UNIVERSITY OF GLOUCESTERSHIRE

Royal Agricultural University Cirencester

THE ROLE OF GRAIN STORAGE SYSTEMS IN FOOD SAFETY, FOOD SECURITY AND RURAL DEVELOPMENT IN NORTH-CENTRAL NIGERIA

By

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DECLARATION

The work within this thesis is based on the author's independent research at the Royal Agricultural University, Cirencester under the supervision of Prof. Ali Parsa and Dr Jim Kempton. The author is responsible for the strategy and tool development, field testing and application, interpretation of results and the conclusion reached within this thesis. All assistance and advice from colleagues have been acknowledged.

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DEDICATION

I dedicate this new level of thinking, to my wife (Susan), son (Peniel) and daughter (Janiel), for the faith they have in the family. The family needed an exposure, a world-class exposure, the United Kingdom gave us the exposure in full.

Abstract

The quest for food security and food is global. The consequences of food insecurity, hunger and unsafe food is detrimental to the health and wellbeing of consumers. Food safety issues have legal and economic costs for food producers (farmers), manufacturers as well as retailers. For this reason, food manufacturers now source for healthy raw materials way beyond their traditional boundaries. The versatility of grains makes it the choice crop for local, national and global food security, therefore its production, processing and storage is of immense importance. Subsequently, this becomes a great opportunity for farmers from around the world, especially those from developing countries like Nigeria and rural communities in Kogi State who are mainly grain farmers. However, inefficient grain storage system is a challenge among the rural farmers in Nigeria. This causes about 60 per cent post-harvest waste of cultivated crops according to the Federal Ministry of Agriculture and Rural Development, Nigeria. The empirical research has shown that post-harvest waste could be more. The inadequate storage structures forced the farmers to use pesticides with nerve agent active as ingredients; which then contaminates the stored grains, with severe unanticipated consequences on food safety and economic well-being of rural farmers. In addition, bye products of crop processing and fodders are not utilised by the farmers, they are usually burnt off. These can however, be baled for use as animal feeds, to encourage mass balance as required by Good Agricultural Practice (GAP). The study, therefore, examined the role of grain storage structures in food safety, food security on the economic development of rural farmers in Kogi State, Nigeria. The study adopted a mixed method approach utilising the questionnaire, on-site observation and interactions with key players along the grain supply chain as tools. Multistage and purposive sampling was used to select three hundred (300) rice and maize farmers spread across fifty (50) communities, making six participants per community. The results show that the

storage systems and length of storage of the farm produce (maize and rice) has a significant impact on the annual income of the farmers, and only 1 per cent of the grain farmers' population earned above the 2017 world's poverty benchmark. The major challenges reported by the farmers included poor processing/storage facilities (43.4 %), poor sales after harvest (30.3 %) lack of agricultural credits (23.3 %) and there was also limited access to technology. The existing storage structures encourage post-harvest waste and losses, affecting the quantity and quality of stored grains, the market value and invariably the farmers' income. Moreover, the rural grain market is erratic with several middlemen dictating the price of grains in their favour. Also, none of the farmers surveyed had access agricultural credit of any kind nor benefitted from Federal or State agricultural schemes. However, overcoming the food safety and economic challenges is only feasible by building strong rural economic institutions where food safety, food security and access to competitive markets is paramount. Hence, blending the challenges recognised in literature regarding rural farmers in Kogi State and Nigeria, with those obtained from the empirical fieldwork, and the key lessons from the case study countries, a Communal Grain Processing and Storage Model (The Communal Model) was developed. In this model, efficient and safe processing platforms and storage systems are provided within each community where all the registered farmers within the community would process and store their grains with the assistance of assigned Extension Officers from the Communal Centres. The Communal Centres also connects the rural farmers and the markets and other key stakeholders. Farmers can either have their grains sold at Guaranteed Minimum Price or stored at the Centre in anticipation of better prices in the future. Community Centres can also act as training hubs where farmers are provided with GAP components and other economic trainings. To build a robust rural institution via the Community Centres, bank accounts would be opened for the farmers (as less than 1 per cent of the farmers surveyed had bank accounts), and a Grain Card would be issued to help keep and build the farmers' "Activity Ratings" each year. The rating can be used for economical purpose like credit assessment to determine eligibility for agricultural credit and to obtain other household items from stakeholders on flexible payments. Private firms would manage the Communal Centres in a public-private partnership with the government while the government plays a regulatory role, thereby strengthening the rural food institution, and creating opportunities for the farmers.

