (21 million ha) suitable for rice and abundant water resources (underground, rivers and lakes) for irrigation; ii) Availability of seed production ventures and seed certification systems (conventional and community based); iii) 18% of the agricultural households are engaged in rice production; iv) Political will of the Government to enhance production and productivity of rice; a 75% tariff on import agreed by the East African Community to encourage domestic rice production v) Suitable policy environment such as exemption of taxes on agricultural inputs e.g. machinery, fertilizers, and subsidy on agricultural inputs such as fertilizers, improved seeds and pesticides (URT, 2009).

According to RLDC (2009), local demand is expected to triple by 2020 due to rising urbanization, incomes and population. The importance of rice is driven mainly by increased urbanization and changes in food preferences in both urban and rural areas, even where rice is not a traditional food crop. Most of rice demanded and consumed by the urban population is sourced from the rural rice producing areas that have stagnating production capacities (RLDC, 2009).

As an operational response to the Agricultural Sector Development Strategy (ASDS), in 2006, the Government started implementing the Agricultural Sector Development

Programme (ASDP) (URT, 2009). ASDP focused on increasing agricultural productivity, profitability and farm incomes. National policies and strategies on agriculture in the country address the need to increase food production to meet the food security objective in achieving self-sufficiency in staple food production, including rice.

Through its National Rice Development Strategy which aims to double rice production by 2018 to provide self-sufficiency for food security and export to neighbouring countries, the Government of Tanzania placed much attention to rice as a strategic commodity in the country to enhance food security and reducing poverty in the country (FAO, 2008). To achieve this goal, some of targets and strategies have been identified for implementation (fertilizer distribution; training and dissemination systems; access to credit/agricultural finance; improving irrigation).

Despite all efforts, rice supply is still increasing at a low rate compared to the increase in demand. The slow increase in supply can be attributed to the fact that the formulated strategies may lack important information about rice supply response that helps in understanding the dynamics of rice production, planning and prioritizing public investment programmes and policy formulation at house hold level.

Various studies of the determinants of agricultural supply generally indicated important roles for price and non- price factors on rice supply response. Fleischer (2007); Kanwar (2004) and Binswanger *et al.* (2010), analysed the supply response of farmers and reported the significance of price and non-price variables in studying how rice and wheat farmers react to the changes in these variables. Of these studies, none focus on Tanzania.

Therefore, policy formulation has been hampered by the lack of relevant empirical studies on supply response.

1.2 Problem Statement and Justification

The government of Tanzania placed much attention to rice as a strategic commodity in the country to enhance food security and reducing poverty in the country (RLDC, 2009). Some of targets and strategic areas have been identified and implemented by increasing government budget allocation from 2.9% in 2000 to 7.4% in 2011 (MAFSC, 2013). Despite all these efforts, the assessment of the performance of the various interventions showed no evidence of success.

For example in 2007 before the intervention the total production was 644000 tons. After the intervention the production was increasing at low rate (729, 739 and 990, 990 in thousand tons) in 2010, 2011, 2012 and 2013 respectively. The consumption during the same years was higher (879, 889, 1020 and 1020 in thousand tons) (FAOSTAT, 2014). Generally local rice production lags well behind demand. Probably the poor performance of various interventions was due to inappropriate formulation/design which can be attributed to inadequate understanding on rice supply response.

Past studies revealed weak supply response for agriculture in developing countries as non-price factors seem to dominate over price factors in farmers' decision making problems (Gulati and Kelly, 1999). The importance of non-price factors has drawn adequate attention in literature; rainfall, market policies, technology and market access. One of the reasons for low response to prices in developing countries is the limited access to technology and poor rainfall (Mythili, 2001). Although the government has made

remarkable efforts to liberalise the rice industry and make technology, inputs accessible and improve market access it remains unclear to what extent farmers respond to these incentives. This makes it essential in this study to examine how farmers also react to such non – price factors. Other scholars indicated that farmers are more responsive to non-price variables than price variables. This study also tested this hypothesis in Tanzanian rice farmers.

This study is therefore, among others, aimed at contributing to the efforts to fill the gap by estimating the determinants of rice supply, both price and non-price factors. Price and non-price elasticities are relevant as they are a medium through which market or trade policies are expected to induce domestic production. Lahiri and Roy (1985), pointed out that price is a key variable in economic analysis, and in the agricultural sector it is crucial to the analysis of farmers supply response. It is against this background that this study investigated how rice production responds to price and non-price incentives as a main objective.

1.3 Study Objectives

1.3.1 Overall Objective

The overall objective of this study was to analyse the determinants of the rice supply in Tanzania.

1.3.2 Specific objectives

Specifically, the study focused on the following objectives:

- i. To estimate elasticity of rice supply with respect to price and non-price variables in Tanzania
- ii. To compare the sensitivity of rice supply to price and non-price factors.

1.3.3 Research hypotheses

This study was guided by the following hypotheses:

- i. Rice supply is significantly affected by price and non-price factors
- ii. Rice supply is more sensitive to non-price factors than price factors.

1.4 Organization of the Dissertation

This dissertation is organized into five chapters. Chapter one presents the background information on the importance of rice as food and commercial crop. The problem statement and justification, objectives and research questions are also presented. Chapter two presents the review of different literature related to this study. Further, this chapter presents a review of literature related to the concept of supply response and the variables that determine it. Chapter three describes conceptual framework of the study, the study area, data collection methods, definitions of dependent and explanatory variables used in the study, method of data analysis. Chapter four presents the discussion of the results. Finally, chapter five presents recommendations of the study.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of the Study

Since the work of Nerlove (1958) set the pace for studies on agricultural supply response to price and non-price factors, a number of studies on agricultural supply response to price and non-price factors have been extensively undertaken in different parts of the world based on individual commodities and at aggregate level (Farooq *et al.*, 2001). These studies are important to agricultural response analysis because prices and non-price factors are the channels which policies affect agricultural variables (e.g. output supply and input demand). Supply response results enhance an understanding of the impacts that alternative policy packages may have on households' production activities and other market participants.

This chapter presents a review of some of the studies on current situation related to rice sector in Tanzania and rest the world. The review based on agricultural supply response by examining critically the objectives, methodology applied and the findings of each of the studies. The theoretical foundation for the present study is also presented.

2.1 Demand and Supply of Rice in Tanzania

Rice is grown by about a third of all Tanzania farmers and consumed especially by higher income earners. The demand and supply situation of the rice market in Tanzania shows that there is high demand that cannot be sufficiently met by the local production. Self-sufficiency varies from about 80% in good years to only about two third of the consumption in bad years. The rest has been supplied by the imports (RLDS, 2009). Leading regions for

rice productions are shinyanga(Bariadi and Maswa), Morogoro (Kilombero, Wami-Dakawa), Tabora (Igunga), Mbeya (Mbarali, Kyela, Kapunga) and 25% of the national rice production comes from Mbeya and Morogoro regions (ATOT, 2013).

Most of rice production in the country is rainfed and annual rainfall variation makes rainfed rice production susceptible to flooding or drought. The risk of drought impedes investment, causing production to stagnate at a subsistence level (AfDB, 2010). The deterioration of drainage and irrigation facilities is posing a considerable constraint to increasing production of rice.

2.2 Trends of Rice Supply in Tanzania

Although substantial volumes of rice are produced in Tanzania, the domestic crop is not even very price competitive in the local market compared to rigidly taxed imports because of relatively high production and transaction costs (USDA World Rice Statistics, 2009).

Rice production in Tanzania stagnated in the early 1980s and then rose sharply, exceeding 800 000 tonnes in 2007 and 900000 tonnes in 2010(REPOA, 2012). The National production in ten years (1998-2007) period has had an overall growth although branded by large fluctuations from year to year (USDA, 2009 in RLDC, 2009). This is highly associated with the growth of cities and population hence the demand of rice by consumers (RLDC, 2009). This is as shown in Table 1.

Table 1: Annual Rice Production Trend (1998-2007)

Year	Area Harvested	Yield(t/ha)	Production(1000t)
1998	209	1.08	530
1999	475	1.8	511
2000	500	1.02	511
2001	530	1.07	569
2002	500	1.29	465
2003	570	1.26	720
2004	650	0.86	556
2005	688	0.83	573
2006	650	1.21	785
2007	665	1.23	818

Source: World Rice statistics RLDC (2009)

Table 1 show that rice production has been fluctuating although the area under rice production has been increasing. The rice production area constituted 18% of the total land under cultivation in the country. The best use of this area is not achieved due to limited use of improved seeds as well as fertilizer. At the same time, access to machinery and other farm implements such as tractors which are currently very low (RLDC, 2009).

2.3 Price and Non-price Factors

Agricultural pricing policy plays a key role in increasing both farm production and incomes and is fundamental to an understanding of the price mechanism in supply response (Rao, 2003). However, price alone is not sufficient to affect policy instrument. The study conducted by Ogazi (2011), showed that pricing policy in the form of economic incentive alone is not a sufficient instrument for effecting domestic rice production. An improved policy package that comprises economic, non-economic incentives as well is required.

Domestic high price leads to importation of low price rice. However, there was a significant increase in rice production from 2005 to 2010 mainly due to the increased land area devoted to rice cultivation. Increased production has led to a steady decrease in rice imports (Andrew and Betrina, 2012). In order to allow farmers to fully benefit from higher prices in export markets, the government's initial steps could be investment in non-price projects such as irrigation.

Binswanger(2010) argued that world prices for rice were likely to remain high for about 20 years due to increase in demand for rice from the middle classes of the main Asian producing countries. This is also attributed to yields that are declining in those countries, partly as a consequence of poor management of irrigation. This would be an export opportunity for Tanzania to produce rice competitively if the prices remain high. However, export markets for rice need to be deliberately developed (MAFSC, 2013). From 2005 imports have been subject to a 75% tariff agreed by the East African Community to encourage domestic rice production. The tariff was imposed before international rice prices shot up at the end of 2007. Its impact was to raise prices for consumers and for local producers (URT, 2009).

2.4 Gender Dimensions of Rice Production

Rural women farmers play a vital role in food production and food security. In the rural areas, women form 60 - 80% of the agricultural labour force (URT, 2009). They dominate food production; processing and marketing of foodstuffs. They also account for about 70% of agricultural workers, 80% of food producers, and 100% of those who process basic foodstuffs and they undertake from 60% to 90% of the marketing (Rainer, 2003). They also contribute to household well-being through their income generating activities (Ayoola,

2011; Rahman, 2008). However, women in agriculture face difficulties in accessing the key factors of production such as land, water, credit, capital and appropriate technologies. The traditional land tenure system does not favour women in Tanzania.

Recently Ayoolaet *al.* (2011) examined the performance of male and female farmers in rice farming in the Northern Guinea Savannah of Nigeria, with a view to determining the parameters for promoting gender equity in farmers' access to opportunities for improved livelihoods from rice production. Results indicated that land, variable inputs; greatly influence productivity of rice for both male and female farmers.

Despite the immense contributions of women to agriculture, various studies have reported that women farmers generally, lack access to adequate productive resources such as land, credit, agricultural inputs, education, extension services, and appropriate technology. These include Rahman(2008)and Ayoolaet *al.* (2011).Therefore any strategic interventions to rice supply should consider the gender issues to ensure that women are not left out.

2.5 Mechanization of Rice Production

Approximately 18% of Tanzanian farmers grow rice, 94% of those farmers are smallholders and 6% are large farmers (URT, 2009).Smallholder farmers cultivate an average farm size ranging between 0.9 to 3.0 hectares. About 70% of Tanzania's crop area is cultivated by hand hoe, 20% by ox-plough and 10% by tractor. About 74% of total rice area is under rain fed low land rice mainly under rainwater harvesting, 20% is upland rice and 6% is under irrigation (RLDC, 2009).

Farmers need effective and efficient tools to simplify their activities. In most rural areas farmers are also livestock keepers with the dominant farming equipments such as oxen ploughs. If available, hired power tillers as well as tractors are too few in the localities hence farmers have to wait for long time before getting the services. This results to some farmers missing the proper ploughing and planting period hence suffering the consequences of weather dynamics.

2.6 Fertilizer Production in Tanzania

Various studies on inputs such as fertilizer reported that usage rates are lowest in developing countries. Africa contains 25 percent of the world's arable land, yet represents less than 1 percent of global fertilizer consumption (Kariuki, 2011; Morris *et al.*, 2007).

