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DISRUPTION RISK MANAGEMENT IN GRAIN CHAIN IN NIGERIA: A SIMULATION STUDY

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K.P. Adeosun

Management summary

Introduction

This study focussed on disruption risks in grain chain in Nigeria. The chain consists of different stages. It includes production, processing, storage and consumption. Rice grain is an important dietary food in Nigeria, in which its sufficiency cannot be over emphasised and this is mainly consumed by households. Currently, the supply of rice is below thresholds and consumption level. Farmers, processors, wholesalers and retailers are major actors in the rice grain chain. Also governments are a vital organ in this chain in the area of policy decisions. Nigeria is currently under-supplied in rice and over the years the supply of rice by Nigerians chain actors have been fluctuating due to some prominent disruption factors associated with the chain. These factors were identified to be weather failure, natural disaster, pests and disease, political instability and infrastructural risk. This has further reduced, and caused uncertainties, in the volume supplied at different points of chain stages. This study was mainly aimed to examine the effect of disruption risks in the grain chain in Nigeria. Specifically, the research explored the actual volume currently supply from different points in the rice grain chain. The research examines the volatility that exists at different points of the chain and describes the prevention and coping strategies applied. Furthermore, the study investigates the critical thresholds of rice grain at different points of the chain. Finally, the research evaluated the cost-effectiveness of different applied risk management strategies. In the study, different risk management strategies common to Nigeria were identified and categorised under prevention, coping and government risk management. The average volume supplied and volatility were determined in the study. The average volume currently supplied from production is 3.61 million tonnes with a standard deviation of 0.53, with 2.28 million tonnes being supplied from processing with a standard deviation of 0.40, and an average of 0.68 million tonnes being supplied from the storage point with standard deviation of 0.31. The standard threshold level holds by Nigerian is projected to be 10.3 million tonnes of paddy rice and 6 million tonnes of milled rice which he expected to reach by 2015.

Materials and methods

The parameters for this study were retrieved from the literature, United State Department of Agriculture data base (USDA) and personal assumptions because of limited data available. Likewise, personal communication was made with some experienced researchers. A simulation model was built in Excel that comprised the disruption factors, average volume supplied from different points, threshold level, risk management strategies and cost. The model first examined the impact of disruption on average flow along the chain, which gave the volume supplied corrected for disruption. Functions in Excel were used to determine the uncertainties in the volume supplied from different points of the chain. A distribution analysis was used to investigate the volume supplied from each stage. In a situation where volume is below the critical threshold level, risk management strategies are applied. Then the costs for these risk management strategies were assessed. With reference to risk management strategies, the study only investigates production and processing points at this level in this study. The reason for this is because rice is under supplied in Nigeria and the current end stocks are held currently from import. Nigeria will begin to have its own end stock when it can supply rice beyond the threshold level.

Results

The results show that at production level, the output shortage is on average 6.94 mt per year. Whilst, the output shortage at processing level will on average 3.75 mt per year. There is a 90% probability that the output shortage will be greater than 5.98 mt of paddy rice and, 3.04 mt of milled rice at 5% percentile, but less than 7.82 mt of paddy rice and, 4.45 mt of milled rice at 95% percentile, in a year. These shortages fluctuate with 0.56 standard deviation at production point and 0.42 standard deviation at processing. The cost to finance the default was also simulated along with the output volume based on two strategic approaches; an increase in paddy rice production, and an increase in the import of milled rice. The average cost for the shortfalls are expected to be €3.34 billion for paddy rice production and €1.95 billion for import of milled rice in a year. Sensitivity analysis was conducted to evaluate the importance of the parameters in the model. The results show that when the probability of occurrence of biological risk increased from 0.57 to 0.85, the average output shortage increased from 6.94 mt to 6.99 mt of paddy rice and whilst the probability of occurrence of infra-structure risk increased from 0.66 to 0.80, the average output shortage increased from 3.75 mt to 3.79 mt of milled rice. Also, when the threshold level at production increased from 10.3 mt to 11.8mt, the average output shortage increased from 6.94 mt to 7.95 mt of paddy rice. Whilst, the threshold level at processing increased from 6.0 mt to 7.5 mt, the average output shortage increased from 3.75 mt to 5.26 mt of milled rice. More so, when the summed impact of disruption increased by 10%, the average output shortage increased from 6.94 mt to 7.21 mt at production and 3.75 mt to 3.87 mt at processing.

Conclusions

From the study, supply of paddy and milled rice fluctuate a lot in Nigeria. Currently, Nigeria is under-supplied of rice which creates gap between rice supply and consumption. However, disruption will further creates gap in rice supply and consumption. The study shows there will be shortage of 6.94 mt of paddy rice and 3.75 mt of milled rice on average in a year. Out of this, 6.48 mt of paddy rice is accounted for as existing gap (under-supplied) and 0.46 mt of paddy rice is due to disruption impact. Whilst 3.60 mt is due to existing shortage of milled rice, 0.15 mt is due to disruption impact. Two different strategies were employed to dissipate the shortage, and they are as follows with their corresponding cost: increase in production of paddy rice which will cost €3.34 billion (€3.12 billion for existing shortages and €0.22 billion for disruption shortages), import of milled rice which amount to €1.95 billion (€1.87 billion for existing shortages and €0.08 billion for disruption shortages).

Recommendations

This research is conducted to examine the effect of disruption risks in grain chain in Nigeria. First, It is also recommended that each actor should take cognisance of risks and apply management strategies such as prevention measures, coping strategies and in case of serious shortages, government can intervene. It is recommended that actors in the chain should get insurance certificates and future contracts. Ex post risk management can be applied by Nigerian government. Two ex post risk management strategies are examined (import of milled and increase in production) in this study that can be used by Nigerian government to meet up its rice sufficiency/consumption level.

Acronyms

PIA	Presidential Initiative Agenda
ATA	Agricultural Transformation Agenda
USDA	United State Department of Agriculture
GON	Government of Nigeria
NERICA	New Rice for Africa
NRDS	National Rice Development Strategy
PHLs	Post Harvest Losses
NEMA	National Emergency Management Agency
(SGRSP)	Strategic Grain Reserve Storage Programme
FAO	Food Agriculture and Organisation
PHCN	Power holding Company of Nigeria
ADPs	Agricultural Development Projects
DFRRI	Directorate of Foods, Road and Rural Infrastructure
NALDA	National Agricultural Land Agency
FMARD	Federal Ministry of Agriculture and Rural Development
FADAMA	Federal Agricultural Development Agency Ministry of Agriculture
FEWSNET	Famine Early Warning System Network
OECD	Organization for Economic Cooperation and Development
IITA	International Institutes of Tropical Agriculture
WFP	World Food Programme

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Chapter 1

1. INTRODUCTION

1.1 Background statement

Grain is one of the major crops grown and also form a major part of Nigeria's staple foods. Nigeria's food regime is based essentially on food grains, which provide 46% of calories and 52% of proteins consumed (Rural Development, 2010). A large part of the food grains produced is retained on the farm for home consumption (Ukeje, 2006). Grain such as sorghum, cowpea, millet, rice, wheat and maize are widely consumed by most households. They are also used as feed for livestock and by various industries such as the breweries. Maize is mainly used by the poultry industry as a raw material for feed, while sorghum is used by breweries for producing beverages. Sorghum and millet are important food grains for households in Northern Nigeria, and are particularly traded in the borders markets close to the Niger Republic. In addition, rice is produced and consumed throughout the country (FEWSNET, 2008).

Local farmers are the major producers of rice in Nigeria. They get their seeds mostly from past harvests, or they buy them from markets or sometimes from government agencies/cooperatives, especially when there is need for improved seeds. Rural assemblers get the grains from farmers for further processing and storage, and for onwards movement to the wholesalers who eventually store the grain in large quantities (Oguoma et al, 2010). The grain moves from wholesalers to industries, retailers or directly to the consumers. Although, Nigeria is one of the major producers of rice globally, what is currently produced locally is not enough to meet local consumption needs, a situation that has made Nigeria a net importer of rice (Daramola, 2005). This may be as a result of disruption risk factors and low production technologies.

Rice commodity flow is the movement of rice volume from one stage to another such as production to consumption. This flow can be disrupted by certain factors such as erratic rainfall, high humidity, droughts, pests and disease epidemics along any rice chain (Lire et al, 2000). These factors reduce the volume of the rice as they flow from one stage to another, thereby causing shortages in terms of quantity. Risk in agricultural food production is defined as an uncertainty (i.e. imperfect knowledge or predictability) because of randomness (Aker, 2010). It is regarded as the probability of losses resulting from incomplete control over the processes with which farmers are concerned (OECD, 2000). Weather factors are essential in rice production. Rice production in Nigeria is still predominantly rain-fed (IPRI, 2009a). Rainfall which increases grain moisture content is a key issue during and after harvest. Smallholder farmers rely on sun drying to ensure that grains are well dried before storage. If unfavourable weather conditions prevent grains from drying sufficiently, then losses will be high. Also, pest and disease affect the grain during storage if they are not stored properly.

According to Dupriez and Leener (1988), farmers are faced with many food production uncertainties in rural areas. These prevent them from acting freely in accordance with their food production wishes. In such circumstances, they have to take some innumerable and highly diversified risks and uncertainties into consideration. In order to cope with various production and post-harvest risks, farmers and wholesalers in developing countries usually engage in informal risk management mechanisms. These range from income diversification activities, production strategies such as crop rotation, crop diversification, water harvesting, irrigation, improved water use efficiency, breeding for heat or drought tolerance, mixed cropping and use of improved seeds (Antonaci et al, 2014). These local means of risk management methods tend to fail in the presence of larger shocks affecting large areas of the farm.

1.2 Statement of the problem

Nigeria's production and consumption of rice have increased significantly since independence in 1960 (FMARD, 2006). However, the production increase has been insufficient to match consumption demands, despite the availability of a vast area of fertile and cultivable land (Akande, 2003). Limited supply has often led to large scale importation of food, especially rice, which is one of the major staple foods consumed by the Nigerian population (Ogunbiyi, 2011). The Nigerian government has recently banned the importation of rice in order to encourage local production.

Grain availability is low in Nigeria due to a combination of low productivity and postharvest losses (Babalola, 2003; IFPRI, 2009b; Agwu et al, 2012). Most of the production and processing in Nigeria still occurs on a small scale and at a cooperative level (IFPRI, 2009b). Climate factors such as rainfall, temperature and humidity are key determinants of grain production and grain losses (Peel et al, 2007). Climate variability is likely to increase post-harvest losses due to the combination of changes in various climatic variables, which may increase in the number of pests and diseases which attack stored grain, as well as it creating an environment for new insect pests to flourish (Paterson and Lima, 2010; Deffenbaugh et al, 2008). Weather instability exposes rice production to uncertainty, such that it may bring output fluctuations. For instance, if rainfall is inadequate or untimely, plants dry up and yields are in jeopardy. If rainfall is inadequate at the beginning of the rainy season, seeds dry up and the harvest is likely to be poor (IITA, 2007). If something is not done with the management of irregularities of disruption risk, it poses a great danger to the food security of Nigeria. This has further seriously reduced the supply of rice and domestic agriculture remains underdeveloped. As a consequence, the country continues to depend on imports to meet domestic demand for food to feed its 170 million people. Nigeria is the most populous country in Africa, therefore, measures should be taken to ensure food production stability and regular commodity flows along the grain chain. Climatic factors are believed to be the strongest elements influencing high fluctuations in crop yield and, ultimately, food supply (Odozi, 2014), with the problem of inadequate storage facilities and, post-harvest inefficiencies potentially leading to serious food shortage.