Key Words: Community, Economy, Farmers, Grains, Poverty, Rural, Storage.

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CHAPTER ONE

RESEARCH OVERVIEW

1.0 Research Background – Importance of grains in global food security

Among all food crops, grains remain the most versatile in terms of utilisation. For this reason, grains are the most important crops in the world. Though rice is the most consumed grain crop, maize is the leading crop in terms of production quantity (Awika, *et al.* 2011, p. 8). Grains are the world's most important sources of food, both for direct human consumption and indirectly, as inputs to livestock production (FAO, 2002, p. 1). What happens in the grain production sector is, therefore, crucial to the household, community, national and global food security. Also, the ease of transportation of grains and grain products makes it an important crop that can be used to combat hunger, malnutrition and food insecurity around the world. Hence, the demand for it is expected to grow in the coming years just as it has been in the past years. Figure 1.1, below shows the global market for grains from 1965, projected to 2030 by the Food and Agriculture Organization of the United Nations.

Inadequate storage systems are responsible for about 25-60% waste of farmers' produce in Nigeria (FMARD, 2016a; Alabadan, 2006; Okuneye, 2001). It is a contributing factor to the paltry earnings of the farmers, especially in rural areas.

The figure depicts a constant demand for grains globally, prompted by the increased global population, seconded by increasing demand for versatile foods both for humans and animals. There are two ways to keep the worldwide grain demands in check – first by increased grain production and secondly, by reducing post-harvest waste and losses, especially for wheat, maize and rice.

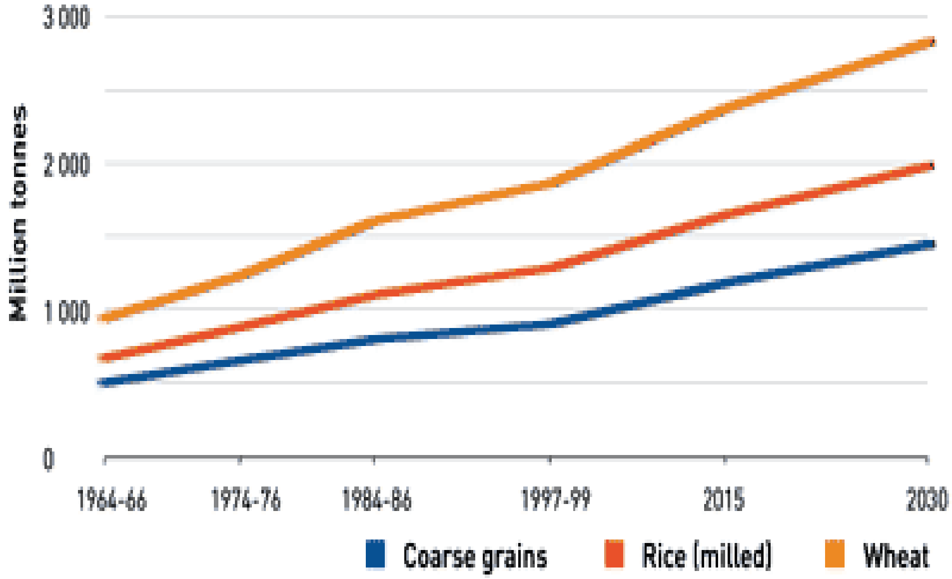


Figure 1.1: World demand for grains from 1965 up to 2030 (projected). Credit: FAO (2002).

In many homes in Nigeria, rice is a staple food, as well as maize. In Kogi State, maize and rice, and a few other grain crops constitute between 80-85 per cent of cultivated crops while tubers such as cassava and yams are grown for family use. The tubers constitute 10-15 per cent of total production. Tubers have very low versatility in terms of utilisation, and it is heavy to transport. It is also not a staple in many places around the world, therefore not a choice food crop for combating food emergencies.