Kherallah *et al.* (2002) pointed out that some potential reasons for the low fertilizer use rates in Africa were high fertilizer costs among others. Among these potential reasons for low fertilizer use in Africa, high fertilizer costs are the most apparent in Tanzania.

NBS identified that only 9% of farmers use fertilizers regularly in 2008. This figure serves to indicate the very low use of fertilizer in Tanzania that has been attributed by farmers' inability to purchase fertilizer due to financial constraints, poor access to credit, and insufficient understanding of correct usage and its potential benefits due to inadequate information and lack of site specific fertilizer recommendations for different soils in the country.

Fertilizer business in Tanzania is governed by the Fertilizers Act (2009) and the Fertilizers Regulations (2011) for quality control which established the Tanzania Fertilizer

Regulatory Authority (TFRA). There is one private fertilizer manufacturing company that is Minjingu Mines and Fertilizer Limited based in Arusha. Only 10% of fertilizer usage in Tanzania is domestically sourced from Minjingu Mines and Fertilizers limited. The vast majority of domestic fertilizer demand accounting for about 90% is currently met through importation (MAFSC, 2013).

The fertilizer prices are contributed by the tax regime and charges that are defined by the laws and rules of the country. The taxes and other charges are shown in Table 2.

Table 2: Tax and Charge Regime for Fertilizers in Tanzania

S/N	Tax	Percentage/Amount
1	Import duty	0%
2	Custom Wharf Rent - CWR	0%
3	Charges on CIF	1.6%
4	Handling charges	USD 6/ton
5	Value Added Tax – VAT	18%
6	Sumatra fee	USD 0.25 /ton
7	Radiation Commission	0.4% FoB
8	Pre-Shipment Verification of Conformity - PVOC charges (TBS)	0.53% FoB
9	Clearing and Forwarding	3 USD / ton

Source: Tanzania Fertilizer Company TFC, URT (2009)

Taxes and other charges contribute to the high prices of fertilizer even before reaching the farmers. Fertilizers are mainly transported from Dar es Salaam City to market centers mainly by road. This nature of transportation contributes to increased prices of fertilizer at farm level due to high distances from Dar es Salaam to rural farmers. Moreover,

Increase in input prices lead to reduced profits and discourage production as well (Isinika *et al.*, 2005). This problem motivated the government to reintroduce fertilizer subsidies from 2003, although on a limited basis.

According to Druilhe and Barreiro (2012), to increase fertilizer use, countries have several options: decrease the cost of fertilizer; increase the availability of fertilizer; educate farmers on proper application and the benefits of fertilizer.

2.7 Review of Studies on Supply Response

A number of studies have focused on the rice supply response in some countries. The nature of price responsiveness of farmers was investigated in details using different methodologies. Goyari and Ranjan (2013) studied the Supply Response in rain fed Agriculture in Eastern India using a Vector Error Correction Approach. The empirical results revealed that the supply elasticity of rainfall was found to be very high. The vector error correction approach was used to avoid the unrealistic assumption of fixed supply on the basis of static expectation.

Conteh and Gborie (2014) assessed the response of rice farmers to price in Sierra Leone. Using the Nerlovian Adjustment Model, the study reported that the magnitudes of the lagged acreages were found to be positive and highly significant. Regarding lagged actual price for both the rice varieties, the short-run price elasticities were lower than long-run, which is suggesting a long term adjustment of the acreage under the crop (Rao, 2014).

Mesike *et al* (2010) applied the vector Error Correction Model to measure the Supply Response of Rubber Farmers in Nigeria. Preliminary analysis suggested that estimations based on their levels might be spurious as the results indicated that all the variables in the

model were not stationary at their levels. Further results indicated that producers' prices and the structural break significantly affected the supply of rubber. Response of rubber farmers to price were low with an estimated elasticity of 0.373 in the short-run and 0.204 in the long-run due to price sustainability and the emergence of other supply determinants indicating significant production adjustments based on expected prices.

Ogazi(2011) analyzed rice output supply response to the changes in real prices in Nigeria. The Error Correction version of an Autoregressive Distributed Lag model approach (ARDL) to co-integration which provides a feasible application on mixed regresses and permits distinct estimates of both long-run and short-run elasticities were employed. The findings showed that pricing policy in the form of economic incentive alone is not a sufficient instrument for effecting domestic rice farmers' response. An improved policy package that comprises economic, non-price incentives as well as effective transmission mechanism could play a critical role to elicit a better response from rice farmers (Ghatak and Seale, 2001).

Yu and Liu (2012)analyzed the Dynamic Agricultural Supply Response under Economic Transformation in china. The study examined the crop sector by estimating the supply response for major crops using a Nerlovian adjustment adaptive expectation model. The authors estimated acreage and yield response functions and derive the supply response elasticities linking supply response to exogenous factors (weather, irrigation, government policy, capital investment, and infrastructure) and endogenous factors (prices). The study reported that farmers respond to price by both reallocating land and more intensively applying non-land inputs to boost yields. Investment in rural infrastructure, human capacity, and technology are highlighted as major drivers for yield increase. Policy

incentives such as taxes and subsidies prove to be effective in encouraging grain production.

Ernest (2010) estimated supply response coefficients for rice in Cameroon and observed that the rice area grown may increase 1.35% for a 10 percent increase in relative world price to producer price. A 10 percent increase in relative price of substitute maize crop accounts for 1.17 % decline in rice area exploited. Examination of the effects of price, weather and governmental expenditure revealed that in the short-run a 10 percent increase in current government expenditure for agriculture will increase area grown by 1.35% and 1.15 %, respectively. Irrigation could enhance area by 0.74 % for 10 percent increase in irrigation effort. The area supply response coefficients provide important implications for both expansions of local market and land resource availability.

Alhaji, Xiangbin and Yan (2014), conducted a study to measure the contribution of price factor (support price) and non-price factor (fertilizer offtake) towards rice production by employing the Nerlovian adjustment model through ordinary least square estimation technique. The findings suggest that support price has strong significant effects on rice production ($P < 0.05$) fertilizer offtake has shown remarkable influence over rice acreage ($P < 0.10$).

Boansi (2013) assessed the magnitude and effect of various price and non-price factors on rice output in Ghana for the period 1966-2009. Coefficients of the output response were estimated through the Ordinary Least Squares (OLS) and tested for stability and appropriate standard Gaussian properties. Output of rough rice was found to be positively and significantly driven by increases in harvested area, yield, own price and world price of

rice with important indirect effects to producers. It however decreases with unit increases in the price of maize, urea fertilizer and with increasing state involvement in the rice market through nominal rate of assistance.

Parikh (1971) studied farm supply response using the distributed lags model. The price variable was the retail price of wheat in the previous year deflated by a general price index and the weather variable, the rainfall at or preceding the sowing time. He found that wheat farmers were more responsive to weather. This fact can be used to suggest that non price variables play a central role to formulation of effective policies to stimulate farmers towards increased agricultural production.

Most rice supply response studies adopted the Nerlovian model. Variables included to study the rice supply response analysis were own price, price of maize as a substitute crop, weather, irrigation, fertilizer and area under cultivation. The information about these variables allows elasticity of rice supply for the effective formulation of appropriate agricultural policies and helps predict short-run and long-run input changes on production (Yu and Liu, 2012).

Apparently, most supply response studies adopted Nerlovian model and time-series Econometric models. Moreover, Supply response can be examined for broad agricultural aggregates or for single commodities. It is the supply response of specific commodities rather than of broad agricultural aggregates that is of importance for formulation and proper targeting of policies (Faroog *et al.*, 2001).

The single commodity studies followed Nerlovian approach and used time-series data to provide predictions on how specific crops production responds to variations in producer prices.

While supply response of broad agricultural aggregates rather than of specific commodities is important in analysing the supply response to agricultural policy reforms, its results are less applicable in informing policies targeting a specific commodity (Binswanger, 1990).

2.8 Review of Supply Response Models

The theoretical framework to guide analytical methods is based on the concept of supply response in agricultural production. There are broadly two ways developed in the literature to conduct supply response analysis. First, the Nerlovian expectation model sometimes known as Nerlovian direct reduced form approach which facilitates the analysis of both the speed and level of adjustment of actual acreage towards desired acreage.

The second approach is supply function derived from the profit maximizing framework. This is also called indirect structural form approach. The second approach involves joint estimation of output supply and input demand functions. This requires detailed information on all the input prices. According to Mythili (2006) and Sadoulet (1995), the second approach faces some limitations in a situation where the agricultural input markets are not functioning in a competitive environment because profit maximization lacks detailed data about prices of input and output.

Since market structure in most developing countries, is not yet developed and functioning in a competitive environment, the analysis of supply behavior of farmers followed the Nerlovian reduced form model. Furthermore, according to Tripathi (2008) there are two

major approaches to estimation of agricultural supply response and the indirect structural form approach and the direct reduced form approach.

2.8.1 Indirect structural form approach

This approach involves derivation of the input demand function and supply function from the available data. It also includes derivation of the input demand function and supply function from the information relative to production function and individuals' behaviours. This method is more theoretically rigorous but fails to take into account the partial adjustment in production and the mechanism used by farmers in forming expectations which are a foundation of supply response analyses. The approach requires detailed information on all the input prices (Tripathi, 2008). Apparently, this is not the best approach for supply response analysis due to its failure to take into account the partial adjustment and expectation formation which are fundamental in modelling and analyses.

2.8.2 Direct reduced form approach

This approach involves the direct estimation of the single commodity supply functions from time series data. Production in agriculture is not immediate and is dependent on past investment decisions and an expectation meaning that production in any period or season is affected by past decisions. The supply level is a function of current economic conditions, at the time decisions were made as well as the expectation about future conditions (Seay, 2004). The majority of supply response studies fall in this category. The most prominent directly estimated empirical models that have been used in previous studies to model supply response of agricultural crops include; partial adjustment model, co-integration and error correction model.

2.8.3 Partial adjustment model

In this model the supply response is directly estimated by including partial adjustment and expectations formation. This is also known as Nerlovian model (Tripathi 2008). According to Granger (1987), Nerlove's supply response model is called partial adjustment adaptive expectations model. As its name suggests, it is based upon two hypotheses which he made about the area allocation behaviour of the farmers.

First, in expectation hypothesis, that the elasticities of acreage using previous year's relative or deflated prices estimated by his predecessors were too low to explain the real situation of supply programmes in the United States. He stated that one reason for this may be the fact that price lagged by one year has been identified with the price to which farmers react in their acreage allocation decisions. He argued that the agricultural prices are most volatile in the economy and the farmers may find themselves with lower incomes if they revised their production in response to wide fluctuations that take place in the relative price of various crops. Hence, to be rational farmers react not to last year's price, but rather the price they expect.

Further, Nerlove (1958) argued that expected price depends to a limited extent on what last year price was. Hence he added, price expectations are shaped by multitudes of influences, so that a representation of expected price as a function of past prices is a convenient way to summarise the effect of these many and diverse influence.

Second, in the adjustment hypothesis, Nerlove observed that because of techno-economic and socio-institutional constraints faced by the farmers, the actually realized change in acreage in a year is only a fraction of desired change which means the process of the realization of desired change may be spread over a number of years.

Most of the existing studies on the agricultural supply response have applied the Nerlovian method. Nerlovian models are built to examine the farmers' output reaction based on price expectations and partial area adjustment (Nerlove 1958). The natures of Nerlovian models specifications of supply response include partial adjustment and expectation formation (Liu *et al*, 2010). This expressing of gradual adjustment process in the form of partial adjustment model was shown by mathematical programming made in this study.

2.9 Modelling Supply Response using Mathematical Programming

Supply responses of primary producers vary considerably according to the choice of supply response models and the characteristics of the crops analysed. The supply response of individual crops covers perennial and annual/seasonal crops.

Annual/seasonal and perennial crops have different characteristics and present different conceptual problems. Therefore, they require the use of different models.