Risk in the grain chain is not only associated with production stage alone but is also present in other stages in the chain such as processing, storage and government policy. This negatively affects farmers, processors, and wholesalers decision's on their production activities, processing and the volume of storage. This may reduce the quantity supplied, thereby reducing the revenue of each actor in the chain. Similar studies have been conducted in Ghana on agricultural supply chain risk identification by Yeboah et al, (2014) and in Thailand on uncertainty factors affecting the sustainable supply of rice production by Thongrattana, (2012). However, I intend to study the effect of disruption risk variables on the volume of rice supplied at the level of production, processing and storage in the rice chain in Nigeria. This may help farmers, processors and wholesalers in Nigeria to make better strategic risk prevention decisions on production, processing and storage practice techniques. Furthermore, it may help governments to review and improve grain importation policy and improve support for grain farmers, and adopt better strategies to dissipate shortages.

1.3 Research objective

The overall objective of this study is to analyse the disruption risk management at different points (production, processing and storage) along the rice production to consumption chain.

The specific research questions are:

- What is the average rice volume supplied by different points of the chain and what is the volatility of rice volume at different points in the chain?
- What risk prevention strategies and coping strategies are applied?
- What are the critical rice sufficiency thresholds at different points of the chain?
- What is the cost-effectiveness of different risk management strategies?

This study will focus on rice as an example of major grains in Nigeria. This decision was made because rice is widely grown in several parts of Nigeria and consumed by most Nigerians as a staple food. In addition, rice is one of the grains chosen for the Presidential Initiative Agenda (PIA) and the Agricultural Transformation Agenda (ATA) of the Nigerian government to increase local production and ensure food security. Rice is also one of the most imported grains in Nigeria with average import of 2.081mt per year (USDA, 2014). In this regard, the Nigerian government wants the rice imports ban to be more effective in order to encourage local production. The output expected in the chain consists of two products: the paddy rice which is supplied at production level and also serves as input for processing, whilst, milled rice is the final consumable product that comes from processing.

1.4 Outline of report

The remainder of this work will be divided into the following sections: chapter two (2) involves an intensive literature review; chapter three (3) focuses on materials and methods and the conceptual framework for the study; chapter four (4) presents the results of analyses undertaken on grain volume aggregates at different points along the chain; finally, chapter five (5) discusses the results, and provides conclusions and recommendations.

Chapter 2

2. DISRUPTION RISKS AND VOLUME FLUCTUATIONS ALONG GRAIN CHAIN IN NIGERIA

The literature review focussed on the Identification of prominent disruption risks, an assessment of their impacts and various risk management strategies used. The literature review starts by explaining the grain supply chain, followed by different risks prominent in the stages. It ends with various risk management strategies that are common in Nigeria.

2.1 Grain supply chain stages in Nigeria

In recent years, the Nigerian government has provided incentives to support actors in the grain chain in the form of subsidizing the price of fertilisers, making loans available with affordable collaterals, taxing of importers through tariffs, subsidizing other agricultural input to the rural farmers and creating markets for their produce. This has tremendously increased the grain production output per hectare in rural areas (Olumeko, 1991). The increase in yield through improved cropping systems and the introduction of high yielding varieties has re-emphasized the need for more resources to prevent post-harvest losses. The government of Nigeria has selected some grains which are covered by the strategic grains reserve policy. These include guinea corn, maize, millet, rice, and wheat. Two government agencies are currently involved in the strategic grains reserve policy in Nigeria; the Grains Production Company and the Grains Board. The former is actively engaged in the production of grains while the latter handles the storage and marketing functions.

In 2012, the Government of Nigeria (GON) initiated the Agriculture Transformation Agenda (ATA) program designed to significantly reduce food imports by increasing production of five key crops: rice, cassava, sorghum, cocoa and cotton. This was initiated to encourage increased local agricultural production and generate employment. It is intended to develop strategic partnerships with the private sector to stimulate investment in agriculture and to repair the value chains in those agricultural sub-sectors (IFPRI, 2009a). Another policy goal was to increase domestic rice production to make the country self-sufficient in rice production by 2015, when rice imports will be banned (USDA, 2014). There has been a long policy era in Nigeria based on grain production and importation. In 1986, there was a policy that banned importation of rice. With this effort, importation of rice was significantly reduced between the mid-1980's and the mid-1990's when the ban was seriously effective (David, 2013). While it was illegal to import rice into the country in the ban era, illegal importation of the commodity through the country's borders still persisted during this period (Akande, 2003).

The prohibition on rice import was lifted in 1995 but an import duty of 120 percent was imposed on the commodity (Lancon and David, 2007). In 2006 the duty was reduced to 50 percent (IFPRI, 2009b). It returned to 100 percent but was temporarily suspended in 2008 due to the high cereal prices. Despite the import duty and unstable rice import quantities, rice imports into Nigeria still remain positive. Aside from ATA, there is a presidential initiative on grains which aimed at addressing the widening demand-supply gap in rice production and attaining self-sufficiency, as well as reducing the huge import bill on rice and other selected crops. The Presidential Initiative proposed a national rice project with the following highlights. It should be private sector led, based on an intensification policy. In addition, NERICA varieties should be used for upland areas while other varieties adaptable to all agricultural zones of the country would also be used. To achieve this, in pursuance of its rice self-sufficiency policy, the Federal Government released 1.5 billion naira for multiplication and distribution of certified rice seeds (Bello, 2003; Ogungbile and Phillip, 1996).

This was followed up with the National Rice Development Strategy in 2009 which aimed at doubling rice production in Nigeria and increasing land area under rice cultivation. The Government of Nigeria, according to Rondon and Nzeka, (2013), introduced a new tariff for rice (effective July 1, 2012) which brought a 30% levy on imported brown rice and a 50% levy on imported milled/polished rice (effective December 31,2013). Nigeria's rice sub-sector has witnessed inconsistent policies, with the government applying and revising tariffs in almost every year. The unstable nature of the country's rice tariff and trade policy structure could limit investment by farmers in their fields, as well as incite inappropriate responses by them to temporal production incentives (Rondon and Nzeka, 2013). However, the taste for imported rice and the high demand for good quality rice among Nigerians- especially urban dwellers, who consume large amounts of imported rice (Erhabor and Ojogho, 2011)- have prevented this policy from bringing substantial improvements to domestic rice production and the imported commodity continues to flood Nigerian markets. This problem is exacerbated by the highly fragmented and poorly serviced nature of the domestic rice value chain. These policy strategies are not applied on rice alone but also on other grains, for instance, there is establishment of the doubling maize production initiative. The overall strategy of the initiative was to ensure that maize production was doubled in two years (2006–2008). While maize production increased between 2005-2006 and 2006-2007, an excess supply of maize, low demand and consequent price declines are said to have served as a subsequent disincentive to farmers (FewsNet, 2006).

2.2 Overview of Nigeria grain chain

A supply chain has been described as a system whose constituent parts include material suppliers, production facilities, distribution services and customers, linked together via the feed-forward flow of materials and the feedback flow of information (Stevens, 1989). The major producers of grain in Nigeria are local farmers. They obtain their seed from the previous harvest, bought at the market, or via government agencies or farmer's cooperatives. The quantity of grain after harvest moves to rural assemblers for semi-processing. The grain is collected by a wholesaler or grain reserve in large quantities for storage. Due to insufficient rice production, imports of milled rice amounting to 48% are needed to complement the current supplied (Olayide et al, 2011). The figure below shows the typical overview of a grain chain in which the Nigeria situation is captured.

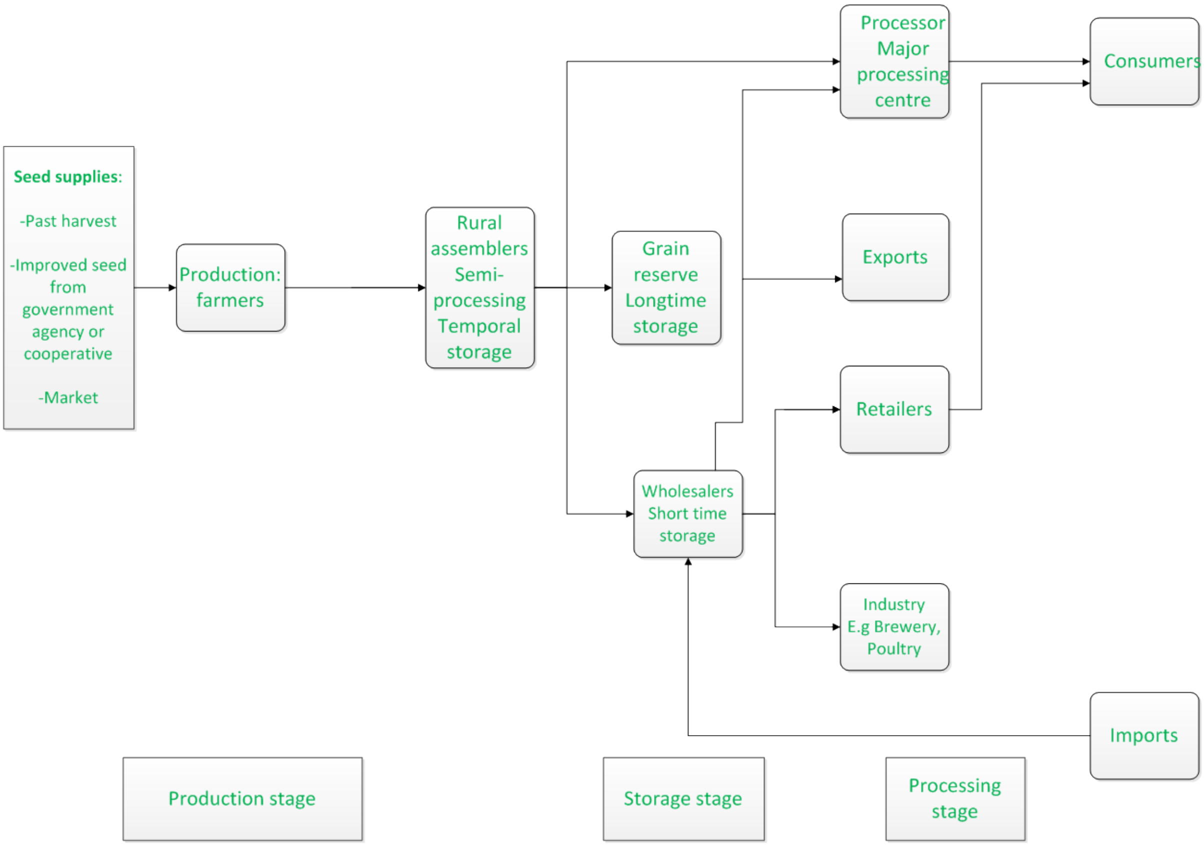


Figure 1; Grain chain in Nigeria.

[a]Figure 1 is adapted to Nigerian situation.