In 2016, Nigeria spent an average of 1.3 trillion Naira ($4.2b) annually to import wheat, rice, sugar and fish. Wheat importation cost 635 billion Naira ($2.06b), rice costs 356 billion Naira ($1.2b), 217 billion Naira on sugar and 97 billion Naira on fish (Emmanuel, 2016). There is a capacity among the farmers in Nigeria to minimise these importations and encourage local production, processing & storage and even export of the agricultural produce. One innovative solution may be to empower the rural farmers inclusively along their line of occupation – farming. Such innovation should be able to connect the rural farmers and the stakeholders for comprehensive and mutual benefits. Another change is the food system that minimises waste and losses.

Storage systems are necessary for food security in Nigeria. It is a vital part of the food supply chain. The art of food storage is an ancient one, but while the idea behind it has remained unchanged, the underlying purposes and intents have diversified over the years. However, the demand for quality food and the need to access specific markets (for economic benefits) has created various standards that food producers and manufacturers must adhere to by all means. Therefore, adequate and reliable storage systems are a vital part of the food network and essential requirements to meet these global food standards that are already in place.

In this study, the Global Good Agricultural Practice (GLOBALGAP) farm assurance for the farms (where the crops are grown) and the British Retail Consortium (BRC) for safe storage and distribution, were considered. The private assurance and global food safety standard can boost consumers' confidence around the world that appropriate procedures have been followed in the production, processing, storage and distribution of grains from the rural communities. In this study, the target is to ensure that the farmers produce their crops by adhering to the components of Good and Agricultural Practice (GAP) need to preserve or protect the environment, animals and welfare of humans (GLOBALGAP assurance). Besides, farmers and local consumers would have access to safe foods too. For storage and distribution of fresh grains to industries, the BRC provides the needed assurance required by the consumers. Based on literature available on this subject, this study understands that the grain storage structures in rural communities play a significant role in food security, food safety, waste/losses and the economic performance of the farmers.

Also, the food supply chain system in this postmodern era is a complex phenomenon. From the farmer through the manufacturers to the retailers and then to the consumers where the finished product could end up as "delicious" or "deadly", each step requires a great deal of real data capture, robust management team and sophisticated record keeping. The reason is that contamination can occur, which could result in serious health hazards. Therefore, they would be a need to trace back through the chain to the farm where the crops were cultivated in order to get to the root cause of the contamination. Alternatively, in some cases, traceability would be to the factory where the finished product was manufactured. Product traceability is vital to the food safety management systems, and this fact cannot be overemphasised.

Also, an emerging concept around Short Food Supply Chains (SFSC), especially in European markets, relates the phenomenon of rural development in the new context of supply networks (like the Alternative Food Networks, AFNs) for organic farming, quality production and direct selling (Renting, Marsden and Banks, 2003). All things being equal, there are many benefits of SFSC to the farmers, the rural economy and the environment – such as reduced packaging, reduced transportation cost and an improved economic activity around the rural communities. However, there are contentious issues as to why consumers attention is shifting towards AFNs (Damian and James, 2010). According to the authors, the reason for the shift relates to the consumers' awareness via increasing media attention and anxiety created around food safety and quality. The diversity of understanding is because of the variety of farming systems and regional settings, different cultural and gastronomic traditions, diversity in the organisational structures of food supply chains, variations in consumer perceptions, and from substantial differences in institutional and policy support (Renting, Marsden and Banks, 2003). The SFSC cuts out the middleman in most cases; hence, the farmers benefit more.

Globally, manufacturers are now sourcing for raw materials way beyond their usual traditional boundaries (Julien, 2010). The new trend creates an opportunity for rural farms to access both the local and global markets. However, to access these markets, crop cultivation and storage at any level must adhere to the requirements of the globally recognised farm assurance system and food safety standard regulations. It has become nearly impossible to access any developed market without adherence to the safety standards existing at these markets.