In this study five different models were identified in the supply response studies of producers of annual crops. These are:

- (i) Simple Koyck distribution lag /simple Nerlovian expectations model
- (ii) Nerlovian expectations model
- (iii) Koyck second order lag model
- (iv) Nerlovian adjustment model
- (v) The expectations adjustment model

2.9.1 Simple Koyck Distribution Lag /simple Nerlovian Expectations model

Koyck(1954) argued that in a dynamic setting the current value of a variable, say Y depends on many lagged values for another variable $X_{t-1}, X_{t-2}, X_{t-3}, \dots$

A general distributed lag function is

$$Y_t = f(X_{t-1}, X_{t-2}, X_{t-3} \dots U_t) \dots \dots \dots (1)$$

Assuming except for the first few coefficients, the coefficients of the distributed lag equation decline in geometric progression in successive periods because it is normally expected that more remote values would tend to have smaller influence than more recent one. Koyck, solved the multicollinearity problem of estimation and obtained the equation (2)

$$A_t = \alpha + \alpha_1 P_{t-1} + \dots + P_{t-k} + \alpha_k \Omega P_{t-(k+1)} + \alpha_k^2 \Omega^2 P_{t-(k+2)} \dots + U_t \dots \dots \dots (2)$$

Where $0 < \Omega < 1$ and when the Koyck model is used in econometric studies, it is usually assumed that k is equal to zero. This would be the traditional Koyck model as applied to supply response studies when there is only one independent variable.

2.9.2 Simple Nerlovian Expectation Model

Nerlove (1958) interpreted the Koyck model in a slightly different way to produce on expectations model, founding the Nerlovian expectations model in linear form of :

$$A_t = a + bP_t^* + U_t \dots \dots \dots (3)$$

where P_t^* is the expected price in period 't'. The assumption is that the rational farmer is more likely to respond to the price he expects rather than to the price of the previous period and the expected price will depend only to a limited extent on the actual price in the previous period. Expressing the expected price in terms of directly observable variable,

$$P_t^* - P_{t-1}^* = \beta (P_t - P_{t-1}^*), 0 \leq \beta \leq 1 \dots \dots \dots (4)$$

where β is the coefficient of expectations. The equation states that for each period the farmer revises the price he expects to prevail in the coming period in proportion to the mistake he made in predicting price this period. This hypothesis of the farmer's price expectations is both plausible and reasonable. On further mathematical treatment, the equation becomes

$$A_t = a_0 + b_0 P_{t-1} + C_0 A_t + V_t \dots \dots \dots (5)$$

Where: $a_0 = a\beta$, $b_0 = bB$, $C_0 = t\beta$, $V_t = U_t - (1-B)U_t$

This is an estimating equation of the Nerlovian expectations model.

Moreover, the complex Nerlovian Expectations Model that postulates different expectation lag coefficients for the expectational variables is more realistic. The expectations hypotheses can be written as:

$$P^*_t - P^*_{t-1} = \beta(P_t - P^*_{t-1}), 0 \leq \beta \leq 1 \dots \dots \dots (6)$$

$$Y^*_t - Y^*_{t-1} = \alpha(P_t - P^*_{t-1}), 0 \leq \alpha \leq 1 \dots \dots \dots (7)$$

Estimating equation whose expectational variables can be written as weighted averages of past values is obtained as:

$$A_t = \alpha_0 + \alpha_{11} P_{t-1} + \alpha_{12} Y_{t-1} + \alpha_{21} P_{t-2} + \alpha_{22} Y_{t-2} + \alpha_{31} A_{t-1} + \alpha_{32} A_{t-2} + W_t \dots \dots \dots (8)$$

Where w_t is a second order difference term and a result of serious estimation problems, complex Nerlovian expectations model which assumes different expectation lag coefficients for expectational variables is seldom used. On the other hand, such model which assumes unrealistically identical expectation lag coefficients is often employed.

2.9.3 Koyck Second Order Lag Function

This model assumes a second order lag function for the dependent variable and can be written as: $A_t = aP_{t-1} + bA_{t-1} + cA_{t-2} + U_t \dots \dots \dots (9)$

This is the simplest generalisation of the Koyck model. The use of a two-period lag for the dependent variable is based on the observation that peak response takes place after a time-lag of two periods. The farmer may be traditionally slow in responding or institutional factors may force him to delay his responses. The subsequent transformation of the two-period lag into a one-period lag is based on the assumption that once the process is started the farmer's resistance to change and the institutional constraints are progressively

reduced. Because of serious estimation problems, the Koyck second-order lag model is seldom used in econometric studies on supply responses. Among other researchers, this model was used by Parikh (1971) to Farm Supply Response analyses.

2.9.4 Nerlovian Adjustment Model

In its simplest form, with one determinant and the assumption of a linear relationship, the model can be presented in the following way: $A^*_t = a + bP^*_{t-1} + U_t$ (10)

$$A_t - A_{t-1} = \beta (A^*_t - A_{t-1}); 0 \leq \beta \leq 1$$
..... (11)

A^*_t is the acreage farmers would plant in period t if there were no difficulties of adjustment. As A^*_t is unobservable, equation (10) cannot be estimated. Therefore assuming that acreage actually planted in period t equals acreage actually planted in period t-1 plus a term that is proportional to the difference between the acreage farmers would like to plant now and the acreage actually planted in the preceding period, hypothesis (11) is made.

Technological or institutional factors prevent the intended acreage from being realised during the period and the parameter (β) is called the acreage adjustment coefficient. Expressing A^*_t in terms of directly observable variables estimating equation is

$$A_t = a_0 + b_0 P_{t-1} + c_0 A_{t-1} + U_t$$
 (12)

Where, $a_0 = ab$, $b_0 = \beta b$, $c_0 = 1 - \beta$, $V_t = \beta U_t$

Additional determinants can be very easily incorporated into the estimating equation. As already discussed, Nerlovian model is flexible to include price and non-price variables. Moreover, the Nerlovian adjustment model is supposed to reflect technological and/or institutional constraints which allow only a fraction of the intended acreage to be realised during the period t while the Nerlovian expectations model is supposed to reflect the way

in which past experience determines the expected prices and other expectational variables which in turn determine the acreage planted.

2.9.5 Expectations - Adjustment Model

Ideally a model of supply response should incorporate a separating lag coefficient for each expectational variable and a different adjustment lag coefficient. This model of supply response is more realistic than the one which assumes either only the expectational or the adjustment element:

$$A^*_t = \alpha P^*_t \dots\dots\dots (13)$$

$$P^*_t - P^*_{t-1} = \alpha_1 (P_t - P^*_{t-1}), \quad 0 \leq \alpha_1 \leq 1 \dots\dots\dots (14)$$

$$A_t - A_{t-1} = \alpha_2 (A^*_t - A_{t-1}), \quad 0 \leq \alpha_2 \leq 1, \quad \alpha_2 + \alpha_1 = 1 \dots\dots\dots (15)$$

The solution to this three equations model will yield the complicated Equation (estimable model) in which it is not possible to isolate α_1 and α_2 . This model of supply response is more realistic than one which assumes either only the expectational or the adjustment element.

It is not possible α_1 and α_2 in such a complicated equation to isolate the effects of changes in factors which bring about changes, firstly in the coefficient of expectation and secondly, in the coefficient of adjustment. Nerlove suggested a way of getting round this weakness and obtained the equation:

$$A_t = \alpha_1 \alpha_2 P_{t-1} + [(1 - \alpha_1) + (1 - \alpha_2)] A_{t-1} - (1 - \alpha_1) (1 - \alpha_2) A_{t-2} \dots\dots\dots (16)$$

If either α_1 or α_2 is equal to one, the term A_{t-1} can be eliminated from the estimating equation.

Apparently, Nerlove's formulation of agricultural supply response is one of the most widely used applied econometric models in the empirical studies. Time series data were often used for the commodity under study to capture the dynamics of agriculture

production over time. For example, the studies by Goyari and Ranjan (2013), Conteh and Gborie (2014) and Yu and Liu (2012) are few among others.

2.10 Time Series Models

A time series is a sequence of data points, typically consisting of successive measurements made over a time interval. Time series models are of special interest in econometrics because they are often used for forecasting (Halcooussis, 2005). The models use the past to predict the future. Available historical data are used to make the best guess about the future. A time series variable can be used to observe the same variables over time (Halcooussis, 2005). Unlike in cross sectional data where variables are observed at a particular point in time, observations for time series data are made through time. The influence of the independent variable is spread out or distributed across several time periods, hence the distributed lagged models. A distributed lag model is a model in which the independent variable(s) appear in a regression with different time lags (Halcooussis, 2005). Predicting the future is not simple no matter how good one is at econometrics. Thus econometric forecasts are far from perfect. Time series econometricians usually encounter a number of problems; 1) the fact that variables can influence one another with a time lag. 2) Variables are often non stationary i.e. they tend to depict a particular trend over time, usually a rising trend, this is always a challenge of time series data analysis and 3) when measuring economic variables using monetary values, price fluctuations tend to distort the data.

2.10.1 Stationarity of variables

A time series variable is called stationary if it does not have an upward or downward trend over time. For a series to be stationary, its mean, variance and autocorrelation pattern must

remain the same over time (Halcoussis, 2005). A time series variable that does not meet these criteria and exhibits a trend over time is called nonstationary.

A non-stationary variable causes misleading results. It will seem as if the regression has much better goodness of fit than it really does, and the non-stationary variable will seem to have a greater impact in the regression than it really does. When a regression has a very strong goodness of fit and significant t-statistic because of a trend or other fact not accounted for in the model, it is often referred to as a spurious regression or correlation (Halcoussis, 2005). This anomaly can be rectified by the use of a method known as differencing, which attempts to de-trend the data to control autocorrelation and achieve stationarity by subtracting each datum in a series from its predecessor. The tests available to diagnose for stationarity are Durbin-Watson, Dickey- Fuller and Augmented Dickey-Fuller(Gujarati, 1995).

2.10.2 Autocorrelation

Autocorrelation also called serial correlation occurs when observed errors follow a pattern so that they are correlated (Leaver, 2003 and Wasim, 2005). The most common type of autocorrelation, first-order autocorrelation, is present when observed error tends to be influenced by the observed error that immediately precedes it in the previous time period (Leaver, 2003). According to Waism (2005), whenever a lagged value of the dependent variable appears as a regressor in an estimating relationship, we have a case of autoregression. This suggests that, the lagged dependent variable cannot be independent of the entire disturbance term because the dependent variable is in part determined by the disturbance term. Moreover according to Gujarat (1995) the lagged dependent variable is

correlated to all its past disturbances; however, it is not correlated to the current or the future disturbances.

2.10.3 Multicollinearity

If one independent variable is a linear function of another, then when one changes value so does the other (Halcooussis, 2005). This condition is known as multicollinearity. Ordinary Least Squares (OLS) assumes that no independent variable is a linear function of another. Independent variables that exhibit multicollinearity contain similar information and tend to move together, and the OLS procedure finds it difficult to estimate their slope coefficients (Halcooussis, 2005). Economics tells us that many factors in different markets and different parts of the economy affect each other, so most regressions always display some degree of multicollinearity (Halcooussis, 2005). According to available literature the most common methods of measuring multicollinearity are; the use of the correlation coefficient which should not exceed 0.8 and the Variance Inflation Factor (VIF) which should not have a coefficient value exceeding 4.

2.10.4 Co-integration techniques

What do you do when the time series data are non-stationary? The methodology of Cointegration and Error Correction Model (ECM) are favoured over the ordinary least square (OLS) estimation method of Nerlovian framework. The OLS technique uses the time series data which are very often suspected to be non-stationary since most of the economic time series data have unit root problem. Therefore, it is biased and the studies employing this mechanism have mostly found low values, sometimes even zero for long-run elasticities (Awosola *et al.*, 2006). So the statistical significance of t-test and F-test loses relevance. The advanced time series methodology of Cointegration can be used with

non-stationary data to avoid spurious regression (Banerjee *et al.*, 1993). Conducting a cointegration analysis is a straightforward way to overcome the restrictive dynamic specification of the Nerlove-model. This method does not impose any restrictions on the short-run behaviour of variables. It only requires a stable long-run equilibrium relationship, which formally implies that there exists a linear combination of variables that is stationary even though each single variable may be non-stationary. Further, cointegration analysis with panel data increases the power of cointegration tests compared to pure time series (Rapach, 2012).