Agricultural supply chains encompass all of the input supply, production, postharvest, storage, processing, marketing and distribution, food service, and consumption functions along the farm-to-consumer. This is applicable for all forms of the given product (either consumed as fresh, processed, and/or food-service-provided), including the external enabling environment (LaLonde and Masters, 1994). Agricultural supply chains are networks that include flows of physical product and information. It begins from input suppliers to producers, in which the commodity proceeds to buyers and to final customers. The importance of agricultural supply chain management is in providing the right products (quantity), in the right amounts, to the right place, at the right time. Governments may get especially interested when such a supply chain has a particular strategic commodity of importance such as food sufficiency, food security or trade (import and export) and critical in the domestic food system. Agricultural supply chain risk management should be structured in such a way as to include the risks involved in other to leverage shortages and achieve performance objectives by farms, and supply chain as a whole. Some participants and services are specialized, whereas others are involved in several different supply chain functions (Jaffe et al, 2010). The agri-food system includes farmers and a diverse range of firms, including backward-linked input suppliers and forward-linked intermediaries, processors, exporters, wholesalers, and retailers. The main activities for direct supply chain entities are as follows:

Input supply*:* This involves production and distribution of inputs such as fertilizer, seeds, packaging, and other things needed in the primary production, processing, and/or trade of the local commodity.
Farm production: This involves primary agricultural production particularly on the farm, sale of a raw commodity at the farm gate or at some other point where the farmer hands over ownership of the

product to the next supply chain participant (depending on the crop, some type of primary processing such as the shelling or bagging of dry grain may take place at the farm level by rural assemblers). The common risks that have direct effect on this stage are risks regarding: weather, humans, biological, institutional and technical aspect. These risks can make the quantity of produce to fluctuate year to year and the farmer has limited or no control over it.

Processing*:* This is the transformation of agricultural raw materials into one or more finished goods through drying, canning, per-boiling freezing and many other methods. In this stage, the associated risks are weather, infrastructure, technical (such as machinery) and human risk.

Storage*:* This involves storage of farm produce temporarily at farm level or the next actor in the chain. The processed product can be store by wholesalers and retailers for onward movement to last actor in the chain. There also can be a long storage time by the government through grain reserves. The risks associated with this stage are weather, biological, infrastructure (storage facilities) and institutional risk.

Import and stock reserve: These are strategy measures employed in case there is shortage. This may be as a result of disruption activities when the quantity of rice is below the critical threshold.

Consumption: This is final output that is available for consumption.

In accordance with the Figure 1, table 1 shows the volume aggregates achieved at different points along the chain between 2000-2014. Table 1 also presents the average flow and uncertainty that occurs in rice supply yearly. This data shows that there is a fluctuation in the volume output that is being supplied from each stage. The uncertainty indicates the minimum and the maximum output that can be supplied from production and processing. The supply from production is what is being processed for final consumption. This table shows the current situation of rice production, processing and storage (which is yearly end stock) in Nigeria. The gap between level of processing stock and consumption is being filled by import.

Table 1: Production, storage and processing of rice (2000-2014) in Nigeria

Year	Production	Processing	storage	Consumption
2000	3.29*	1.97*	0.50	3.02
2001	2.75	1.65	1.01*	3.05
2002	2.92	1.75	1.35*	3.30
2003	3.11*	1.87*	1.00*	3.67
2004	3.33*	2.00*	0.62	3.75
2005	3.56*	2.14*	0.61	3.80
2006	4.04*	2.54*	0.62	4.04
2007	3.18	2.01	0.32	4.10
2008	4.17*	2.63*	0.48	4.22
2009	3.54	2.23	0.12*	4.35
2010	4.47*	2.82*	0.53	4.80
2011	3.56	2.87*	1.02*	5.60
2012	3.76*	2.37	0.88*	5.30
2013	4.40*	2.77*	0.65	5.80
2014	4.04*	2.55	0.61	6.10
Mean	3.61	2.28	0.68	4.33
SD	0.52	0.40	0.31	0.98
Min	2.75	1.65	0.12	3.02
Max	4.47	2.87	1.35	6.10
Normal mean*	3.82	2.40	1.05	-
SD*	0.47	0.40	0.17	-

USDA (2014), unit: million tonnes

*Normal mean: This is the average of volume assumed not to be affected by disruption over the period. This means the average volume supplied under normal circumstances. The normal mean will be used as the basis for normal flow in the model in materials and methods.

The above table shows the quantity of rice produced, processed and stored for the period of fifteen (15) years in Nigeria. This data was retrieved from the data base of United state Department of agriculture. It shows the amount of quantity that is being emanated from each stage. It is clear in the table that Nigeria is not producing sufficient rice to feed her population and still depends on import of processed rice from other countries. The average rice paddy that is being supplied by Nigerian currently is on average 3.61 mt per year, with a minimum of 2.75 mt and a maximum of 4.47 mt of paddy rice. An average of 2.28 mt is being processed from it (USDA, 2014). The milled rice supply also varies from 1.65 mt at its minimum and 2.87 mt at its maximum. This can be compared to average consumption of about 4.33 mt of milled rice and the standard threshold level of 6 mt of milled rice expected in 2015. In order to bridge this gap, Nigeria has always had the ability to, as a last resort, import milled rice. These mostly come from Thailand and United States which amount to an average of about 2.08 mt. This is also supported by study conducted by Akpan e tal (2012), on the shortfall in domestic production in Nigeria. In an attempt for Nigeria to reach its threshold level (sufficiency level), distribution analysis was done to account for the gap between the present supply and the projected threshold level.

2.2.1 Grain volume production in Nigeria

Grain serves as major staple food for the populace, and is used as feed for livestock and also by the brewery industry. The production of food grains traditionally occupies a major part of the Nigerian agricultural industry. Nigeria has 30.2 million hectare of arable land, has amongst the best and largest areas of arable land in Africa (Ohiwerei, 1997). Nigeria's milled rice production in 2013-2014 is forecast at 2.8 million tons, up from a revised 2.4 million tons in 2012-2013. However, industry analysts indicate the figure will drop below 2.6 million tons by 2014-2015 (USDA, 2014). Rice is cultivated in virtually all of the agro-ecological zones in Nigeria albeit with varying prospects. Rice is grown majorly in the middle belt, including the states of Benue, Kaduna, Kano, Niger, and Taraba. In the east, rice production typically occurs in the states of Enugu, Cross River, and Ebonyi. Ekiti and Ogun States are the major rice producing areas in western Nigeria (Izuchukwu, 2011). Rice production in Nigeria is still predominantly rain fed with an emphasis on lowlands. In line with previous findings, recent studies reflect a less than 10 percent use of irrigation amongst rice producers (Izuchukwu, 2011). However, consumption demand exceeds production levels such that Nigeria remains a net importer of rice. From about 1,400 tons of milled rice imported in 1965, Nigeria has imported between 500,000 and 1 million tons of rice between 2005 and 2007 (FAOstat, 2008). Despite numerous efforts and goals, Nigeria's rice production did not meet its target of food sufficiency in 2007. However, rice production has been on the increase from about 2.1 million tons at the turn of the century to 3 million tons in 2007 (Daramola, 2005).

2.2.2 Grain processing in Nigeria

Grain processing is very essential in the grain chain, because it changes the form of the grain to a well-accepted form by consumers. Most of the grain processing in Nigeria still occurs at a small scale level for individual small-scale level processors and their cooperative societies. Powered paddy (unprocessed rice grain) processing is still limited in many producing areas in Nigeria (Ogunbiyi, 2011). Thus, paddy processing in many rural producing communities still depends mainly on manual options. Due to credit constraints, usually no more than two threshing machines are available, even in rural communities with electricity. Many farmers sell their paddy unprocessed, which results in poor quality and low farm-gate prices. Where accessibility is an added problem (for example in; isolated markets), farmers must accept a further cut in the farm gate price from rural assemblers and/or rural wholesalers (FAO, 1992).

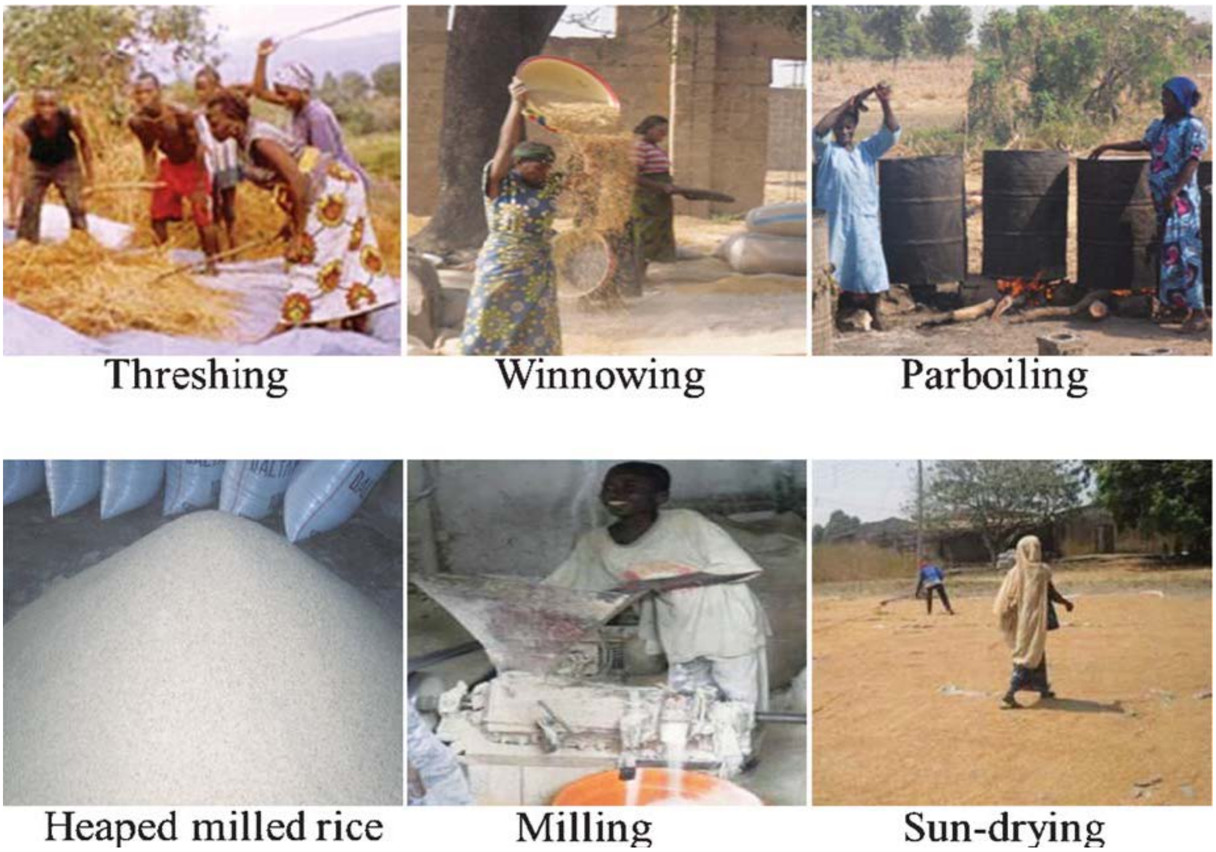
Figure 2 below shows the different texture of rice processed in Thailand and Japan compared to what is being processed in Nigeria. This has always made foreign rice attractive to Nigerians compared to the locally processed products.

Source: Ogunbiyi, (2011)

Figure 2: compare the processed rice from other countries against Nigeria

Usual in most parts of Nigeria, paddy rice processing is generally done away from the farm; rice stalks are cut by sickle and transported home. They are manually threshed and winnowed mostly by legs and sticks to obtain rough (paddy) rice. Nigerian rice is parboiled before it is milled. The paddy rice is soaked in water at 60 to 70℃ for 10 to 12 h (usually overnight). Thereafter, it is steamed for 20 to 90 min, depending on its quantity and the type of container used, until the kernels split. The steamed paddy is evacuated at the onset of kernel splitting and laid out on drying slabs (usually not elevated), tarpaulins, or mats to sun dry. At this stage, there is a danger of small stones becoming mixed in with the rice grains, thus reducing their marketability. All of these processes are done manually and can be laborious (Ogunbiyi, 2011).