For the safety of the consumers and the integrity of the retailers or manufacturers, each step along the production-storage-manufacturer-distribution-consumer chain must ensure that hazards are potentially avoided, removed or minimized before the next stage of the string or before the raw grains gets to the consumers (for short-chain) or the manufacturers or secondary processors (for long chains). This can be achieved by providing adequate information concerning production environment, transportation, storage and every other information about the food items (that is, safety and provenance), and their unique quality assets(Morgan, Marsden and Murdoch, 2006; Ilbery and Mayne, 2005).

This research is mainly concerned with the management of the supply chains between the farm and the point of storage of the raw branded grains, ready for secondary processing or food manufacturing or for direct consumption (Figure 1.2, below). While adherence to GlobalGAP assures safe production at the farms, the adherence to BRC food safety standard ensures the safety of the storage systems, stored grains and distribution. The target is to provide safe food materials suitable for global markets.

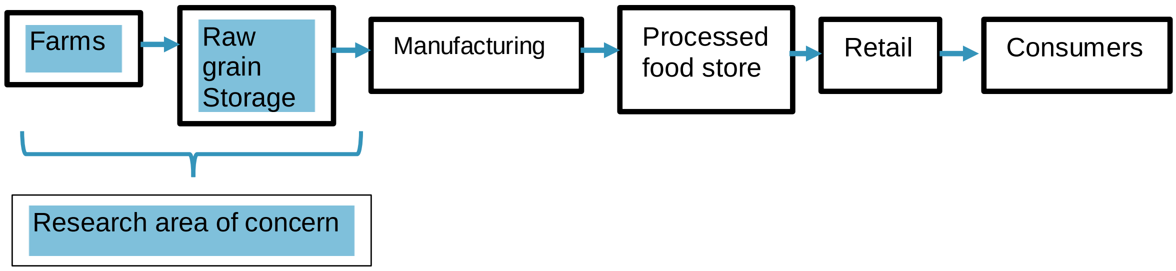


Figure 1.2: The area of research

1.1 Why grain storage systems are essential in global food security and Nigeria's rural livelihood

There is a growing awareness of the need for better rural structures and services in many developing countries where, for many years, agricultural buildings and arrangements have been built traditionally with few improvements (FAO, 1994). Agricultural buildings and structures have become an essential part of integrated rural development programmes and must be taken seriously. Storage structures are vital in food security. A right proportion of the grains produced in Africa is stored on-farm, it is essential to develop effective storage methods and compositions, especially for the modern, high-yielding grain varieties being adopted by farmers, which are more susceptible to pests than traditional types (Mrema *et al.,* 2011, p. 1). With increase outputs occasioned by using high-yielding grain verities, comes the needs for adequate storage systems. This is one area that literature has consistently identified as a problem confronting farmers in Nigeria – inadequate storage systems. There is a need for a formidable solution to the problem.

The incidence of food shortages and price instability is common in Nigeria. As an import-dependent country for primary staple foods, especially rice, wheat, maize and tomato paste, the need for storage cannot be over-emphasised, especially for locally produced grains. According to DeRose, Messer and Millman (1998, p. 53), food shortage happens when there is not enough food supply to provide the people who live in a region, required energy and vitality. The authors listed the causes to include natural disasters (like drought, flood, or fungus), political disasters (like civil conflict) and also some misguided economic policies such as (price controls, hoarding) – all of which discourage the production of essential foods. Boko Haram, Herdsmen/farmers clashes and incessant kidnapping in Nigeria has affected Nigeria's food security, food safety and the rural economy.

Sustainable grain storage model is vital in Nigeria's agriculture, as it can also help in the government in grain price stabilisation. Food price instability can bring unexpected hardship to the rural people and destabilise family budgets. Storage is particularly vital because of the inelastic demand for foods. In this circumstance, there is a need to meet average demand by storing excess supply during the harvesting season for gradual release to the market during off-season periods.