When combined with cointegration, the ECM, considering the partial adjustment and adaptive expectation of farmers which are fundamental in the analysis of agricultural supply response, gives distinct long-run and short-run elasticities among variables (Townsend and Thirtle, 2010). Moreover, the partial adjustment model is nested within the error correction mechanism. Steps are briefly explained below:

First, the data series for each variable is tested for stationarity by using Augmented Dicky-Fuller (ADF) statistics and the lag length is chosen by the Akaike Information Criterion (AIC) that ensures the residual is empirically white noise. The regression equation for ADF is expressed as follows:

$$\Delta Y_t = U_0 + U_1 t + (\delta - 1)Y_{t-1} + \sum_{i=1}^k \psi \Delta Y_{t-i} + V_t \dots \dots \dots (17)$$

Where, V_t is pure white noise error term and k is chosen lag length. If H_0 is rejected statistically then the series (Y_t) is stationary. If not, the first difference is taken to make it stationary. Testing for stationarity is necessary to determine whether the model follows a ‘Differenced Stationary Process’ (DSP) or a ‘Trend Stationary Process’ (TSP). The

distinction between DSP and TSP is important since variables following different stationary processes cannot be co-integrated (Tzouvelekas *et al.*, 2001). Once the stationarity of individual series is established, the linear combinations of integrated series are tested for cointegration. If they are cointegrated, it implies a longrun equilibrium relationship. The cointegration analysis is carried out by applying Johansen test.

The co-integration method has been used in agricultural supply response analysis in other countries by a number of researchers, namely; Townsend *et al* (1997), Schimmel *et al* (1996) and Thiele (2000). One major use of the co-integration technique is to create long-run equilibrium relationships between variables.

2.10.5 Johansen Method of Cointegration

To test for cointegration, two main approaches have been developed: one involves the estimation of a static model where all variables enter in levels (Engle and Granger, 1987), and the other involves the estimation of an error correction model (Johansen, 1988). The Johansen procedure is preferred over the Engle-Granger approach for two major reasons. First, in the multivariate case it avoids the identification problems one may encounter with the Engle-Granger approach if there is more than one co-integrating vector. Second, the Dickey-Fuller test employed to test for cointegration in Engle Granger regressions too often rejects the existence of equilibrium relationships (Rahji, and Fakayode, 2008). The first problem may be resolved at least partly by applying a cointegration analysis with panel data.

Johansen (1988) and Juselius (1992) mechanism of cointegration in a multivariate framework is a form of VECM where only one cointegrating vector exists. Its parameters can be interpreted as the estimates of long-run relationship between the variables

concerned. Suppose that Y_t is an $(n \times 1)$ vector of non-stationary $I(1)$ variables, then the unrestricted vector auto regression (VAR) of Y_t up to 'k' lags can be specified as:

$$Y_t = K + \sum_{i=1}^k \Pi_i Y_{t-i} + V_t, \quad t=1,2,\dots,T \dots\dots\dots(18)$$

$\Pi_i = n \times n$ Matrix parameter that measures the long-run effect of the respective lag levels of Y on its current level and V_t is an identically and independently distributed n -dimensional vector of residuals. The first-difference of equation (8) is used to formulate the error correction representation of Y_t as:

$$\Delta Y_t = \gamma \Delta Y_{t-1} + \dots + \gamma_k \Delta Y_{t-k+1} + \Pi Y_{t-k} + U_t$$

Where; $\gamma_i = (1 - \Pi_1 - \dots - \Pi_i)$; $i=1,2,\dots,k-1$, $\Pi = -(1 - \Pi_1 - \dots - \Pi_k)$

$\Pi = n \times n$ is an $(n \times n)$ coefficient matrix for the variables

$U_t = n \times 1$ Column vector of disturbance terms

The estimates of γ_i and Π provide the information regarding the short-run and long-run adjustments to the changes in Y_t respectively. The cointegration analysis primarily tests the impact matrix to gather information on the long run relationship(s) among variables contained in the Y_t vector. If the rank of Π matrix (r) is equal to zero, the impact matrix is a null vector thereby implying that there is no cointegration. If Π has a full rank (i.e., $r = n$), then the vector process of Y_t is stationary. It implies that there is no problem of spurious regression and the appropriate modelling strategy is to estimate the traditional VAR in levels. Once the co integration among the variables is established, the ECM is used to analyse the short-run and long-run dynamics in the model. Cointegration analysis allows nonstationary data to be used so that spurious results are avoided. It also provides applied econometricians an effective formal framework for testing and estimating long-run models from actual time-series data (Tzouvelekas *et al.*, 2001).

2.10.6 Vector error correction mechanism

According to Goyari *et al.* (2013), Error Correction Mechanism (ECM) has two distinct characteristics: first, it is dynamic in the sense that it involves lags of the dependent and independent variables; it thus captures the short-run adjustments to changes of particular adjustments into past disequilibria and contemporaneous changes in the explanatory variables (Chinyere, 2009). Second, the ECM is transparent in displaying the cointegrating relationship between or among the variables.

Deaton (2003) argued that the coefficients of lagged explanatory variables give an indication of short-run adjustments. The coefficient of Error Correction Term (ECT) must be negative and significantly different from zero. The negative value implies that if there is a deviation from the current and long-run levels, there would be an adjustment back to long-run equilibrium in subsequent periods to eliminate the disequilibrium (Awosola *et al.*, 2006).

2.11 Review on Area as the Proxy Variable for Output

There is a great deal of disagreement in the literature on what the precise measure of output is. The three choices for measuring output are the acreage under cultivation, production or yield per unit area, and total production in terms of weight or tonnage produced (Mshomba, 1989). Some researchers claim that area under the crop could be a better proxy for the planned output. They argue that area statistics are not only readily available and more dependable but also least influenced by external factors.

Rao (2003) indicated that, the choice of the proxy employed influences the results of the study. Most time series studies for particular crops use acreage as the proxy for output.

while Belete (1995) postulated that, acreage is mostly used as a proxy for output because acreage is thought to be more subject to the farmers control than production output, Mythili (2008) hypothesized that acreage response underestimates supply response and farmers respond to price incentives partly through intensive application of other inputs given the same area, which is reflected in yield.

However, Most supply response studies favoured area. Some of the researchers who favoured area responses are; Nerlove (1958), Belete (1995), Muchapondwa (2009), Leaver (2003) and Rao (2003). Output is measured in terms of crop weight or volume produced or marketed, which can be better expressed in terms of planted acreage than harvested tonnage (Askari and Cummings, 1977).

Kanwar (2004) studied the supply response of major oilseed crops in India. The results showed that an increase in the price of oilseeds was correlated to increased acreage rather than an increase in production output. Based on these facts, the present study used area as a dependent variable.

2.11.1 Price Variables

Agricultural supply depends on prices of both output and input. According to Muchapondwa, (2009), price is the most important determinant of supply. This idea is in line with the free market theory that, if the output prices increase the profit increase and that motivates producers to produce more. Similarly, an increase in input prices leads to increase in production costs that depress supply.

Agricultural pricing policy plays a key role in increasing both farm production and incomes and is fundamental to an understanding of this price mechanism in supply response (Rao, 2003). Nevertheless, the price variable remains a debatable issue among

various supply response researchers. The main question as to which price (the pre-sowing prices, the post-harvest prices, the annual average prices, the absolute prices or the relative prices), influences the farmer's decision-making process remains unanswered. This fact suggests that Variables should be selected based on economic theory for meaning supply response analysis.

According to Rao (1989), the price variable used is usually a measure of relative prices; prices paid relative to prices received; output prices relative to input prices or crop price relatives. These are alternative measures of incentives and the choice among them is often dictated by the availability of reliable price data. Farm prices are an important determinant of farm incomes which in turn affect the farmers' ability to increase the quantity and improve the quality of resources available to him.

Maulda (2010) introduced the producer price of maize lagged by one period, as an explanatory variable in the supply response equation. This is justified by the fact that farmers are assumed to take past price experience into account when forming their production expectations (Seay *et al.*, 2004).

2.11.2 Supply shifters variables

Most researchers in the field of supply response included rainfall variable to capture variations in weather (Parikh, 1971). Weather was found the factor which influences farmer's decisions to land allocation. However, it was not the total annual rainfall that was important, but the rainfall received during the production months was relevant. This was so because, it was felt that favourable moisture conditions during production period would encourage farmers to bring more area under cultivation of the crop in question

(Singh, 1998). Therefore, the average rainfall received in the six production months was considered in the present study (October, November, December, January, February and March) was used in the hectare response model as a proxy for the weather factor.

Based on the literature, Non-price factors seem to dominate price factors in farmers' decision-making (Rao, 2003; Mythili, 2008; Askari and Cummings, 1977; and Gulati and Kelly, 1999). Generally, the non-price factors were found to be more supply responsive than price variables. This fact has most importation policy implications to stimulate rice producers in Tanzania. However, no study has been conducted to test this hypothesis. Therefore, the present study was conducted to fill this gap.

Nerlovian model which is the famous and successful econometric model in agricultural supply response analyses was applied in this study. Nerlove's adaptive model and partial adjustment model guided much of the empirical analysis. The single commodity studies followed Nerlovian approach and used time-series data to provide predictions on how specific crop production will respond to variations in producer prices. This is important for formulation and proper targeting of policies than broad agricultural aggregates. Supply response of broad agricultural aggregates is important in analysing the supply response to agricultural policy reforms (since these reforms have a significant impact on the entire economy). But its results are less applicable in informing policies targeting a specific commodity.

2.12 Conceptual Framework

The conceptual framework is a useful guide which shows the relationship between context, dependent and independent variables. Problem statement as it describes both contextual and local environments. Figure 1 shows conceptual framework.

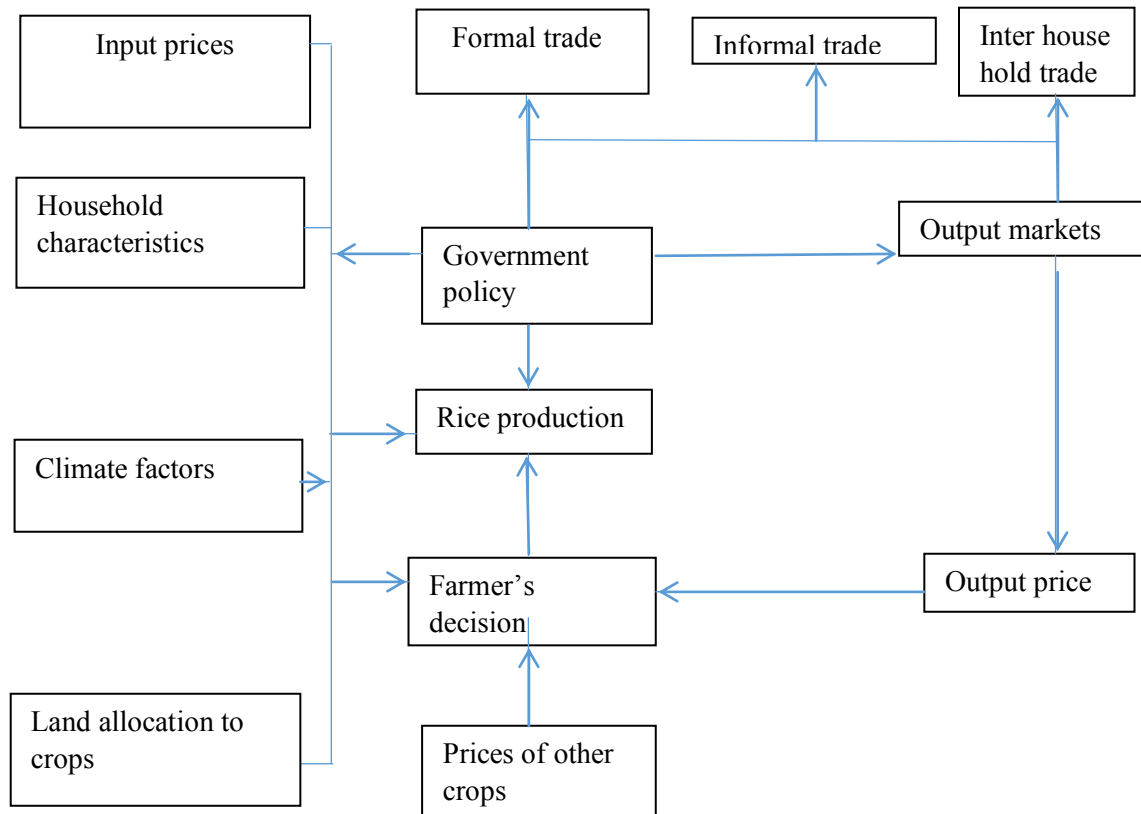


Figure 1: Factors influencing smallholder farmers' decision in rice production

Source: Adopted from Phiko (2014).