Figure 3 shows different stages of rice processing in Nigeria. Though some high technology has started to surface, it has but is yet to become accessible to everybody at an affordable price. Therefore, a large number of people still use the methods depicted above.



Source: Ogunbiyi, (2011)

Figure 3: Various stages in rice processing in Nigeria.

According to Adewuyi (2004), the parboiling process takes over 16 h for a batch of 50 kg. However, the use of very large parboiling tanks, especially in Lafia, has made it possible to handle more paddy rice (from 400 to 600 kg per batch). The milling operation, which is the final stage of paddy processing to table rice, is traditionally done in Nigeria with mortar and pestle at the homestead level. Although mechanical rice mills and hullers are available in commercial plants in Nigeria, much of the rice milling is done by co-operatives, the largest of which is in Lafia, where there are more than 700 small Engleberg type abrasive mills which dominate the commercial processing of Nigerian domestic paddy rice (Overseas Development Institute, 2000).

Rice harvesting is basically done manually in Nigeria. Farmers can be faced with inadequate labour to meet harvest schedules; when labour is available, they are further faced with the need to pay high, and sometimes unaffordable, wages. The lack of available labour and excessive competition for existing labour can result in delayed harvesting and thus a poor quality harvest. Quality control of un-husked and un-milled rice presents additional problems in postharvest processing. In addition, weather extremities lead to high percentages of broken rice. Threshing, winnowing, drying, and cleaning (all of which are performed before parboiling and milling), and in some cases storage, are all still largely performed manually. This makes paddy rice processing very slow and encourages deterioration and subsequent poor quality of the milled rice (Ogunbiyi, 2011).

2.2.3 Grain storage in Nigeria

Storage activities are essential in agriculture, enhancing availability and price efficiency by providing utility. Storage is significant in agriculture because agricultural production is periodical, while the demands for agricultural commodities occur throughout the year. In this situation, there is the need to meet average demand by storing excess supply during the harvesting season for gradual release to the market during off-season periods. Inadequate post-harvest facilities has been one of the major issues in Nigerian agriculture for a long time. This has resulted in considerable waste of agricultural output and hence considerable loss to the economy. Nigeria is losing about 2.4 billion tonnes of food yearly to poor harvest and storage facilities (Olumeko, 1999).

Year-round grain availability is low in Nigeria due to a combination of low productivity and postharvest losses. Stored grains are partially lost to storage pests and diseases. An estimated 10 percent of the total production of grains, and 20 percent of the total production of tubers, are lost or wasted annually to poor storage or lack of storage (Babalola, 2003; Agwu et al, 2012). The losses were mainly in maize, rice, sorghum, millet, cowpea, groundnut, soya beans, yam, cassava, plantain and fruits. In monetary term, the country is losing a total of N48billion (€281 million) annually on post-harvest losses. It has been observed that different localities in Nigeria have peculiar storage methods depending on the types of crop grown (Adesida, 1988). It has been noted that farmers achieve varying degree of success in applying the basic principles involved in the safe storage of food (Birewar, 1990). The traditional grain storage structures in different parts of Nigeria are made of varying locally available materials. Usually, the type of locally available materials indicates the type of structures. The structures are made of paddy straw, split or whole bamboo poles, planks, reeds, robes, mud brick etc. Most of the structures are constructed at the beginning of harvesting season. The time of harvesting varies slightly throughout the agro-climatological zones, usually occurring between the months August and January. The grains are stored either in threshed or unthreshed forms. The different types of on-farm storage structure found in the three different climatic zones of Nigeria have been appraised (Igbeka and Olumeko, 1996; Olumeko, 1991).

Some structures are used for temporary storage (mostly intended for the drying of the crop), while others are for long-term storage. Temporary storage methods are grouped into aerial storage (maize cobs are sometimes tied in bundles, which are then suspended from tree branches, posts, or tight lines outside or inside the house), storage on the ground, or on drying floors and open timber platforms. Long-term storage methods include: (i) storage baskets (cribs or thatched rhombus) made exclusively of plant materials; (ii) calabashes, gourds, earthenware pots; (iii) jars; (iv) solid wall bins (mud rhombus); and, (v) underground storage (Nukenine, 2010). It is important to keep the grains cool and dry during storage. Deterioration of stored grains results from an unconducive environment which leads to the interactions of physical, chemical and biological variables existing in the system. Therefore, it is imperative to understand the inter-relations and interactions of these variables in order to design an effective control and management of these factors for safe storage (Hall, 1970). In Nigeria rice storage at the farm level is still small scale and is based on traditional uneconomic methods. Rice storage functions are mainly performed by grain traders within the cereals marketing chain. Lack of adequate funding of their storage activities leads to short-duration rice storage, as shown in Table 2.

The table below explains the length of period which paddy rice can be store before processing. These were the responses of some farmers when asked to answer how long they store their rice before sending it for processing or sell it out for processing. About 66.36% of the farmers store their paddy rice for about 2 to 4 weeks before releasing it out for processing.

Table 2: Length of rice storage (weeks) in Nigeria

Storage duration (weeks)	Number of farmers	%
< 2 weeks	37	33.64
2-4 weeks	74	66.36
> 4 weeks	0	0
Total	**111**	**100**

Source: Babalola, (2003)

2.3 Disruption risk in grain chain in Nigeria

Risk in agricultural food production is defined as an uncertainty (i.e. imperfect knowledge or predictability) because of randomness. It is regarded as the probability of losses resulting from incomplete control over the processes with which farmers are concerned (OECD, 2000). Farmers in Nigeria need to manage the risks associated with negative outcomes, which, ultimately, affect the quantity of rice produced. There are a number of risks that are accompanied with food production. This greatly impedes the effort of farmers in terms of their agricultural production and productivity. This risk mainly derives from extreme weather shocks, such as drought, floods and erratic rainfall. Other risk such as biological factors, which include insect pests, and crop diseases, are recurrent events affecting agricultural production. Indeed, climatic and biological events may hit the overall farming system of a certain area in the country and this may have serious implications on how to deal with agricultural risks (Antonaci et al, 2014). Agricultural production as observed in Nigeria is affected by weather and climate which dictate outputs. We usually observe long spells of drought; torrential rainfall and flooding could seriously disrupt production and lead to fall in supply of agricultural commodities (Oguoma et al, 2010).

Adejuwon (2005), reported that in a year with low precipitation, crop yield sensitivity becomes more pronounced. Changes in climate and atmospheric composition can negatively affect food supply at the household community, and national levels through the biophysical conditions of farm lands, including excessive moisture and heat, drought, pests, diseases and weeds. In addition, food supply is influenced by yield, which is in turn influenced by climate conditions that can be direct through damages on crops harvested or whilst still on fields waiting for harvesting, or indirectly through biophysical conditions. All of these could result in lower crop yields and reduced total production, as well as considerable management problems (Kulshreshtha, 2011). Grains constitute the bulk of production in Nigeria (Nukenine, 2010; World Bank, 2011). This is one of the key contributions to ensure food security in Nigeria. However, there is problem of poor post-harvest management that leads to losses of 20–30 % grain volume, with an estimated monetary value of more than US$4 billion annually (FAO, 2010). The situation of low crop yields has been blamed for food production problems in Nigeria, but this is not the only major problem. Nigeria suffers also huge losses as a result of post-harvest problems. This leads to 20–30 % of the yield of the crops harvested never reaching the consumer. These losses contribute to hunger and high food prices by removing part of the supply from the market, therefore increasing scarcity and increasing food prices. Post-harvest losses (PHLs) denote a measurable decrease of food grain across the post-harvest system which may be quantitative, qualitative and economic (De Lucia and Assennato, 1994; FAO, 1977). Food loss is a subset of PHLs and represents the part of the edible share of food that is available for consumption at either the retail or consumer levels, but is not consumed for various reasons (Hodges et al, 2010). The postharvest system comprises interconnected activities from the time of harvest through crop processing, marketing and food preparation, to the final decision by the consumer to eat or discard the food. Quantitative loss denotes reduction in volume. This can be quantified and valued (FAO, 2010).

Furthermore, post-harvest operations for maize follow a chain of activities starting in farmers' fields and leading, eventually, to consumers in a form they prefer. When determining the losses that may occur in this chain, it is conventional to include harvesting, drying, threshing, transport to store, farm storage, and transport to market and market storage (FAO, 1977). Losses of maize attributed to the threshing and shelling process might be caused by grain cracking, breakage, and partial or total consumption by insects and birds (FAO, 2010). In addition to this problem, it is important to mention storage loss in detail. Storage losses depend upon temperature and humidity, which may encourage growth of mould and create conditions conducive to insect infestation. The type of storage structures or containers used, the duration of storage and the storage management implemented prior to, and during, storage also affect storage losses (World Bank, 2010; Nukenine, 2010). Traditional African storage structures expose the grain to rodents and to insect attack and provide favourable climatic conditions for their proliferation, as well as for micro-organisms (Ngamo et al, 2007). Although relatively simple and inexpensive to construct and maintain, traditional storage systems that are not air tight lead to substantial post-harvest losses (Mughogho, 1989).

2.3.1 Causes of disruptions

According to Lire et al (2000), the major risks in the grain chain comprised failure of farming methods, storage and processing. The natural causes of risk include losses due to pests and diseases, and perishing of products. It also includes those losses due to adverse or unfavourable weather conditions such as highly erratic rainfall, high humidity, drought and flood. Other risk factors that constitute risk to rural farmers are commodity price fluctuations, poorly functioning or missing markets for inputs and outputs, unexpected changes in policies, and unstable government (Horace, 1959). Farming is a risky occupation because, to some extent, it faces a lot of risks. It is risky because results depend relatively on certain factors over which the farmer has no control. Agriculture operates under uncertain conditions and factors which the farmer can only influence to a minimal degree. For instance, they have no control on frequent rainfall, face difficulties managing certain sudden attack of locusts and they cannot stop the outbreak of serious diseases fatal to crops. With respect to this, farmers need to develop strategies that could help minimize the effects of such risks in the event of their occurrence. According to Dupriez and Leener (1988) and Dalton (1982), the risks farmers face fall under the following five major headings:

Weather risks and natural disaster

This comprises of weather factors such as erratic rainfall, high humidity, wind storm, flood and drought. Weather hazards subject farming to uncertain effects. For instance, if rainfall is inadequate, untimely, or fluctuates, plants dry up and yields are in jeopardy. At times, sudden hurricanes flatten plants to the ground, which can cause enormous losses in crop yield. A spell of exceptionally cold weather destroys flowers and young fruits. In fact, there are many varied ways of combating weather risks, but there is no adequate or full proof way of protecting crops from bad weather (Donye and Ani, 2012). Recently in 2012, two major flood events took place between the months of September and October in Nigeria. These were due to Cameroon releasing waters from their Ladgo dam. This water flooded a major river in Nigeria. These events made most of the country's rivers overflow their banks and submerged hundreds of kilometres of urban and rural lands. It had a serious negative effect on crop production as many crop farms were eroded. The main attribute of the severity of the flood disasters in Nigeria that year lies in the fact that they were sudden and unexpected. Most of the central states of Nigeria and other surroundings states along the rivers Niger and Benue were seriously destroyed. This caused huge destruction to the rural and urban infrastructures (farmlands/crops, roads, buildings, drainages, bridges, power-lines, etc.) and socio-economic lives of the areas (Ojigi et al, 2013).