1.2 Statement of the problem and justification

There are concerns in critical areas that warrants this research. These have been identified in the introduction to include food safety and traceability network, food security to combat hunger, the need to minimize waste and losses of global staple grains such as wheat, maize and rice and finally the need for the economic improvement of the local farmers in Nigeria.

1.2.1 Food Safety in Nigeria – contamination and its implication on rural livelihood in Kogi State

Casualties resulting from food poisoning abounds in Nigeria, especially in rural areas. Ihenkuronye (2013) reported that over 200,000 people die of food poisoning annually, occasioned by poor food handling. Similarly, deaths resulting from the abuse of agrochemicals by farmers during storage has been reported (Obinna, 2015). In Kogi State and Nigeria, reports of entire family members being killed after having a meal together are frequent (Premium Times, 2017). According to the World Health Organization, the most common clinical presentation of the foodborne disease takes the form of gastrointestinal symptoms; however, such conditions can also have neurological, gynaecological, immunological and other symptoms. Multiorgan failure and even cancer may result from the ingestion of contaminated foodstuffs, thus representing a considerable burden of disability as well as mortality (WHO, 2018a). Globally, reports of over 200 diseases caused by unsafe food containing harmful bacteria, parasites, viruses, chemical substances, resulting in an estimated two million deaths every year, abound (WHO, 2015). In addition, Ewepu (2012, p. 1) reported severe cases of food poisoning in Nigeria too. Food safety is, therefore, a serious concern in Nigeria, hence justifying the study in this area.

Between 2014 and 2016, the European Commission rejected 109 processed and semi-processed food products of Nigeria origin exported to the European Union. Some of the food items were rejected because they contained foreign agents, such as glass fragments, rodents' excrement, and dead insects. Elevated levels of chemical contaminants, used in fumigation, such as aluminium phosphide, dichlorvos, dimethoate, trichlorphon, cyhalothrin, were also discovered in the products. In addition, microbes, such as salmonella, aflatoxins, and mould growth, were also found in some of the products (RASFF, 2016).

The implication is that the agricultural sector of Nigeria's economy suffers when this rejection happens. The rejection also sends wrong signals to other grain buyers, businesses and countries, about Nigeria's products.

In addition, the presence of mycotoxins in a store is of pressing importance to food safety. For food safety and quality, the need to quickly detect these toxins, which may result from the use of agrochemicals, veterinary products, cross-contamination or formation during food processing, cannot be overemphasized (Azhar, *et. Al.,* 2017). According to the authors, mycotoxins are produced as secondary metabolites by fungi at preharvest or postharvest periods, usually growing on feeds, grains and other cereals.

A food system that guards against these contaminations is of importance to the welfare and economic performance of the rural farmers in Kogi State, Nigeria.

1.2.2 Food Insecurity in Nigeria – occasioned by the waste in rural communities in Kogi State

One consequence of food waste and loses, usually occurring during and after harvesting, is the problem of food insecurity. On-farm and post-harvest waste alone accounted for up to 40 per cent of the total crop yield in Nigeria, owing to lack of appropriate “on-farm and off-farm storage facilities” are the significant problems confronting Nigerian agriculture (Okuneye, 2001, p. 3). In 2015, the average waste was 60 per cent (FMARD, 2016a).

By definition, food losses refer to the decrease in edible food mass throughout the part of the supply chain and wastes are irrecoverable losses especially during the post-harvest processing and at the end of the food chain – that is, at the retail and final consumption (Parfitt, Barthel and Macnaughton, 2010). Grain storage materials have been identified to reduce the instance of food waste and losses, for example, the uses of Purdue Improved Crop Storage (PICS), especially for cowpea (Baributsa, Lowenberg-DeBoer and Moussa, 2010) and maize (Williams, Murdock and Baributsa, 2017). Postharvest waste and loss are universal, but the situation is worrisome in Nigeria. Various literature on food waste and losses around the world exist, with different figures on the actual post-harvest waste and losses. The bottom line is that considering the food needs of the world today, the role of structures to prevent post-harvest waste, cannot be over-emphasised. Where waste is above 5 per cent, it is considered too much.