Figure 1 shows the framework for farmer's response to price and non-price factors. It can be seen that the formal trade, informal trade and inter-household trade form the rice output market. The output market will influence the output prices which are also largely affected by government through policy intervention (Akanni and Okeowo, 2011). Government policy through subsidies also affects the agricultural input prices which in turn affects farmers' decision towards production of rice. Government policy also affects formal trade through export and import bans/or tariffs. Moreover, land policy also affects the amount of land allocated to specific crops. Prices of other crops influence the farmer's decision of whether to invest in rice or not since the farmer is eager to invest in other crops which might be perceived as more profitable than rice. In turn the farmers' decision affects the

amount of land and labour allocated towards maize production. Household characteristics affect the farmers' decision to invest in rice and physical conditions such as weather contribute to rice productivity.

This reflects the adaptive expectation approach where by the response of producers to produce more or less depends on how prices are set by the markets. The choices are made to become producers or suppliers, to produce more today than yesterday. The high supplies today depend on prices in the past, today and the prices tomorrow.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Research Design

The study employed the longitudinal design as it utilized data collected at many times inquiry. The Study was based on the secondary time series data covering the period of (1999-2008).

3.2 Description of the Study Area

This study covered the whole country basing on high paddy producing regions in Tanzanianamely Mbeya,Mwanza, Morogoro, Shinyanga and Tabora.Tanzania has a total area of 94.5 million hectares of land, out of which 44 million hectares are classified as suitable for agriculture. It is estimated that about 21 million hectares are suitable for rice growing. In 2008, area under rice production was 675 thousand hectares (URT, 2009).The land belongs to the Government. Land ownership is under the respective villages/districts and governed by the Village Act No.5 of 1999, which recognizes customary rights. However, the village governments under the Local Government Authority are the ones responsible for allocation of the land for various uses.

The population is approximately 44 million people by 2014, with 45 percent of the population under 15 years of age and annual population growth rate is 2.8 percent (URT, 2009).

3.3 Location and Population

Tanzania is located in East Africa. It lies on the east coast of Africa, between 1degree and 11degrees south of the Equator.It consists of the mainland and a number of offshore

islands including Zanzibar Mafia and Pemba. Its borders include Kenya and Uganda to the north, Zambia, Malawi, and Mozambique to the south, Rwanda, Burundi, and Congo to the west, and the Indian Ocean consists the eastern border, with 800 km of coastline. Tanzania is Africa's 13th largest country and the 31st largest in the world. It covers an area of 945000 sq.km.

Tanzania is the only country in the world which has allocated at least 25 per cent of its total area to wildlife national parks and protected areas. The total protected area is equivalent to the size of the Federal Republic of Germany and Belgium combined. The 55 000 sq. km Selous Game Reserve, the largest single wildlife area in Africa, is bigger than Belgium, Costa Rica, Denmark, Burundi, Israel, Lesotho and Kuwait.

Tanzania's economy relies mostly on agriculture, employing 80% of the workforce. The GDP annual growth rate is 7% (MAFSC,2013).However, the economy is still suffering from slow growth and a shortage of foreign exchange, and agriculture, in particular, from poor availability of credit and equipment. The majority of Tanzanians are subsistence farmers.

Tanzania has one of the fastest growing urban populations in East Africa, rising 2.7% per year, currently population is 44.9 million. The growing middle class prefer rice over other staples. In Central Corridor, Rice is extensively produced in the three regions Tabora, Shinyanga and Morogoro where there are more favorable growing conditions. Manyara, Singida and Dodoma have some supplementary production in their low lands. Rice is a predominantly important crop in Central Corridor; 48 % of rice cultivated land in Tanzania is found in the CC (RLDC, 2009).The investors can use the advantage of the

growing gap in rice supply and demand by investing in rice production to serve the rapidly growing market in Tanzania.

3.4 Climate and Agro-ecological Zones

The climate of Tanzania is diverse due to the presence of tropical agro-ecological zones that support both lowland and upland rice. Most of the lowland rice is irrigated whereas the upland one is rain fed. Due to climate change and ever changing rainfall patterns, Tanzanian government has invested a lot of efforts in irrigation infrastructure building (URT, 2009). The success of these irrigation schemes depend well on the permanent water sources such as river basins. Because Tanzanian rainfall pattern is both unimodal and bimodal this affects not only weather, supply and demand of the consumed rice but also the supply responses. Irrigation practice is regarded as one of the effective approaches offering prospects for expanding total cultivated area, increasing and stabilizing food and cash crops, extending growing seasons as it reduces the impacts associated with variability of rainfall (temporal and spatial rainfall availability) and temperature hence ensuring stable and higher food security with and without climate change (Kumar, 2011 and Fleischer,2007).

3.5 Sampling Procedures and Sample Size

The present study covered the whole country. Thus the sample size was not an issue. However, most of the data were based on the rice high producing regions namely Tabora, Shinyanga and Morogoro, Mwanza and supplementary production in Manyara, Singida and Dodoma.

3.6 Data Collection Methods and Sources of Data

The study used secondary time series data obtained from the Government institutions such as Tanzania Meteorological Agency (TMA), National Bureau of Statistics (NBS),

Ministry of Agriculture, Food and Cooperatives, various reports from publications including journal articles and reports were accessed. This is due to the fact that additional information from different perspectives was needed to enrich the study. The study employed quarterly data covering the period 1999-2008 obtained from the Ministry of Agriculture and Food Security.

3.7 Limitation of the Data

Secondary data access was a major challenge because the responsible ministry could not easily respond to the data requested. Yet, there was normally many missing data. The present study was limited to the data for few variables and duration (rice price, maize price, fertilizer, rainfall for 1999-2008). Insufficient data may pose limitations in terms of inclusion of both duration and required variables for the study. Some data on variables such as credit and labour were not included although they were important in the study.

3.8 Theoretical Frame Work

The study was based on the Nerlovian theory. Generally, agricultural supply response is based on two identified frameworks, Nerlovian expectation model and profit-maximizing approach. While the former captures the dynamics of agriculture by incorporating price expectations and /or adjustment costs; the later involves joint estimation of output supply and input demand functions (Mythili, 2008). In contrast to the Nerlovian model, the profit maximizing approach requires detailed information on the quantities and input prices, which is not available for the present study.

Based on this, the present study employed Nerlovian expectation model as a framework to model rice supply response in Tanzania. However, Thiele (2000) argued that a fundamental methodological weakness of the Nerlovian model comes down to the

assumption that production adjusts to a fixed target supply, after which actual supply adjusts. But this assumption has been found to be unrealistic under dynamic conditions of Nerlovian model, unless with stationary model.

In this regard, Thiele (2000) argued further that estimating Nerlovian method is unlikely to capture the full dynamics of supply response, thus biasing elasticity downwards. Besides, since most economic time series used for estimating Nerlovian model often exhibit non-stationary tendencies, it means estimated output supply elasticities based on nerlovian model are likely to be subjected to danger of spurious regression outcome. Therefore an alternative approach to Nerlovian method to overcome the limitations mentioned above is to employ cointegration analysis as noted by Thiele (2000). This approach was used in the present study.

Moreover, the supply model used in this particular study is based on economic theory and previous work done in the field of supply response by Belete (1995), Leaver (2003) and Mythili (2008). It is not always possible to estimate a model suggested by theory, because it is not always possible to include all the variables initiated by theory due to the non-availability of data and quantification problems. There had been several successful studies that used econometric models to estimate elasticities, estimators developed from ancient Nerlovian model based on Supply response Functions.

The supply curve shows the relationship between price and quantity Supplied on the assumption that other determinants of supply are held constant. These other determinants are rainfall, fertilizer prices of competing crops, wages etc. When the 'ceteris paribus' assumption is not met then there will be shifts in the supply curve.

The supply function is indicated by equation 19:

$$Y = f (Pr_{t-1}, EPr_t, Pm_{t-1}, EPm_t, Z_t, U_t) \dots\dots\dots (19)$$

Where:

Y = Area under rice cultivation in hectares

Pr_{t-1} = is the Price of 100 kilograms of rice at a previous year in TZS

EPr_t = is the expected Price 100 kilogram of Rice at a current year in TZS

Pm_{t-1} = is the Price of 100 kilograms of maize at a previous year in TZS

EPm_t = is the expected Price 100 kilogram of Maize at a current year in TZS

Z_t = is set of exogenous variables like climate and institutional factors or non-price actors.

The simple supply equation is: $S_t = a + bP_t + U_t \dots\dots\dots (20)$

Where, S_t = quantity supplied in period t, P_t = price in period t, U_t = Error in period t

a and b = Constant parameters.

The following type of relationship should form the basis for the analysis. -

$$S_t = a_0 + a_1 P_t + a_2 P_t + a_3 R_t + a_4 W_t + U_t \dots\dots\dots (21)$$

where: P_t = Index of prices of competing crops in period t, W_t = the wage rate in period t

R_t = Rainfall in period t, a_0, a_1, a_2, a_3, a_4 = Constant parameter, S_t, P_t and U_t as previously defined.

The choice of the other determinants of supply depends on the characteristics of the production schedule of each crop or product. It is to be further noted that these characteristics may even change in the same country or locality over time. What therefore, needed is a comprehensive supply model which can incorporate the various alternative opportunities open to the farmer.

For this study, the proposed model is elucidated by utilizing Nerlovian model, which defines the changing aspects of agricultural supply by incorporating price expectations and the adjustment costs. Hence, the functional model can be stated as:

$$A_t = \alpha_1 + \alpha_2 P_t^* + \alpha_3 Z_t + U_t \dots\dots\dots(22)$$

where, Z_t represents supplementary exogenous factors and U_t is an error term. As the expected price (P_t^*) is unobservable, the expectations are presumed to follow:

$$P_t^* - P_{t-1} = \lambda(P_{t-1} - P_{t-1}^*), \quad 0 \leq \lambda \leq 1$$

.....(23) Where: P_t^* = Expected relative price at t,

P_{t-1}^* = expected relative price at t-1,

P_{t-1} = actual price in previous year, t-1 λ = Adjustment coefficient, P_t indicates real price at time t.

Moreover, (23) suggests that cultivators adjust their expectations of future price with regard to previous experience, and that they can learn from their past blunders. Substituting (23) into (22) and simplifying gives:

$$A_t = \lambda\alpha_1 + \alpha_2\lambda P_{t-1} + \lambda\alpha_3 Z_{t-1} + (1-\lambda)U_{t-1} + V_t \dots\dots\dots(24)$$

Where, $V_t = U_t - (1-\lambda)U_{t-1}$

Hence, from (24), it can be seen that the current year expected price is a proportion of both last years' expected and actual price. Consequently, price expectations are weighted moving average of past prices in which the weights decline geometrically.

Equation (24) is the adaptive expectation model. Bearing in mind that the partial adjustment model with the supposition that the desired area A_t is actually a function of price (P_t) as well as other exogenous factors (Z_t):

$$A_t^* = \alpha_1 + \alpha_2 P_t + \alpha_3 Z_t + U_t \dots\dots\dots(25)$$

Since the desired area under cultivation was unobservable the partial adjustment (PA) hypothesis becomes: $A_t - A_{t-1} = \pi(A_{t-1}^* - A_{t-1}), 0 \leq \pi \leq 1$(26)

where, π is the estimated rate of area adjustment coefficient between desired and actual area in the previous time. If π tends to 0, area remains constant from one year to the other, and if $\pi = 1$, then, adjustment is immediate. Characteristically, adjustment to the desired level is possible to be imperfect due to physical and institutional limitations, fixed capital. It is significant also that, offers the relationship between the short and long-run elasticities. Substituting (26) into (25) gives the partial adjustment model

(PAM) model, which is:

$$A_t = \pi\alpha_1 + \pi\alpha_2 P_{t-1} + \pi\alpha_3 Z_{t-1} + (1-\lambda)A_{t-1} + \pi U_t \dots\dots\dots(27)$$

Combining (22) and (25) gives: $A_t^* = \alpha_1 + \alpha_2 P_t^* + \alpha_3 Z_t + U_t \dots\dots\dots(28)$

where the desired area level (A_t^*) as well as expected price (P_t^*) are unobservable. Substituting (23) and (25) in (28) and simplifying, reduces the system to the estimating (29).

$$A_t = \pi\alpha_1 + \pi\alpha_2 P_{t-1} + \pi\alpha_3 Z_{t-1} + (1-\lambda)A_{t-1} + \pi U_t \dots\dots\dots(29)$$

Where: $\beta_0 = \lambda\pi\alpha_1, \beta_1 = \lambda \pi \alpha_2, \beta_2 = (1-\lambda) + (1-\pi), \beta_3 = -(1-\lambda)(1-\pi), \beta_4 = \pi \alpha_3$
 $, \beta_5 = -\pi \alpha_3, V_t = \pi U_t - \pi(1-\lambda)U_{t-1}$

Therefore the estimable form of Nerlovian model is given by equation:

$$A_t = \beta_0 + \beta_1 P_{t-1} + \beta_2 Z_{t-1} + V_t \dots\dots\dots(30)$$

The values of adjustment and expectational coefficients obtained through manipulation of the coefficients of lagged dependent variables will enable to find out, whether farmers adopt the expected price or adjust the desired area in allocating acreage under individual crops. The model specification was built based from the foundation of the above theories.