Rainfall and humidity, which affect moisture content, is a key issue during and after harvest. In Nigeria, farmers rely mostly on sun drying to ensure that grains are well dried before storage. If unfavourable weather conditions prevent grains from drying sufficiently, there will be a great loss. Should climate change lead to more unstable weather, including damper or cloudier conditions, PHLs may increase. Weather factors are key determinants of grain losses. In hot, humid climates, farmers typically use open storage structures to allow a substantial airflow. Conversely, in hot dry climates farmers use sealed storage with no airflow as the grain enters the store fully dried (Peel et al, 2007). Climate change is likely to exacerbate post-harvest losses. This is due to, among other things, a combination of changes in various climatic variables, such as temperature and humidity. This may lead to an increase in the number of pests and diseases which attack stored grain, as well as create the environment for new insect pests to flourish (Paterson and Lima, 2010; Deffenbaugh et al, 2008).

Biological and environmental-relater risks

According to Meuwissen et al (2001), attributed production and disease risk as major biological and environmental problems farmers faced with in their production activities. Insects and fungi are the most common causes of losses of stored maize in tropical or subtropical countries. The speed with which they multiply is influenced by the prevailing environmental conditions (Nukenine, 2010). Fungi, in particular, attack maize and contribute to both quantitative as well as qualitative loss in food value. This decreases the monetary value of the crops (Lewis et al, 2005). Plant health is subject to certain hazards. They may be attacked by microorganisms carrying diseases. They may also be eaten by caterpillars, slugs, insects, and rodents, monkeys and loose animals which devastate crops. Other biological risks include pest attacks, rotting and fermentation, or damage caused by wandering animals. Other biological factors that cause uncertainties in food production are the diseases in crops, diseases in cattle, the quality of the implements used by farmers, and so on (Donye and Ani, 2012).

It may happen that a farmer or processor is ill or dies. For instance, the ongoing humanitarian crisis in North Nigeria has forced some of the crop farmers and pastoralists to abandon their farms, homes and migrate to the neighbouring countries of Niger, Chad and Cameroon for the safety of lives. This has drastically affected agricultural production in the region. In March 2008, the National Emergency Management Agency (NEMA) recorded about 65 per cent of northern farmers had migrated to the southern part of Nigeria because of the insecurity they faced (Obioha, 2009). The terrorist attacks on small-scale farmers and mechanized farmers in the Nigeria's northeast serve as part of disruptions that mitigate the commodity movement achieved along the grain chain. Most of these farmers who produce beans, onions, pepper, maize, rice, livestock and catfish in the Lake Chad area for the southern states, have been forced to migrate to another part of the country in which they cannot continue the farming process. This is not only applicable to production alone; all stages are affected as the actors responsible for actions in the various stages have been affected by displacement (Eme et al, 2014)

Technical risks

Technical risks are those which comprise of failure of farming methods, storage and processing, and imperfections in the transport systems. There can be a risk of theft, fire, and damage of equipment, buildings and other working implements for agriculture and processing. The implements have different levels of sophistication. It can be operated manually, by animal traction, by a motor or a machine. Dalton, (1982), reported that the characteristics of agricultural inputs influence the way they are used. These implements complement one another to make effective use possible. Production and processing will be limited by the unavailability of one particular input. In addition, the response in output to a change in the level of a single input will depend on the level and variation in the level of all other inputs. However, mechanical breakdown may occur at a critical time of food production (Jaffee et al., 2010). For example, when a plough develops a fault, it may take sometimes for the farmer or processor to get repair parts and this can result to setback in production and processing activities. Farmers can also be confronted with a lack of the technical knowledge about the existence of these production implements. Also, there can be untimely delivery of these inputs which might constitute a great measure of uncertain in food production.

Political and institutional risks

This is a very serious issue when it comes to agriculture in Africa and Nigeria is not an exception. Policies instability is one major problem that limits farmer's production in Nigeria. The policy about import and export keep on changing without long periods of stability. This has made farmers sceptical about producing large quantities, because this may result in price uncertainties. According to CBN/NISER (1992) reports, prior to the policy reforms in Nigeria, trade policy was inward looking and perceived mainly in terms of protection for the growing of the domestic manufacturing industry that was largely import dependent. Little consideration was given to the stimulation of export of both agriculture and domestic products. For several years, a large import of food, especially grains such as wheat, rice and maize were allowed into the country at very cheap prices. This eroded the competitiveness of domestically produced grains, a situation that acted as a major disincentive to farmers through ultimately creating a state of uncertainty for farmers in rural societies. They would not produce such crops on large scale for fear of losses of produce due to lack of good storage facilities and also the possible sales at lower prices. In addition, policy on fertilizer procurement and prices has been dwindling overtime. Fertilizer consumption steadily declined from the earlier growth path of the 1960s to the mid-1990s when its use by farmers was encouraged by availability and reasonable prices. The usage has been reduced drastically due to availability and affordability difficulties occasioned by government procurement and distribution inefficiencies. Furthermore, fertilizer consumption is too low in Nigeria being 10-12kg/ha and whilst agrochemicals (pesticides, herbicides, etc) access still a luxury to farmers, less than 10% of potential demand is currently met (Azih, 2008).

Infra-structure risks

This refers to the problem of machinery breakdown, which leads to a shortage of volume supplied from processing. This may lead to significant losses if is not fixed in time. In addition, infrastructure risk also refers to the absence of the necessary equipment in storage houses. Most of storage facilities by farmers in Nigeria are locally made such as mud rhombus, thatched rhombus, in-hut storage such as earthen pot and warehouse storage. This may be inefficient to store grain for long time. Also, inadequate capacity may be detrimental (Echiegu, 2013). For instance, construction of the silos in Nigeria was through extra-budgetary allocation but by late 1992 when the government stopped extra-budgetary expenses, funding became grossly inadequate, resulting in the abandonment of the 25 on-going sites by the construction contractors at various levels of completion. An investigation revealed that about 3720 mt of grain was currently in stock. Therefore, the capacity utilisation of 186,000 mt was under-utilised (Olajide and Oyelade, 2002). Table 3 shows disruption factors and their various forms of occurrences.

Table 3 : Summary of disruption risk factors and their examples

Type of risk	Country	Examples	Sources
Weather-related risk	Nigeria and Thailand	Erratic rainfall, high humidity, excess temperature, rainfall untimely	Donye and Ani, 2012, Peel et al, 2007, Thongrattana, 2012
Natural disasters	Nigeria	Flooding, drought, fire, wind storm	Banmeke et al, 2012, Ojigi, et al, 2013,
Biological and environmental-related risk	Netherlands	Pest and disease, animal attack, illness, death rotten and fermentation	Deffenbaugh et al, 2008, Meuwissen et al, 2001, Paterson and Lima, 2010
Political and Institutional risk	Ghana and Nigeria	Policy instability, failure of policy implementation, distribution inefficiency of government incentives, governance-related risk and uncertainty (e.g, corruption), Security-related risk and uncertainty, terrorism, war	Azih, 2008, Christopher and Lee, 2004, Cudahy et al, 2008, Dorosh et al, 2009, Eme et al, 2004, Yeboah et al, 2014,
Infrastructure risk	Nigeria	Facility breakdown, inadequate equipment, degraded and undependable transport system, energy supply failure, yield of rice (e.g milling and packaging) can vary	Olajide and Oyelade, 2002,
Technical risk	Nigeria	Machinery breakdown, unavailable of spear parts, technical know-how, untimely delivery of input	Adekunle et al, 2009, 2012, Jaffee, et al, 2010

2.4 Risk prevention (Ex ante) management and coping strategies at different points of grain chain in Nigeria

Dinar et al (2008), defined adaptation strategies as measures used beyond a single season that are needed to respond to a new set of evolving conditions (biophysical, social and economic) not previously experienced. Conversely, coping strategies have evolved over time through people's long experience in dealing with the known and understood natural variation that they expect in seasons combined with their specific responses to the seasons as it unfolds. Rural farmers in various places have been reported to adopt some risk prevention strategies in response to some uncertainties and risks that are encountered in their agricultural activities (Donye and Ani, 2012).

2.4.1 Prevention strategies

According to Dupriez and Leener (1988), farmers are faced with many food production uncertainties in rural areas. The most common risk prevention strategies identified in Nigeria range from production strategies such crop rotation, mulching, water harvesting, irrigation, improved water use efficiency, breeding for heat or drought tolerance, use of improved seeds, dry season farming, early harvesting, planting of trees to serve as wind break against incidence of storm, and use of disease resistant seeds, (Antonaci et al, 2014). These local means of risk prevention methods tend to fail in the presence of larger shocks affecting large areas of the farm (Akpan, 2012). The processors make sure that spare parts are available, or are at their disposal where they can easily access it in case of machinery breakdown. Also, farmers seek information from extension agents on weather forecasts.

2.4.2 Coping strategies

These strategies involve measures taken by actors in the chain to manage risk. This includes income diversification activities (such as engaging in off-farm work to complement the income from farming), mixed farming system (such as rearing animals to compliment income), and use of agrochemicals against diseases and pest infestation, crop diversification, insure farm, mixed cropping, and income reserve (Akindele, 2015). The processors take contracts and insurance of their processing facilities.

2.4.3 Strategies for reducing post-harvest grain losses

In order to reduce post-harvest grain losses there is a need to maintain grain moisture content at acceptable levels. To minimize the risk of mould growth and mycotoxin contamination, maize grain should have moisture content between 12 % and 13 % for storage in bags, or below 12.5 % for bulk storage in bins or silos deterioration (Pixton and Warburton, 1971). Tefera et al, (2011c), reported in his paper that the use of high yielding maize varieties with resistance to post-harvest insect pests is important, particularly to prevent maize weevil and larger grain borers. He also mentions in his work that a potential option to minimize storage losses is to use resistant varieties which possess chemical compounds that deter insect feeding or inhibit their growth. Some of these varieties have a tight husk cover and ear tips, creating inaccessible conditions for insect infestation. These varieties may also reduce the potential risk associated with consumption of treated maize with insecticides and they are generally compatible with other insect-control methods.

Furthermore, there are two new storage technologies which have been developed and are being promoted in Africa. These are super grain bags and metal silos (Tefera et al, 2011a,b,c; Kimenju and

De Groote, 2010). The super grain bag, also known as the IRRI super bag, has been used in rice storage, but is also suitable for storage of other cereals (Kimenju and De Groote, 2010). Actellic super has been adopted by small scale farmers for grain storage in Kenya as well as other countries in Africa. Actellic super is a cocktail of 1.6 % Pirimiphosmethyl and 0.3 % Permethrin. It has been promoted as a chemical which is effective against the LGB in combination with practices such as immediate shelling and treating (Farrell and Schulten, 2002). Effective grain storage plays an integral part in ensuring the domestic food supply and in stabilizing food supplies at the household level by smoothing seasonal food production (Tefera et al, 2011a).

2.5 Government risk management strategies (ex post) in Nigeria

The post-harvest storage systems in Africa need considerable investment in order to improve their performance to a point where PHLs can be substantially reduced. For grains, it may include inventory credit schemes and warehouse receipt systems to accelerate the efficient removal of the grain from the farmer into safe centralized storage (Coulter and Shepherd, 1995). Public and private sectors need to develop, invest, and manage, the introduction of interventions and prevention strategies. The following are the coping strategies develop by Nigerian government:

2.5.1 Grain reserve in Nigeria

The Strategic Grain Reserve Storage Programme (SGRSP) was established in 1989 in anticipation to increase levels of grain production. This was as a result of the government's determination to fulfil the FAO declaration that member countries must hold a minimum food reserve sufficient to sustain its population for 90 days in case of famine, national disaster or war. In order to realise the above mentioned objectives and to provide adequate food for the Nigerian populace, the Federal Government through the Ministry of Agriculture started the construction of 33 metal silo complexes with 25000t capacity for grain storage (Adejumo and Raji, 2007). For the purpose of this ten (10) hectares of land were acquired for each of the complexes all over the country. However, only four (4) ha were developed, leaving six (6) ha for future expansion. The complexes were built on well drained, firm land and connected to the national grid (PHCN) to supply electricity. They were also located near major trunk roads for easy accessibility. The following service buildings and facilities were provided at all the food reserve location: (a) control room; (b) bagging plant; (c) warehouse; (d) spare parts store; (e) weighing room (30 t capacity); (f) quality control laboratory; (g) administrative block; (h) standby generator (380KVA); (i) fuel station; (j) borehole with reserve capacity of 2500 gallons per day for water supply; (k) two 250 t/h cleaners to remove foreign bodies which could damage conveying machinery; and, (l) two dryers (batch type) with capacity of 30 t/h for drying incoming grain with about 18% (w.b) moisture on arrival (Babalola, 2003).