3.9 Model Specification

3.9.1 Nerlovian Model

The present study adopted the Nerlovian model approach in modelling the determinants of rice supply in Tanzania. The choice of the model was based on the reason that the market structure in Tanzania is not yet developed and functioning in a competitive environment whose analysis requires profit maximization function.

Among other features, this model is built to examine farmer's output reaction based on price expectation and partial adjustment which are the foundations of the present study. The pioneering work of Nerlove (1958) on supply response also enables one to determine short run and long run elasticities. The Nerlovian supply response approach has the flexibility to introduce non-price production shift variables into the model. According to Nerlove (1958), desired output can be expressed as a function of expected price and supply shifters. According to Kirti and Goyari (2013), the significant feature of the model specification used in the study is that it addresses the endogeneity problem by capturing different responses to own- and cross-prices.

The model is expressed as a desired yield of a crop in year t and is a function of expected relative prices P and exogenous shifters Z written as:

$$Y_t^* = \alpha_1 + \alpha_2 P_t^* + \alpha_3 Z_t + U_t \dots\dots\dots(31)$$

Where;

Y_t^* = desired cultivated area in hectares in period t.

P_t^* = Expected relative price of the crop and other competitive crop in year t.

Z_t = Sets of exogenous variables say a set of supply shifters such as technology change, weather condition, institutional factors.

U_t = Unobserved random factors affecting area cultivated in year t

The model describes the dynamics of rice production supply by incorporating price expectations and α_i ($i=1, 2, 3$) are long run coefficients to be estimated, essentially α_2 is the long run coefficient of supply response.

However, due to technological and institutional constraints the partial adjustment is crucial. Farmer's response is constrained by factors like small land, credits, lack of inputs, weather conditions (Maulda, 2010). Therefore full adjustment in the desired position in a short period subject to the constraints are required. In order to capture this possibility, the Nerlovian model assumes that the change in yield between two periods occurs in proportions to the difference between expected output for current period and actual output in the previous period. The mathematical model can be written as illustrated in equations.

$$Y_t - Y_{t-1} = \delta(Y_t^* - Y_{t-1}) \quad , 0 \leq \delta \leq 1 \dots\dots\dots (32)$$

$$Y_t = \delta Y_t^* + (1 - \delta)Y_{t-1} \dots\dots\dots (33)$$

Equation (32) postulates that at any particular time period t , only a fixed fraction of the desired adjustment is accomplished. Where, δ is fraction that measures the speed of adjustment, and $(Y_t^* - Y_{t-1})$ is amount of adjustment. The idea is that the current level of y_t , will move only partially from the previous position, y_{t-1} , to the target level. The smaller the value of δ the greater the adjustments lag.

Furthermore, due to uncertainty and discounting of current information the future is not fully predictable. Price that farmers expect at harvesting time is unobserved thus one has to form expectation based on actual and past prices. Farmers form expectations about what will happen in the future based on what has happened in the past. Modelling expectations is crucial in all models which study how a large number of individuals, firms and

organizations make choices under uncertainty. In the Nerlovian model a farmer services his expectations by some portion of the extent by which his expectation in the past period differ from actual one (Lahiri and Roy, 1985).

The farmers' expected price at harvest time can be observed. So, we have to formally define how decision-makers form expectations built on the knowledge of actual and past price and other observable information. We assume that rational farmers maintain in their memory the magnitude of the mistake they made in the previous period and learn by adjusting the difference between actual and expected price in t-1 by a fraction (Tripathi, 2008).

One simple version of adaptive expectations is stated in equations 34 and 35

$$P^*_t - P^*_{t-1} = \lambda(P_t - P^*_{t-1}) \quad 0 \leq \lambda \leq 1 \dots\dots\dots(34)$$

$$P^*_t = \lambda P_{t-1} + (1 - \lambda)P^*_{t-1} \dots\dots\dots(35)$$

Where;

P^*_t = Expected relative price at t; P^*_{t-1} = expected relative price at t-1

P_{t-1} =actual price in previous year; λ = Adjustment coefficient. Its value lies between 1 and 0; If $\lambda = 1$, expected current is equal to previous year actual price. If $\lambda = 0$, means that there is no difference between the current year's expected price and previous' year actual price. Equation (34) suggests that cultivators adjust their expectations of future price with regard to previous experience, and that they can learn from their past blunders.

Now unobserved variables P^*_t and Y_t^* are eliminated by substituting (31) and (35) into (3) Then by some algebraic manipulation the estimable reduced form model becomes:

$$Y_t = \beta_1 + \beta_2 P_{t-1} + \beta_3 Y_{t-1} + \beta_4 Y_{t-2} + \beta_5 Z_t + V_t \dots\dots\dots (36)$$

This reduced form estimable equation is called the distributed lag model with lag dependent variable as independent variables. The β coefficients except that of lagged dependent variable show the short run elasticities when taken in logarithmic form. The long run elasticities of supply are obtained by dividing the short run elasticities by adjustment coefficient that is 1-coefficient of one-lagged dependent variable ($1 - \beta_3$).

There are significant modifications in the way the model has been employed in actual empirical work. Most of these differences can be grouped in three categories. First are modifications affecting the variables used by Nerlove; second addition of factors of particular interest in the situation under investigation, corresponding to the variable z ; finally some attempts to represent quantitatively situations not considered by Nerlove primarily perennial and slow maturing crops (Askari and Cummings, 1977).

Transformations of all variables of inclusion in logarithmic forms for suitability of mathematical operations as well as for the direct estimation of both the short-run and long-run price elasticities are important. The general specification of the Nerlovian model can be written for economic estimation adopted from work done by Phiko (2014), Belete (1995), Leaver (2003) and Mythili (2008) as:

$$\ln Y_t = \beta_0 + \beta_1 \ln P_{t-1} + \beta_2 P_{Mt-1} + \beta_3 \ln F_{t-1} + \beta_4 \ln R_{t-1} + U_t \dots \dots \dots (37)$$

Where;

Y_t = Natural log of area under rice cultivation in period t ; Hectarage is being used as the dependent variable due to the fact that planned output is best reflected by the area planted. Hectare is preferred as the dependent variable simply because the planned output is well mirrored by the area planted (Belete, 1995).

P_{t-1} = previous price of 100 kilogram of rice in TZS. It is predicted that the better the prices in a particular year the more will be the drive offered to farmers for land resources being allocated to rice from other competing crops. Therefore, coefficient for this variable will be positive.

PM_{t-1} = price of 100 kilogram of maize in the previous year in TZS. Maize is the main substitute crop it competes with rice for land. If the previous period price of rice was low, farmers would rather reallocate the land to maize cultivation expecting to realize better income. This variable will have a negative coefficient. However, intuitively the agronomical requirements for the two crops (maize and rice) are not the same (maize does not grow in flood plains). Therefore this argument is true if the land is favourable for both crops.

F_{t-1} = Natural log of quantity of fertilizer supplied in the market in Tonnes in period t-1, irrespective of the type of fertilizers used. It is anticipated that the more the fertilizer is available at affordable price, the more the farmer is expected to be motivated to produce rice, hence the coefficient is expected to be positive. It also shows the market accessibility by the farmers.

R_{t-1} = Natural log of weather variable estimated by the rainfall amount in period t-1 in millimetres (mm). This reflects the importance of irrigation. It is anticipated that the more the rainfall is conducive the more the farmers are going to allocate land to rice hence the coefficient is expected to be positive.

β_i = are the coefficients to be estimated.

U_t = is error term assumed to be white noise.

3.10 Data Analysis Techniques

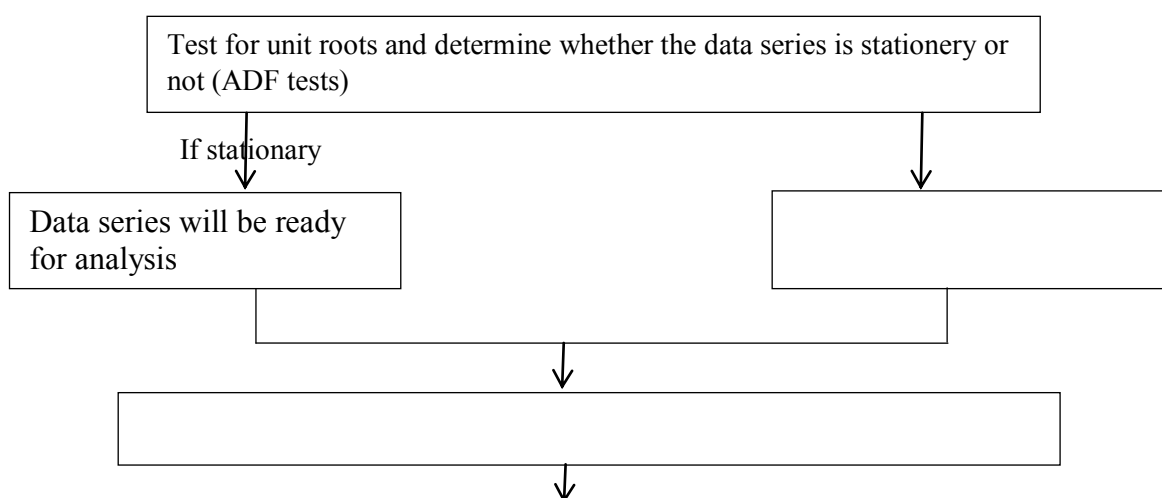
Supply response describes the extent to which the quantity supplied changes relative to variations in economic and non-economic factors. Micro-economic theory states that the main determinant of the supply of a product is its own price. Acreage response has been the dominant feature in estimates of crop supply response, particularly when trying to identify the influence of price on changes in output. There is limited empirical work attempting to estimate the yield response of crop production to price changes. Most direct supply estimation has been focused on changes in acreage planted as a proxy for total supply. This study uses acreage response functions to identify the impact of economic and non-economic factors on changes in rice output in Tanzania.

The Nerlovian partial adjustment model was used to analyse the supply response of rice farmers to economic and non-economic factors. An econometric view 3.1 software package was used for data analysis. The estimation of the Nerlovian model may result in residuals that violate the assumption of normality of the error terms (Leaver, 2003). To ensure normality of the residuals, the estimating equations used in this study were expressed in logarithmic form. The transformation is acceptable because it ensures that the errors are both homoscedastic and normally distributed (Maddala, 2001). An additional benefit of using the logarithmic form is that the coefficient of the price variable can be directly deduced as the short-run supply elasticity.

The time series data of the selected variables first have to be tested for unit roots. The Augmented Dickey Fuller test was performed on each of the logarithmic all series to formally ascertain whether they contained a unit root. This was important to test whether the classical assumptions of regression are violated or not

The EViews 3.1 software was used to develop variables Pr_{t-1} i.e. Price of 100 kilograms of rice at a previous year in TZS and EPr_t i.e. the expected Price 100 kilogram of Rice at a current year in TZS. On the other hand, Pm_{t-1} is the price of maize of the previous year and EPm_t i.e. the expected Price of 100 kilograms of Maize at a current year in TZS.

The estimation of model may result in residuals that violate the assumption of normality of the error terms. This is an abridging assumption of the classical normal linear regression model, and must be satisfied for the method of ordinary least squares to be the best linear unbiased estimator (BLUE) (Phiko, 2014). To ensure normality of the residuals, the estimating equation used in this study was expressed in logarithmic form. The transformation is necessary because it ensures that the errors are both homoscedastic. The Breusch-Godfrey LM test for autocorrelation was employed to allow a decision to be made regarding the presence of autocorrelation among the residuals. First was to conduct a Unit Root test. When variables are non-stationary in levels, as is the case with most time series, a regression estimated can be spurious. The Augmented Dickey-Fuller (ADF) test was used to test each of the variables for the presence of a unit root. Conceptual framework for analysing supply response is presented in Figure 2.



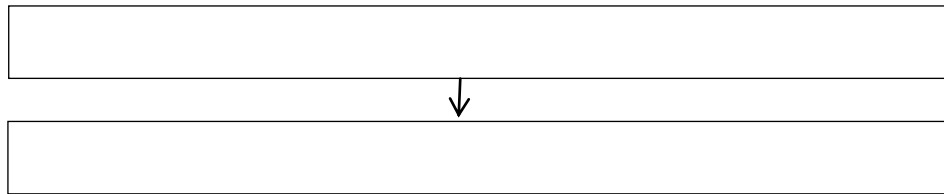


Figure 2: Framework for analysing supply response

Source: Own design

Figure 2 presents the conceptual framework used for analyzing the supply response in the present study. Firstly each data series was tested for stationarity using the Augmented Dickey Fuller test (ADF test). Non-stationery data was made stationery by differencing. This was done to avoid spurious regression results and unstable models. The Simple Adaptive Expectation Model was applied to select the best price variable. Thereafter the chow test procedure was performed in order to test for any structural breaks within the rice series. The OLS method was applied to calculate the supply parameters of the functions. Diagnostic tests were performed to validate quality of the supply model and then the short and long-run supply elasticities were determined.

Moreover, diagnostic testing was very important in time series analyses. The consequences of model mis-specification in regression analysis can be severe in terms of the adverse effects on the sampling properties of both estimators and tests (Greene, 2002). Therefore, several misspecification tests were employed in order to test for the validity of the supply model. These diagnostic statistics include tests for heteroskedasticity, serial correlation, stability of long-run coefficients, and the Jarque-Bera normality test of the residuals. Wasim (2005) argued that whether the model suffers from the auto-correlation problem or not, it cannot be tested by using the DW d-statistics, since the model includes a lagged dependent variable in the set of regressors. Therefore for such an equation an alternative test statistic known as Lagrange Multiplier Test.

In this chapter the rice supply model was constructed. Work done by Belete (1995), Leaver (2003) and Mythili (2008) was used as a framework for the supply model for this study. A review of the methodology used in the estimation of the elasticities is provided as well as the data used in the study. Variables used were selected based on economic theory and data availability. Acreage response functions were selected to identify the influence of price and non-price factors on changes in rice output. Emphasis was placed on model diagnostic tests in order to validate the quality of the model. Satisfactory results on the diagnostic tests ensure reliable results from the supply models and are therefore an important part of the study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Unit Root Test

4.1.1 Natural log of area cultivated with Paddy in hectares

Appendix 2 shows that natural log of area cultivated for paddy along with its correlogram which exhibits an ACF converges very slowly, indicating that this is a non-stationary series. However, this is an informal technique of testing the stationarity in time series data. To confirm if the series is really non-stationary or not, the present study used the Dickey-Fuller (ADF) unit root test for stationarity.

Table 3: A Unit Root Test for Natural log of area cultivated with Paddy

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LAREAPADY(-1))	-1.072618	0.394985	-2.715591	0.0116
D(LAREAPADY(-1),2)	0.030667	0.339646	0.090291	0.9287
C	0.068236	0.063951	1.066997	0.2958
R-squared	0.520975	Mean dependent var		0.000000
Adjusted R-squared	0.484127	S.D. dependent var		0.468118
S.E. of regression	0.336223	Akaike info criterion		0.755610
Sum squared resid	2.939186	Schwarz criterion		0.897055

The H_0 states that natural log of area cultivated for paddy is non-stationary whereas the H_a states that it is stationary. The results show that the ADF test statistics (-2.72) is larger than the 5% McKinnon value of statistics (-3.34). Thus we fail to reject the null hypothesis that natural log of area cultivated for paddy is non-stationary. Therefore we have enough evidence to ascertain that natural log of area cultivated for paddy is non-stationary at level.

4.1.2 Natural log of rice price

Table 4 shows the ADF unit root test for natural log of rice price variable. The H_0 states that natural log of rice price is non-stationary whereas the H_a : states that the natural log of rice price variable is stationary.

Table 4: ADF unit root test of natural log of rice price

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LRICEPRICE(-1))	-2.166506	0.330477	-6.555690	0.0000
D(LRICEPRICE(-1),2)	0.320035	0.182418	1.754404	0.0907
R-squared	0.839024	Mean dependent var		0.001991
Adjusted R-squared	0.833062	S.D. dependent var		1.229807
S.E. of regression	0.502475	Akaike info criterion		1.527929
Sum squared resid	6.816982	Schwarz criterion		1.622225
Log likelihood	-20.15497	Durbin-Watson stat		2.042389

The results show that the ADF test statistics is -6.55 (Appendix 4) which is less than the 5% McKinnon value of statistics (-3.34). Thus this unit root test shows that natural log of rice price is stationary at level.

4.1.3 Natural log of maize price (Lmaizeprice)

The H_0 states that Lmaizeprice variable is non-stationary whereas the H_1 : the Lmaizeprice is stationary. The result shows that the ADF test statistics is -1.69 which is greater than the 5% McKinnon value of statistics -4.28. We fail to reject a null hypothesis that Lmaizeprice is non-stationary. Thus the unit root test shows that Lmaizeprice is non-stationary at level.

Table 5: ADF unit root test for natural log of maize price

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LMAIZEPRICE(-1)	-0.201956	0.119259	-1.693422	0.1019
D(LMAIZEPRICE(-1))	0.065501	0.192864	0.339622	0.7368
C	2.544723	1.489621	1.708303	0.0991
R-squared	0.097369	Mean dependent var		0.022551
Adjusted R-squared	0.030507	S.D. dependent var		0.258018
S.E. of regression	0.254052	Akaike info criterion		0.192081
Sum squared resid	1.742640	Schwarz criterion		0.332201
Log likelihood	0.118784	F-statistic		1.456277
Durbin-Watson stat	1.977333	Prob(F-statistic)		0.250835

4.1.4 Natural log of average annual rainfall in mm (Rainfall)

Table 6 shows the ADF unit root test for natural log of average annual rainfall variable. The H_0 state that natural log of average annual rainfall is non-stationery whereas the H_a : states that the natural log of average annual rainfall variable is stationery. The results show that the ADF test statistics is -3.63 and it is less than a 5% of the McKinnon value of statistics(-3.55). Therefore, we reject a null hypothesis that natural log of average annual rainfall is non-stationery series. Thus, the unit root test shows that natural log of average annual rainfall is non-stationery at level.

Table 6: The ADF unit root test of Natural log of Average Annual Rainfall

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LRAINFALLF(-1))	-1.011155	0.278114	-3.635759	0.0012
D(LRAINFALLF(-1),2)	0.005578	0.196113	0.028441	0.9775
C	0.011671	0.030563	0.381877	0.7057
R-squared	0.502789	Mean dependent var		0.000000
Adjusted R-squared	0.464542	S.D. dependent var		0.223681
S.E. of regression	0.163679	Akaike info criterion		-0.684128
Sum squared resid	0.696557	Schwarz criterion		-0.542683
Log likelihood	12.91985	F-statistic		13.14583
Durbin-Watson stat	1.976730	Prob(F-statistic)		0.000114

4.1.5 Natural Log of Average annual fertilizer consumption in Tonnes

Table 7 shows the ADF unit root test for natural log of average annual fertilizer variable. The H_0 state that natural log of average annual fertilizer is non-stationery whereas the H_a : states that the natural log of average annual fertilizer variable is stationery. The results show that the ADF test statistics is -4.96 (Appendix5) which is less than a 5% of the McKinnon value of statistics (-3.55). Thus we reject a null hypothesis that natural log of average annual fertilizer is non-stationery series at level.

Table 7: The ADF unit root test of Natural Log of fertilizer

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFERTILIZER(-1))	-1.452237	0.292900	-4.958137	0.0000
D(LFERTILIZER(-1),2)	0.222046	0.190310	1.166758	0.2539
C	0.039477	0.014158	2.788297	0.0098
R-squared	0.615095	Mean dependent var		0.000000
Adjusted R-squared	0.585487	S.D. dependent var		0.098602
S.E. of regression	0.063483	Akaike info criterion		-2.578404
Sum squared resid	0.104781	Schwarz criterion		-2.436960
Log likelihood	40.38686	F-statistic		20.77460
Durbin-Watson stat	1.942139	Prob(F-statistic)		0.000004

Next was a co integration analysis to assess the existence of a long-run equilibrium between the variables. This concept of cointegration is based on the fact that even though individually variables may not be stationary, their linear combination may be. Estimating cointegration variables in levels might still be meaningful despite individual variables being non-stationary. Table 8 gives the results of the cointegration test.

4.2 Cointegration of Variables

The Unit Root Test on the series indicates that some of the variables were stationary at levels while others were not. Next was a cointegration analysis to assess the existence of a

long-run equilibrium between the variables. According to Timothy *et al.* (2013), Cointegration is preferred to differencing because cointegration equation retains important long run information which would otherwise be lost if alternative method of differencing were used. Estimating cointegration variables in levels might still be meaningful despite individual variables being non-stationary. The necessary condition before running the Vector Error Correction Model (VECM) is that the variables must be cointegrated at the level (Greene, 2006).

Table 8: Results of Cointegration Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RESIDUAL(-1)	-0.647766	0.271881	-2.382538	0.0245
D(RESIDUAL(-1))	0.444815	0.264377	1.682506	0.1040
C	0.001913	0.060874	0.031419	0.9752
R-squared	0.174345	Mean dependent var		0.043525
Adjusted R-squared	0.113185	S.D. dependent var		0.335317
S.E. of regression	0.315771	Akaike info criterion		0.627038
Sum squared resid	2.692199	Schwarz criterion		0.767158
Log likelihood	-6.405569	F-statistic		2.850652
Durbin-Watson stat	2.012795	Prob(F-statistic)		0.075298

The Angel Granger Cointegration test: H_0 = the residual is non-stationary [the variables are not cointegrated] and H_1 = the residual is stationary [the variables are cointegrated]

The results show an ADF Test Statistic of -2.38 implying that the residuals are stationary at 5% (given critical value of -2.9). This implies existence of a long run relationship between the non-stationary variables. In other words, the variables are co-integrated. It is therefore possible to run an Error Correction Model (ECM).

4.3 Autocorrelation Test

Further, a test for serial autocorrelation was also conducted. The Breusch-Godfrey (BG) test is a general test for higher order autocorrelation. A significant *R-squared implies autocorrelation problem. The results in Table 9 show that the observed *R-squared is insignificant at 5% level, indicating that there is no problem of autocorrelation.

Table 9: Breusch-Godfrey Serial Autocorrelation Test Result

	Value	Probability
F-statistic	0.915646	0.413791
Obs*R-squared	2.197724	0.333250

4.3 White Heteroscedasticity Test

The White Heteroscedasticity test (no cross terms) was employed to check for presence of heteroscedasticity. A significant observed R-squared implies presence of the problem of heteroscedasticity (Gujarati, 1995). Results of this test showed that the observed R-squared is insignificant at 5% level as reported in Table 10. This means that the error terms are homoscedastic.

4.4 Empirical Estimation and Interpretation of the Supply Response Model

Table 11 presents estimation results. The results show that the explanatory variables used; riceprice, maize price, fertilizer and rainfall (these are 1 year lagged), explained 65.77% of the variation in area under cultivation (paddy area of rice) over the period 1999 – 2008 period.