Food grain storage policy in Nigeria requires 5%, 10% and 85% storage of total annual grain output at the federal, state and on-farm levels, respectively. At the federal level is the strategic grain reserve held for the Nation's food security. At the state level is the buffer stock for both price stabilization and planting materials for the upcoming season (Umeh et al, 1996). Government interventions in commodity storage are mainly designed to stabilize prices, ensure food security in time of disasters, and to support producers. The strategy used to achieve these is management of grain reserves. Strategic stocks may be publicly-owned and managed, or could be privately held commercial stocks governed by national rules set by national governments (OECD, 2012). Presently, Nigeria has the following grain and their corresponding amount in the national grain reserve: corn (8,735 tons), sorghum (7,227 tons), millet (2,299 tons), soyabean (9,800 tons), paddy rice (6,000 tons) and garri (1,476 tons) (USDA, 2014). Under the Strategic Grains Reserve Programme (SGRP), government acts as the buyer of last resort for farmers produce. Eight of the planned metal silos have been completed nationwide, with the capacities listed in Table 4.

Table 4 shows the available storage facilities in Nigeria. The storage is based in different states within the country. The reserves ensured that the country have a stock in case there is disaster such as famine, so that the government can dissipate shortages of food grain. The United Nation has made it mandatory that every country should have certain amount of food in their storage reserve.

Table 4. Government installed grains storage capacities of completed metal silos under the SGRP

Location	State	Capacity '000t
Lafiagi	Kwara	11,000
Minna	Niger	25,000
Gombe	Gombe	25,000
Akure	Ondo	25,000
Ogoja	Cross rivers	25,000
Irrua	Edo	25,000
Makudi	Benue	25,000
Jahun	Jigawa	25,000
Total installed capacity		**186,000**

Source: Olajide and Oyelade, (2002)

Lack of funding has slowed completion of the other silos and limited the full utilization of completed ones. For example, the eight completed ones held only 3.72 thousand mt of assorted grains in 1999. These storage levels cannot meet requirement during a food disaster or encourage more production. Also, farmers have no direct access to government silos (Babalola, 2003). Because farm-level grain storage may not deliver the benefits of large-scale storage, the government has put in place capital-intensive storage structures in various parts of the country. Under the National Food Security Programme, the government assigned grain storage responsibilities to the three government tiers as follows in Table 5:

Table 5 depicts the programs started by the Nigerian government by different arm of government, and the percentage of volume of grain each strategy program should acquire at different tiers of government. The strategy that has the highest percentage (75% of on-farm adaptive storage) is at local government level. The reason is that the local government is the arm of government is most close to the people.

Table 5. Grains storage responsibilities by Federal, State and Local government

Programs	Minimum % of grain to be held at different levels of government own storage (critical thresholds at various level)	Arms of government
On-farm adaptive storage	75%	Local government and interested foreign organizations
Buffer stock reserve	20%	State
Strategic grain storage reserve	5%	Federal

Source: Babalola, 2003

2.5.2 Import strategy

Being the largest market in West African, Nigeria plays a pivotal role in the regional economy. Policies implemented in the country also have far-reaching effects on the economic positions of other countries throughout the region. The country is also of significant strategic importance for the United States in the non-oil trade as it is amongst the world's largest importers of U.S. wheat, with purchases valued at $959 million in 2013 (USDA, 2014). Large demand by Nigerian breweries creates market opportunities for sorghum imports. The GON is also encouraging the utilization of sorghum to produce nutritious fortified foods, typically blended with soybeans for school feeding programs. This is used by the World Food Program food aid programs for Chad, Niger, Mali and Benin (USDA, 2014). Nigeria's import of polished/milled rice was estimated at 2.6 million tons in 2012-2013, a drop by 200,000 metric tons as compared with the import figure for 2011-2012. (USDA, 2014).

However, this has reversed and the volume of imported rice entering the market has grown higher as imported rice has become more available and still sells at lower prices than rice produced in Nigeria. Nigerians also generally prefer parboiled long grain, polished and de-stoned imported rice over local varieties. Nigerians have continued to feed on imported rice that enters the market through the increased cross border informal rice trade. There is also inadequate infrastructure to produce and bring local rice to markets in urban areas at competitive prices when compared with imported rice. These are part of the reasons why local rice continues to cost more when compared with imported rice.

2.5.3 Agronomic support

There is government policy in place to increase domestic rice production in order to make the country self-sufficient in rice production by 2015, when rice imports will subsequently be banned. Attempts have been made to reach farmers with required inputs of fertilizers and improved seeds. However, implementation has been spotty and all supporting infrastructure is grossly inadequate. Many farmers continue to state that the GON policies and efforts have had little or no impact on their production (USDA, 2014). These policy measures rekindled an interest in agriculture on the part of many Nigerians and Nigerian organisations. The government (federal, state and local) through different agencies like Agricultural Development Projects (ADPs), Directorate of Foods, Road and Rural Infrastructure (DFRRI), National Agricultural Land Agency (NALDA) made efforts to increase food production through incentives given to farmers and organisations in the form of farm inputs, tractor and equipment hiring services, land allocation, provision of land clearing and preparation facilities, irrigation, and agricultural extension services. To ensure that farmers can cultivate crops throughout the year in the north of Nigeria, dams with irrigation facilities and irrigated land (FADAMA) were provided by the government. More farmers in the north of Nigeria are engaged in FADAMA agriculture than in the south as a way out of problems of short rainfall duration (Adesiji and Obaniyi, 2012). It would be important to foresee specific interventions that the government can put in place, together with the private sector, in order to decrease the losses faced in case of extended drought or other natural disasters. These interventions can include the development and support of specific financial services, agricultural insurance products and development of appropriate technologies. Another possible intervention that the government can put in place to support producers is the implementation, in the context of disaster risk management of well-designed farm safety nets schemes. It should be noted that more recent approaches to disaster risk management have emphasized the necessity of constructing more resilient food production systems and livelihoods which are more capable to absorb impacts and deal with negative effects of disruptive events (FAO, 2011; WFP, 2011).

Chapter 3

3. MATERIAL AND METHODS

The conceptual framework was structured to capture and explain the model for the study. The output and input parameters are explained and the data necessary for the analysis are stated. The threshold for each stage is also stated. The risk indications are explained to illustrate strategies for output management. The impact of the occurrence of disruption is also provided.

3.1 Conceptual framework

Figure 4 describes the design for the model built in Microsoft Excel for the analysis of specific objective four. It captures the disruption impact at the different points of the chain. The model explained as thus, if the volume supply from the stages is below threshold level due to disruption impact, then risk management strategies will be applied to dissipate the shortages. This brings the volume back to threshold level and the expected output supplied at different points. Also the cost implication for each strategy is evaluated to identify the most cost effective strategies. It is assumed in this model that the output of one stage is an input of next stage. However, it's important to mention that storage stage would not be investigated in the model due to short supplied of milled rice at the processing. Therefore, storage stage is not part of the model. This is included in the conceptual framework because it could be used for other grains that have excess supply at processing.

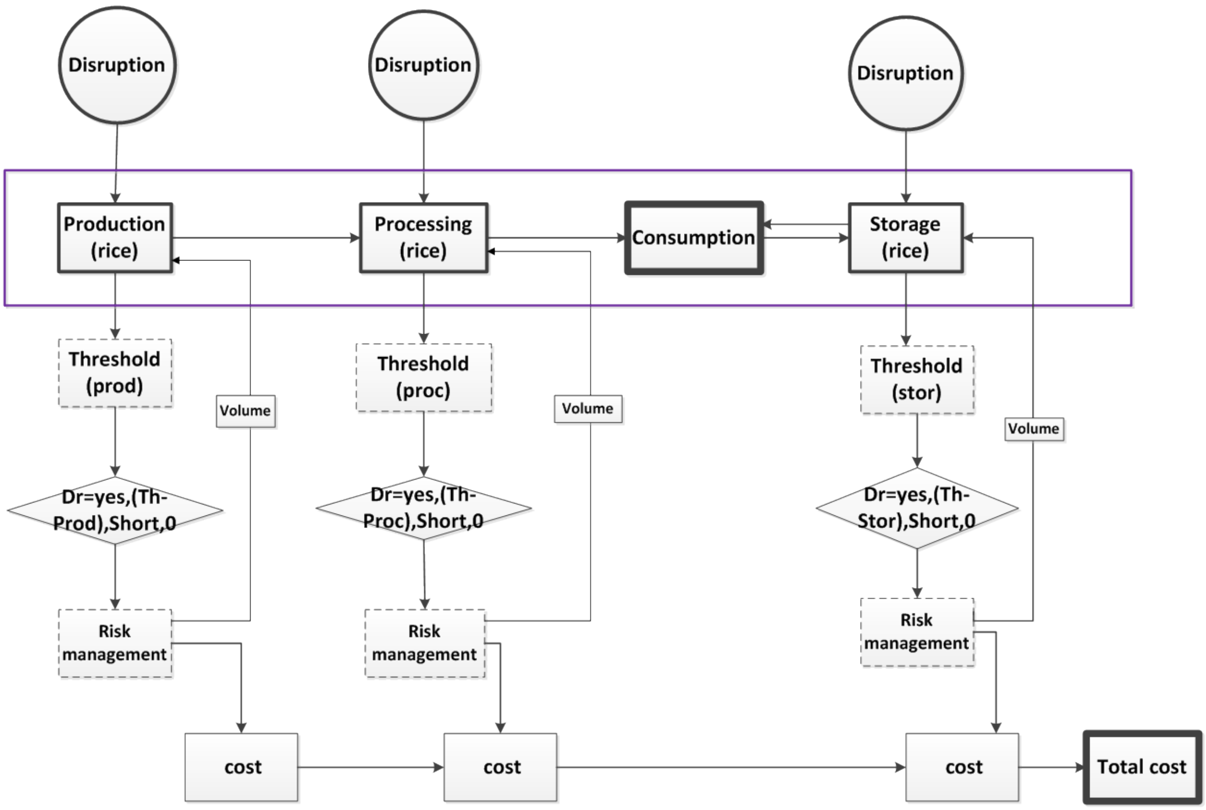


Figure 4: Schematic simulation model structure

Bold boxes: These indicate that both disruption and chain stages are stochastic.

Dash boxes: These indicate both threshold level and risk management strategies are deterministic.

Double bold boxes: These indicate the output (the actual quantity available for consumption) and total cost of risk management strategies.
Purple bold box: It indicates that all the stages are on the same chain.
The model is built in Microsoft Excel and IF function is used to determine the uncertainties as follows:, if disruption occurs, output supplied is reduced, when the output corrected for impact is deducted from thresholds, it gives the amount of shortage caused by impact of disruption, then risk management strategies are applied. This will be added back to the initial quantity at the stage. In a case where the quantity is equal or greater than thresholds, then no need of risk management strategy.