Table 10: Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	4.603906	1.393601	-2.586038	0.0157***
LMAIZEPRICE	-0.169966	0.229303	0.741230	0.4652
LRICEPRICE	0.191063	0.132550	-1.441442	0.0161***
LRAINFALL	0.421341	0.348641	1.800279	0.0834**
LFERTILIZER	0.213100	0.468200	1.805425	0.0626**
R-squared	0.657752	Mean dependent var		2.337676
Adjusted R-squared	0.574329	S.D. dependent var		0.175572
S.E. of regression	0.138876	Akaike info criterion		-1.963776
Sum squared resid	0.501453	Schwarz criterion		-0.732487
Log likelihood	19.93852	F-statistic		9.787127
Durbin-Watson stat	1.557232	Prob(F-statistic)		0.002436

Note: *significant at 10%, **significant at 5%, and ***significant at 1%.

The F-statistic of 9.78 is significant explaining that the explanatory variables in this model are relevant in explaining hectareage. Furthermore, there is no first order serial correlation as can be appreciated by the value of Durbin-Watson Statistic of 1.6 which is close to 2. The high value of the Adjusted Coefficient of the determination, R^2 , 65.77% manifests the overall model as a good fit. Only about 34.23% is left unexplained, attributed to other factors and this is captured by the disturbance term.

4.4.1 Interpretation of results

4.4.1.1 Elasticity estimates of rice supply with respect to price and non-price variables

Farmers increase amount of land allocated to rice as price increases. Changing producer price influences farmers' willingness to allocate land to rice. A 1 percent increase in the price of rice leads to a 0.19 percent increase in area under rice production in the next period. Assuming that everything else (including the production technology) remaining the same, the increase in production will require an increase in the area under the rice

production. The coefficient has been found to be significant at 5%. This is consistent with the cobweb phenomenon which basically states that a rise in current period price of an agricultural crop leads to its increased production in the following period.

There is a negative relationship between the lagged producer price of maize and amount of land allocated to rice. This is consistent with the premise that farmers will reallocate land to maize cultivation in case of price of maize being higher in relation to that of rice. The results show an elasticity coefficient of -0.17 implying that a 1 percent increase in the price of maize, decreases land allocated to rice by about 0.17 percent. One of the determinants of supply response in agriculture is how readily can land and labour be shifted from one crop to another (Alexander, 2014). The price of maize has been found to be insignificant at 10% in influencing area cultivated for rice. This can be attributed to the fact that these crops grow in different land conditions. This means that the price of maize may rise; still farmers cannot shift all their land to its cultivation, due to different agronomical requirements of the two crops (Timothy, 2013).

Therefore, land allocation cannot easily be shifted to rice cultivation, or vice versa. However, the fact of economic theory states that farmers reduce production of rice in favour of maize if the price of maize is good, because maize is a substitute food for rice in most households.

A positive and significant relationship between rainfall and area under cultivation has been found in this study. The variable (rainfall) is significant at 10% with the coefficient of 0.42. This implies that a 1 percent increase in rainfall translates into a 0.42% increase in area allocated to rice in the next period, if everything including prices and technology remains the same. This elasticity is also relatively higher as compared to the other.

The coefficient of fertilizer is in line with the theoretical expectation and significant at 10 percent level. This clearly indicates that farmers' willingness to allocate more land to rice will depend on the availability of fertilizer. Thus, Fertilizer availability to smallholder farmers is also critical in determining the amount of land allocated to rice in the current season. This was shown by a positive relationship that exists between fertilizer and area cultivated for rice. A 1 percent increase in the amount of fertilizer available resulted into a 0.21% percent increase in the amount of land allocated to rice. The supply of fertilizer at affordable price acts as an adequate incentive to the farmers to go for extensive cultivation in the longrun. Phiko (2014) analysed the response of smallholder maize farmers in Malawi to price and non-price factors. The study found that availability of inorganic fertilizer is among factors that affect smallholder farmers' decision to allocate land to maize. . However, intuitively, the most relevant variable would be the price of fertilizer because price is more relevant variable than the fertilizer quantity for supply response study.

4.4.1.2 Comparison of the sensitivity of rice supply to price and non-price factors

Results show that rice supply is more sensitive to non-price factors than price factors.(i.e. supply elasticity of rainfall is 0.42 and that of fertilizer is 0.21) than those of price factors (own price elasticity is 0.19 and price elasticity of a substitute crop, maize is 0.17).The study by Kirti and Goyari (2013) support the findings of the present study that non-price factors are more important and complementary to price. Increasing the price of maize however, pulls farmers to reallocate or withdraw vital inputs from rice production into maize production in pursuit of making better returns as rational beings. An increase in the farm gate price of local rice increases the financial base of farmers and allows them to meet some vital production cost which consequently leads to the positive effect on output.

The higher elasticity of rainfall indicates that, weather is one of the key factors that affect rice supply. This shows the importance of irrigation in rice production in Tanzania. The findings of the present study support those obtained by Goyari and Ranjan (2013), that supply of rice is more responsive to non-price factors than price factors. Moreover, Boansi (2013) obtained the results that fertilizer is a very vital input in rice production. His study similarly supports the findings of the present study.

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The overall objective of this study was to analyse the determinants of rice supply in Tanzania. The study found that rice supply is most driven by both price and non-price factors. Quantitative effects of price and non-price incentives were examined to attain an overall objective of analysing the impact of price and non-price incentives on supply of rice crop over the period 1999-2008. The analysis has applied the Nerlovean supply response modelling technique. Diagnostic tests conducted confirmed that each of the regression equations explains the model well and is well specified.

Econometric results from the study indicate that own price was significant (at 5 percent) and has positive effects on rice area cultivated with an elasticity of 0.19. This is suggesting that farmers mostly allocate land to crops on the basis of their previous price. This implies that a rise in the price of rice leads to a rise in area cultivated for rice. With price of maize, it has had a negative effect on rice land allocation, being statistically significant at 10 percent. As a competing commodity in consumption to rice, a rise in the price of maize will lead to fall in rice hectareage. Rainfall and fertilizer have also been found to be significant at 10 percent significant levels and elasticities of 0.42 and 0.21 respectively. This again indicates that rainfall pattern and availability of agricultural inputs alter hectareage allocation of rice.

In light of the above findings the overall conclusion made is that in the long-run farmers are responsive to price and non-price incentives and offering of good prices for agricultural produce is one of the keys to food security status of a country. Furthermore,

the estimates of the present study lead to the conclusion that Tanzanian rice farmers are responsive to prices of competing food crops to rice, availability of farm inputs (fertilizers), and rainfall conditions. This implies that rice farmers adjust land resource allocation in accordance with the prevailing conditions of these variables.

The results of this study support other studies conducted at aggregate level or regional level like Palanivel (1995) and Kanwar (2004) which also concluded that non-price factors like rainfall, irrigation, consumption of fertilizer, are highly significant in boosting rice production. Phiko and Alexander (2014) further obtained the results that farmers are unresponsive to price factors but are responsive to non-price incentives. Among the non-price factors, estimated supply elasticities of rainfall come as the most dominating factor influencing acreage behaviour.

5.2 Recommendations

Basing on the research findings, strategies that put more emphasis on non-price factors like irrigation, and adequate fertilizers supply at affordable price are crucial for policies promoting rice production. If therefore the goal of the government is to have more rice in the country, it has to increase public investments in non-price variables that is rural infrastructure such irrigation and efficient facilities that facilitate fertilizer trade so as to enhance access by smallholder farmers to inorganic fertilizer. The government policy of subsidizing fertilizer or making fertilizer less expensive for the poor is crucial and should continue.

Moreover, Mechanization of rice production would be one of the key areas for intervention in rice sector in Tanzania because of its indirect effects. Farmers need effective and efficient tools like power tillers and tractors to simplify their activities.

Hired power tillers and tractors are too few in the localities and farmers have to wait for long time before getting the services and missing the proper planting periods hence suffering the consequences of weather dynamics.

These results have valuable policy implications in the formulation of climate change mitigation and adaptation strategies. Government policy cannot affect natural conditions like rainfall, but it can compensate for the negative impact of climate change by increasing investment in irrigation, promoting efficient use of water, and encouraging adoption of drought-resistant varieties. Therefore, increasing public spending on infrastructure like irrigation is a vital concern to stimulate rice production. Increasing area under irrigation makes the farmers less dependent on weather conditions and can encourage farmers to allocate land resources to rice.

Finally, rice farmers also respond to price variables and price of substitute crops such as maize. In response to this, the government policy would be to keep prices of other food crops relatively low in order not to drive away farmers from rice production to other crops.

However, the government would also like to ensure low rice prices in the country. To ensure these input prices should be kept low and input subsidies should be provided timely to lower rice production cost and hence lower rice price in turn. Therefore, input policy of subsidizing farm inputs that enable farmers to access fertilizer and other inputs should continue. Price support and control which may cause distortions in the rice market needs to be minimized. The focus of future research could therefore be on how best this could be achieved or on estimating the optimal rate to use in order to mitigate the adverse effect of pricing policy.

5.3 Area for Further Research

Many studies, which provided estimates of supply response, have mostly used time series aggregated data. This type of data set covers variations across states. The state specific characteristics and its contribution to the varying supply response would provide better information for drawing inferences at the specific locations (regional or national level). Panel data has a distinct advantage of providing regional and temporal variations for dynamic models. Very few scholars have worked with panel data in supply response analysis. Study by Gulati *et al* (1999) and Kumar *et al.* (1997) are the few which used pooled cross section- time series data across regions of India. In Tanzania particularly, this has not been well focused yet. Panel data (cross-sectional time series data) is more detailed and informative than time series data. Therefore the study to fill this gap is highly required.

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APPENDICES

Appendix 1: 5% McKinnon Value Decision Criterion

n	Model	%	θ_1	θ_2	θ_3	T	$C(p)$
	constant,	no					
2	trend	1	-3.9001	-10.534	-30.03	29	-4.29905
		5	-3.3377	-5.967	-8.98		-3.55414
		10	-3.0462	-4.069	-5.73		-3.19332

Appendix 2: A Unit Root Test for Natural log of area cultivated with Paddy

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LAREAPADY,2)

Method: Least Squares

Sample(adjusted): 1999:4 2006:4

Included observations: 29 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LAREAPADY(-1))	-1.072618	0.394985	-2.715591	0.0116
D(LAREAPADY(-1),2)	0.030667	0.339646	0.090291	0.9287
C	0.068236	0.063951	1.066997	0.2958
R-squared	0.520975	Mean dependent var		0.000000
Adjusted R-squared	0.484127	S.D. dependent var		0.468118
S.E. of regression	0.336223	Akaike info criterion		0.755610
Sum squared resid	2.939186	Schwarz criterion		0.897055

Appendix 3: ADF unit root test for natural log of rice price

ADF Test Statistic	-6.555690	1% Critical Value*	-2.6453
		5% Critical Value	-1.9530
		10% Critical Value	-1.6218

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LRICEPRICE,2)

Method: Least Squares

Sample(adjusted): 1999:4 2006:4

Included observations: 29 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LRICEPRICE(-1))	-2.166506	0.330477	-6.555690	0.0000
D(LRICEPRICE(-1),2)	0.320035	0.182418	1.754404	0.0907
R-squared	0.839024	Mean dependent var		0.001991
Adjusted R-squared	0.833062	S.D. dependent var		1.229807
S.E. of regression	0.502475	Akaike info criterion		1.527929
Sum squared resid	6.816982	Schwarz criterion		1.622225
Log likelihood	-20.15497	Durbin-Watson stat		2.042389

Appendix 4: The ADF unit root test of Natural Log of fertilizer

ADF Test Statistic	-4.958137	1% Critical Value*	-3.6752
		5% Critical Value	-2.9665
		10% Critical Value	-2.6220

MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(LFERTILIZER,2)

Method: Least Squares

Sample(adjusted): 1999:4 2006:4

Included observations: 29 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LFERTILIZER(-1))	-1.452237	0.292900	-4.958137	0.0000
D(LFERTILIZER(-1),2)	0.222046	0.190310	1.166758	0.2539
C	0.039477	0.014158	2.788297	0.0098
R-squared	0.615095	Mean dependent var		0.000000
Adjusted R-squared	0.585487	S.D. dependent var		0.098602
S.E. of regression	0.063483	Akaike info criterion		-2.578404
Sum squared resid	0.104781	Schwarz criterion		-2.436960
Log likelihood	40.38686	F-statistic		20.77460
Durbin-Watson stat	1.942139	Prob(F-statistic)		0.000004