In figure 4, only disruption risks occurring in the stages are investigated. Therefore, we assumed there is no disruption risk between the stages. Note: these model shows what happens if there is disruption occurrence, if the commodity falls below the critical threshold as a result of disruption impact, the risk management strategies are applied. This will be added back to the commodity available to meet with the set threshold level. Also the cost for quantity applied is being evaluated.

The above model shows the commodity flow and the effect of disruption factors on the quantity that comes out from each stage of the chain. The quantity supplied from production to processing, where the paddy is being removed, then ready for consumption. As shown in figure 5, we store the excess quantity that may remain after consumption. This is part of stock available for next year consumption. The effect of disruption results in quantity uncertainty which makes quantity less than critical threshold level. This has a number of implications on each actor in the chain. These implications may be shortage of grain to processed, stored, low income and consumption. In other to meet the threshold level, actors or the government have to drive some strategic measures such as import, stock reserve or increase grain production to upgrade the quantity to threshold level. The above framework shows the quantity of grain supplied from production, processing and storage activities. Firstly, it shows the normal flow of quantity, which may be equal or more than the threshold level, and, second, it shows the uncertainties in the quantity achieved as a result of disruption events.

3.2 Data

Input

The inputs for the model were gathered through a literature review (Daramola, 2005; USDA, 2014). This consists of different parameters fitting in the model. These parameters include the following; average flow, disruption factors, impact, threshold level, risk management and cost. In some cases, assumptions are made where the specific data could not found.

3.2.1 Average flow

Normal commodity flows at different points over a period of 15 years (2000-2014) were determined to find the average quantity flow and the fluctuation over the years. Table 6 shows average volume supplied from production and processing, and what consists storage after consumption. The reason for these 15 year data is to give the average volume on which subsequent analysis is built on.

Table: 6 Average rice quantity flows over a period of 15 years

Chain stages	Unit	Normal Mean	SD	Country	Period	Sources
Volume of production (paddy rice)	mt/year	3.82	0.47	Nigeria	2000-2014	USDA, 2014
Volume of processing (milled rice)	mt/year	2.40	0.40	Nigeria	2000-2014	USDA, 2014

Data from United Department of Agriculture on Nigeria grains: http://apps.fas.usda.gov/psdonline/psdQuery.aspx

The above table shows the average and standard deviation of rice grain supply, processed and stored per year over a period of 15 years in Nigeria. The above data were collected from USDA on rice in Nigeria. This gives the average production and processing over the period of 15 years. It is shown in the above table that Nigeria produced 3.82 mt of paddy rice per year on average and processed 2.40 mt of milled rice per year. The average volumes listed in the table above are volumes of paddy and milled rice supplied in Nigeria under normal circumstances. This shows there is no effect of disruption on the normal mean in the table.

3.2.2 Disruption occurrence

Table 7 gives parameters of disruption event based on assumptions relevant to Nigeria situation and supported by expert experience (Akindele, 2015; Taru, 2015; Enete, 2015). The frequency, period of the event and impact of disruption, as shown in the table, were assumed because there is limited data on it. The volumes supplied were corrected with disruption effect to give the impact. Parameters of the disruption factors can be input in the distribution function in Microsoft Excel when incorporated into the model design.

Table 7: Data for disruption factors distribution

Disruption types	Parameterisation[a]	Time unit	Period	Frequency[b] (this is the number of times the event occurred within period	Country	Percentage impact on volume supplied[c]	Sources (Personal communication)
Weather/ Natural disaster	0.50	Frequency /year	2008-2011	2	Nigeria	({1, 2, 3, 4} {10%, 20%, 30%, 40%})	Akindele, 2015
Political instability	0.43	Frequency /year	2006-2012	3	Nigeria		Enete, 2015
Biological risk	0.57	Frequency /year	2007-2013	4	Nigeria		Akindele, 2015
Infra-structure risk	0.66	Frequency /year	2004-2006	2	Nigeria		Taru, 2015

[a]Parameterisation: This is the number of occurrence per period.
[b]Frequency: Measure the number of times the event occurred within the year with respect to the mean.
[c]Percentage impact on volume supplied: This is the percentage of impact based on the number of occurrences of disruption

on the normal volume to give the volume supplied corrected for disruption. It can be interpreted as follows: if disruption event happened once within a year, it will has 10% reduction in average volume supplied, if the disruption event happens twice within a year, it will has 20% reduction in average flow, if the disruption event happens three times within a year it will has 30% reduction in average volume supplied, whilst if it happens four times within a year it will has 40% reduction in average volume flow.

The experts were able to give the percentage of reduction in volume supplied if the above disruption factors happened. The percentages were calculated from the average volume supplied to give the impact of the disruption on the volume available for consumption at different points in the chain. Experts also stated that it was possible that all of the disruption factors could occur at the same time.

3.2.3 Threshold policy standard

Nigeria's threshold levels for rice supply are indicated in the table 8. These thresholds were given based on the policy study done for the Nigerian government on the projection of what volume of rice Nigeria should need supply to feed its population without depending on input by 2015.

Table 8: Nigeria threshold policy standard

Chain stages (Rice)	Thresholds level	Time unit	Sources
Volume of Production (Paddy rice)	10.3 mt	mt/year	Daramola, 2005
Volume of Processing (Milled rice)	6.0 mt	mt/year	Daramola, 2005

mt: Million tonnes.

Data from table 8 was retrieved from a projection study done by Daramola (2005), on rice sufficiency in Nigeria. It was projected that before Nigeria can boast of full supply of rice that can feed its population, it must be able to supply the amount stated above as its sufficiency level. This means anything below this threshold level has fallen below the critical level, therefore, something has to be done to maintain the standard critical level. For Nigeria to be rice self-sufficient, the country must produce on average 10.3mt paddy rice per year and should be able to process 6mt milled rice per year from the paddy. With this, Nigeria can feed the population without depending on import.

Table 9 shows the management strategies applied when there is shortage of rice. Currently in Nigeria, the strategy applied to dissipate shortage is the import of milled rice. Though, the Nigerian government is making all efforts to ensure efficient production that can supply enough paddy rice to feed the population.

Table 9: Policy and risk management strategy

Chain stages (Rice)	Strategy	Cost/unit[b]	Sources
Volume of Production (Paddy rice)	Increase in production[d] (give incentives to farmers to increase the hectare of land in the following year, subsidize fertilizers and provide irrigation), this is the strategy adopted in this study. Other strategies suggested are Stock reserve of paddy rice and import of paddy rice to be processed in Nigeria.	€482 per tonne	Adesiji and Obaniyi, 2012
Volume of Processing (milled rice)	Import of milled rice, import of paddy rice[a] (trade by barter[c]; export surplus grain, such as maize to other countries and get rice in return or complement rice with substitutes such as maize or sorghum)	€520 per tonne	Olayide et al, 2011

[a]Import paddy: Initiative is being consider by government but no huge step has been taken (Ukaoha, 2005). Though it has started but is on minimal rate, there is limited data on it.

[b]Cost per unit: This is the amount that is expected cost one million tonnes of rice from increase in production and import of milled rice.

[c]Trade by barter: This can be in form of exchange between two countries such that Nigeria supply the grain(maize) they have in excess stock and get back rice for an exchange.

[d]Increase in production: These were sum up of activities to increase production. Therefore, with activities, the output was quantified to be 10.3mt of paddy rice, that is, if these activities can be ensured and sustained, supply will reach this amount.

Table 9 presents risk management strategies adopted in case of rice shortages and their corresponding cost. While the cost for production and processing were retrieved from literature. In addition, the strategy applied for each activity was enumerated above based on literature reviewed. The quantity flow was determined from the difference between normal flows and the threshold level to give the volume of shortages.

3.3 Simulation model

Simulation analysis is used to model disruption factors. These are based on the probability distribution of the occurrence over a period of years. This will help to simulate the effect of input on the output. The Nigeria grain chain is used to investigate the effect of disruption events on volume uncertainty at different points of the chain, such as production, processing and storage. The effects of this uncertainty are examined using simulation model. This stochastic model is specially built in Microsoft Excel for this study and @risk is added to simulate the data. The visual representation of the model can be seen in figure 4. Below in table 10, the parameters for the analysis are stated. Poisson distribution is used for disruption factor because is a discrete distribution and depict the occurrences of an event over time. Whilst Normal distribution is used for average volume supplied because is a continuous distribution and subject the uncertain volume supplied to many different sources of uncertainty or error.

Table 10: Parameter values in the default situation

Parameters	Distribution type	Description	Parameterization	Unit
Volume of production	Normal	Mean	3.82	Mt/year
		SD	0.47	
Volume of processing	Normal	Mean	2.40	Mt/year
		SD	0.40	
Disruption				
Weather/natural disasters	Poisson	Lambda	0.50	Frequency /year
Political instability	Poisson	Lambda	0.43	Frequency /year
Biological risk	Poisson	Lambda	0.57	Frequency /year
Infrastructure risk	Poisson	Lambda	0.66	Frequency /year
Impact				
Percentage impact on volume supplied (Production and processing)		Volume supplied Correct for disruption impact	({1, 2, 3, 4} {10%, 20%, 30%, 40%})	Mt/year
Threshold level				
Production stage	Deterministic		10.3	Mt/year
Processing stage	Deterministic		6.0	Mt/year
Cost of risk management strategies				
Increase in production	Deterministic	Cost/unit	€482	Per tonne
Import of milled rice	Deterministic	Cost/unit	€520	Per tonne

Table 10 shows the stochastic distribution used for the simulation. This enabled us to fit the parameters into the model and see how they affect the output default. The numbers in the table were collected from data stated in section 3.2.1 and 3.2.2. The results are discussed using mean, range, 5% percentile and 95% percentile. The 5% percentile means there is a 5% chance that output value is below 5% percentile value while 95% percentile indicates there is a 95% chance that output value is above 95% percentile value. The descriptive statistics provide mean, minimum, maximum and the range of values of 5000 iterations.

3.4 Sensitivity analysis

Sensitivity analysis shows variations in the output value of a model that can be assigned to different sources of changes in the model inputs (Saltelli et al, 2008). The model varies the inputs value to get the effect on the output. In this model there are five input parameters; volume of production; volume of processing; and, disruption factors, the threshold level, disruption impact and cost of risk management strategies. To investigate what the effect of one input uncertainty has on the output, one input parameter will be changed at a time, whilst the other four parameters stay constant. Sensitivity analysis was conducted on, disruption impact, disruption probability and threshold level to see what happened to the output default value. In this situation when one input varies the others remain constant.

Table 11 Parameter values for sensitivity analysis

Category	Default value	Sensitivity value
Disruption		
Biological risk (production)	0.57/year	0.85/year
Infra-structure risk (processing)	0.66/year	0.80/year
Threshold level		
Production	10.3 mt	11.8 mt
Processing	6.0 mt	7.5 mt
Impact		
Percentage impact on volume supplied[a] (Production and processing)	({1, 2, 3, 4} {10%, 20%, 30%, 40%})	({1, 2, 3, 4} {20%, 30%, 40%, 50%})

[a]Percentage impact on volume supplied: This is the percentage of impact based on the number of occurrences of disruption on the normal volume to give the volume supplied corrected for disruption. It can be interpreted as follows: if disruption event happened once within a year, it will has 10% reduction in average volume supplied, if the disruption event happens twice within a year, it will has 20% reduction in average flow, if the disruption event happens three times within a year it will has 30% reduction in average volume supplied, whilst if it happens four times within a year it will has 40% reduction in average volume flow.

Chapter 4

4. RESULTS

In this chapter, the results of the simulation model are discussed. These include the results of the simulation in the default situation and, the results of the sensitivity analysis.

4.1 Output shortage

In this section, the results of the simulation in the default situation are given. The results below, shown in Table 12, show uncertainties of output shortage and cost.

Table 12 Expected grain shortages and risk management cost

Category	Average	5% percentile	95% percentile
Production (Paddy rice)	6.94 mt	5.98 mt	7.82 mt
(Processing) Milled rice	3.75 mt	3.04 mt	4.45 mt
Cost of paddy rice (Cost of risk management)	€3.34 billion	€2.89 billion	€3.77 billion
Cost of milled rice (Cost of risk management)	€1.95 billion	€1.59 billion	€2.31 billion

The results show the default distribution of different disruption factors. There are shortages, on average, of output of paddy rice of 6.94 mt/year. This will cost €3.34 billion on average to dissipate the total shortages. The results above show that there is a 90% probability that shortage volume of paddy rice will be greater than 5.98 mt but less than 7.82 mt with accompanying cost that ranges between €2.89 billion and €3.77 billion in a given year. For milled rice, there is a 90% probability that the consumption shortage will be greater than 3.04 mt but less than 4.45 mt with an average consumption shortage of 3.75 mt in a year. The corresponding cost uncertainties for the volume ranges from €1.59 billion of 5% percentile to €2.31 billion of 95% percentile with average cost of €1.95 billion. Table 12 shows the existing gap between volume supplied and threshold level, the shortages caused by disruption impact, risk management strategy and the cost.

4.1.1 Output shortages on thresholds

There is a big gap between rice sufficiency and the current rice volume supply in Nigeria. The simulation analysis conducted at different stages in the rice chain shows the uncertainties of the rice shortfalls in Nigeria. With respect to rice sufficiency, there is a deficit of 6.94 mt of paddy rice and 3.34 mt of milled rice on average per year. These shortfalls can range between a 5.09 mt minimum and 8.91 mt maximum of paddy rice; for milled rice this ranges between a 2.18 mt minimum and 5.17 mt maximum in a year. In a year, there can be a 5% probability that the shortfalls will rise above 7.82 mt of paddy rice and 4.45 mt of milled rice. With this result, there is a 90% probability that

Nigeria will face shortfalls between 5.98 mt to 7.82 mt of paddy rice, and 3.04 mt to 4.45 mt of milled rice, every year. The level of shortage will depend on the percentage of impact and frequency of disruption factors. Table 12 show that Nigeria is under-supplied by 6.48 mt of paddy rice, and 3.60 mt of milled rice. Whilst disruption impact caused a shortage on average 0.46 mt of paddy rice, and 0.15 mt of milled rice. The amount of risk management to apply depends on the level of shortages from disruption impact, therefore will cannot called existing shortages to include risk management strategy.

4.1.2 Cost implication of output shortages

In order to be able to dissipate the shortage, the cost to finance it is simulated. These costs were based on different strategies used at different points of the chain. The results show that Nigeria will spend on average €3.34 billion to increase paddy rice production, while spending €1.95 billion to import rice in a year. The uncertainties in the cost range from €2.38 billion minimum for paddy rice and €1.18 billion minimum for milled rice, to a spend maximum of €4.19 billion for paddy rice and €2.75 billion for milled rice in a given year. In addition, there is a 90% probability that Nigeria will not spend anything less than €2.89 billion, but less than or equal to €3.77 billion in a year to increase paddy rice production. There is also a 90% probability that Nigeria will spend nothing less than €1.59 billion, but less than or equal to €2.31 billion, to import rice in a year. This is supported by a recent publication on daily newspaper that Nigeria spends 1 billion naira (€4.54 million) on daily basis for the importation of milled rice (Njeze, 2015). The risk management applied to dissipate the shortage will cost on average €3.12 billion for shortage due to under-supplied of paddy rice, and 1.87 billion for shortage due under-supplied of milled rice in a year. Whilst €0.22 billion will dissipate shortage of paddy rice due to disruption event in a year, and on average €0.08 billion will be used to import of milled rice in a year.

4.2 Sensitivity analysis results

During the sensitivity analysis all variables are kept constant while one variable varies between different amounts. The input parameters were presented in Table 11.

Table 13 Sensitivity analysis results

	Default		Sensitivity	
Parameter	**Expected output shortage value**	**Expected cost of risk strategy (paddy and milled)**	**Sensitivity results Value (average)**	**Expected cost of risk strategy (paddy and milled)**
Increased biological risk (Paddy rice)	6.94 mt/year	€3.34 billion	6.99 mt/year	€3.37 billion
Increased infra-structure risk (Milled rice)	3.75 mt/year	€1.95 billion	3.79 mt/year	€1.97 billion
Higher threshold level at production (Paddy rice)	6.94 mt/year	€3.34 billion	7.95 mt/year	€3.83 billion
Higher threshold level at processing (Milled rice)	3.75 mt/year	€1.95 billion	5.26 mt/year	€2.73 billion
Increased impact at production (Paddy rice)	6.94 mt/year	€3.34 billion	7.21 mt/year	€3.48 billion
Increased impact at processing (Milled rice)	3.75 mt/year	€1.95 billion	3.87 mt/year	€2.01 billion

The variables that are varied are the volume supplied correct for disruption, disruption factors (biological risk and infra-structure risk), and threshold level to see the effect on the expected output default. The results show that when the probability of occurrence of biological risk increased from 0.57 to 0.85, the average output default increased from 6.94 mt to 6.99 mt of paddy rice, whilst the corresponding cost increased from €3.34 billion to €3.37 billion. More so, the probability of occurrence of infra-structure risk increased from 0.66 to 0.80, the average output default increased from 3.75 mt to 3.79 mt of milled rice and the corresponding cost increased from €1.95 billion to €1.97 billion. Also, when the threshold level at production increased from 10.3 mt to 11.8mt, the average output default increased from 6.94 mt to 7.95 mt of paddy rice and corresponding cost increased from €3.34 billion to €3.83 billion. Whilst, the threshold level at processing increased from 6.0 mt to 7.5 mt, the average output default increased from 3.75 mt to 5.26 mt of milled rice and corresponding cost increased from €1.95 billion to €2.73 billion. More so, when the summed impact of disruption increased by 10%, the average output default increased from 6.94 mt to 7.21 mt at production and 3.75 mt to 3.87 mt at processing.

Chapter 5

5. DISCUSSION, CONCLUSIONS AND RECOMMENDATIONS

In this section, model is discussed. It will be followed by conclusions and recommendations for further research.

5.1 Discussion

A specific model is designed for the study to investigate disruption risk management in grain chain in Nigeria. The model used normative approach and personal assumptions due to limited data available to investigate grain chain. The following variables were capture in the model: disruption factors, average flow, threshold level, risk management strategies, and the cost for risk management strategies. The model variables were parameterised using discrete and normal distribution. The probability of occurrence of disruption factors were summed together in the analysis and one discrete distribution was assumed.

In addition, storage stage though included in the conceptual framework but was not investigated due to limited data. However, this model can be used to examine other types of grains by re-structuring the model to fit in alternatives the country settings. In order for the model to be applicable, it should be adjusted to the specific situation in the studied country to show the direction of the flow. Nonetheless, the model can be used as an example or guideline for other type of grains. Also, the model structure can be use to evaluate sufficiency level of two different types of grain in a particular country.

Also, no disruptions such as transportation were assumed within the stage, therefore only disruptions at the stage level were assumed in the model. More so, example of grain (rice) investigated here is under-supplied in Nigeria, that means, there is existing shortages not accounted for by disruption. Therefore with impact disruption event, it further increases the total shortages to be dissipated. However, the model may give output shortage due to disruption impact alone if there is no existing shortage. Also, the shortage amount may be increased if disruption factors within the stages are included in the model.

Furthermore, the model gives different forms of output in different stages, for instance, paddy rice is supplied from production. This is not in a consumable form while it moves to processing where the chaff is removing to give milled rice that is ready for consumption.

The sensitivity results give slight increase amount different from the default value when the model input increases. This may be due to the fact that the increases in inputs may not equally proportional to the increase in output.

Finally, for further research a study can be done to examine the joint effects of disruption risk in-between the chain stages and the impact on the quantities that move to the next stage. This may help to examine the influence it has on threshold level.

5.2 Conclusions

The first objective of this study is to determine the average volume and volatility of rice supplied at different points of the rice grain chain. The average volume of rice supplied from production, processing and storage were determined to be 3.61 mt, 2.28 mt and 0.68 mt per year respectively. These range from minimum to maximum and expected standard critical thresholds of 6 mt of milled rice and 10.3 mt of paddy rice.

The second objective of this study is to identify the risk prevention strategies and coping strategies applied at different points of the chain. The prevention strategies include crop rotation, mulching, water harvesting, and irrigation. The coping strategies include income diversification activities (such as engaging in off-farm work to complement the income from farming); mixed farming system (such as rearing animal to compliment income). The government ex post risk management strategies include import of milled rice, increase in rice production, strategic grain reserve, support for the farmers by providing incentives in form of subsidies and vital information with regard production techniques and weather forecast.

The third objective of the study is to determine critical rice grain sufficiency thresholds at different points of the chain. The critical level that Nigerian hold as standard from production is 10.3 mt per year of paddy rice and 6 mt per year of milled rice. Two strategies were included in the analysis to dissipate shortages; these were an import of milled rice and an increase in rice production. The range of shortages were determined to be 5.09 mt per year of paddy rice and 2.18 mt per year of milled rice at as a minimum, with 8.91 mt per year of paddy rice and 5.17 mt per year of milled rice at its maximum. These quantities show the ranges of additional needed volume to be supplied in order for Nigeria to reach its threshold level. Hence, the risk management was applied to bring it back to the threshold level.

The fourth objective is to determine the most cost effective strategies used to dissipate shortages. It was determined based on the volume of shortages and quantities needed to dissipate it. The results show that the consumption default fluctuates with 6.94 mt on average, with standard a deviation of 0.56 observed from paddy rice output; milled rice fluctuates with 3.75 mt on average, with a standard deviation of 0.42. It is observed that there is a 90% probability that the output default will be between 5.98 mt of paddy rice, 3.04 mt of milled rice and 7.82 mt of paddy rice per year, 4.45 mt of milled rice. Nigeria will record a shortfall of 6.94 mt of paddy rice on average every year and 3.75 mt of milled rice on average every year. There are two strategies adopted to address the shortfall in the study. First, if Nigeria wants to use an increase in rice production to address the paddy rice shortage, it will cost a total sum of €3.34 billion on average. On the other hand, using an import approach for rice milled to address the shortfall will cost a sum of €1.95 billion on average.

5.3 Recommendations

The following recommendations are drawn from the study.

This research is conducted to examine the effect of disruption risks in grain chain in Nigeria. First, it is also recommended that each actor should take cognisance of risks and apply management strategies such as prevention measures, coping strategies and in case of serious shortages, government can intervene. It is recommended that actors in the chain should get insurance certificates and future contracts. Ex post risk management can be applied by Nigerian government. Two ex post risk management strategies are examined (import of milled and increase in production) in this study that can be used by Nigerian government to meet up its rice sufficiency/consumption level. However, it is necessary to state that these strategic choices depend on the policy motives. Other strategies such as import of paddy rice, and trade by barter between other countries, can be employed to address the shortages. The Nigerian government must also evaluate each strategy to know if this is possible to finance it and examine other socio-economic benefits in terms of sustainability and employment opportunities.

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