Globally, Gustavsson et al., (2011, p. 12) estimated that roughly one-third of the food produced in the world for human consumption every year – approximately 1.3 billion tonnes – gets wasted; and at the same time, consumers in rich countries waste almost as much food (222 million tonnes) as the entire food production of sub-Saharan Africa (230 million tonnes). There is a need for a food system that prevents or minimise the waste and loss problems, hence once again, justifying this study.

1.2.3 Poor rural livelihood in Nigeria despite rural agricultural programmes

Efforts by the Nigerian government and donor agencies from across the world to tackle rural poverty and improve the economic situation of the rural farmers in Nigeria have not yielded the expected results. A notable example is that of the World Bank, whereby since 1974, it has committed $1.2 billion (about £900 million) for Agricultural Development Projects (ADPs) to increase farm production and improve welfare among smallholder farmers in Nigeria. The ADP is a unique agricultural project with funds from the World Bank. Of the five ADPs and a supporting Agricultural Technical Assistance Project (ATAP), all implemented between 1979 and 1990, only two of the six projects have had satisfactory outcomes (World Bank Group – IEG, 2012), even though the project was heavily funded.

Also, the Nigerian government commits between 1.5 to 3 per cent of the annual budget to agricultural development projects, amounting to 300 million British Pounds each year. The establishment of National Strategic Grain Storage Programme in 1987, led to the construction of 33-grain storage structures (silos) across the

Nigerian States, were geared towards food security. However, the silos project has gulped six hundred million pounds (£600 m) from 1987 to date. The grain silo project in Kogi State has received an equivalent of approximately six million pounds (£6 m). There is a need to evaluate the current condition of the silos with the aim of building a model for its utilization.

Nigeria currently harbours the second largest impoverished population in the world, after India, although the world's impoverished people are distributed very unevenly across regions and countries. Many people living on less than $1.90 a day – based on purchase power parity exchange rates - resides in two regions—Southern Asia and sub-Saharan Africa where Nigeria is located (World Bank, 2015a). These regions account for approximately 80 per cent of the total global number of impoverished people. Nearly 60 per cent of the world's 1 billion of poor people live in just five countries as at 2011: India, Nigeria, China, Bangladesh and the Democratic Republic of the Congo - ranked from the highest to the lowest.

In Nigeria, between 71 to 112 million people are reported to be living in poverty or in dangerous poverty situation at different times (World Bank, 2018a, p. 1; OXFAM 2017, p. p. 4 and BBC, 2012, par. 3;) from 2010. In Kogi State alone, eighty per cent of the population resides in rural areas (Kogi ADP, 2003, p. 2; KSMRD, 2015, p. 1), against the national average of 62 per cent (NBS, 2016). Over ninety-nine per cent, (99.5%) of the population of those who reside in rural areas in Kogi State are farmers, and 73.5 per cent of the rural population is reported to be extremely poor (almost the total number of rural farmers in Kogi State (Ibitoye and Odiba, 2015, p. 1)

While food safety and food security are topical issues around the globe, the economic performance of farmers is equally essential, especially in developing countries. Nigeria is a peculiar case because more than half of the population of about 200 million are farmers. There are potentials for the farmers to access local, national, regional, and global markets. However, agricultural products must be world-class. The product must be subjected to the available global standards. There is a need for a strategy to build a rural institution efficient enough to ensure safe food system from the farm to the fork.

Therefore, the research has addressed the gaps in knowledge with the following aim and objectives.

1.3 The Aim

The study aims to build a food system in Kogi State Nigeria that ensures the production and storage of grains (for consumption and market) that are safe, with minimal waste, contribute to the food security and improve rural livelihoods.

1.4 Objectives of the study

The specific objectives of the research were to:

1. Identify good practices in case-study countries in relation to regulations, private standards and access to markets;
2. Evaluate the situation in agriculture in Kogi State - Nigeria with a focus on post-harvest processing and storage systems;
3. Appraise the contribution of grains to food security and how the typology of grain storage systems in Kogi State reflects on farmers' income;
4. Develop models to support rural economic development while ensuring food safety, food security and waste minimisation.

1.5 Theoretical background

The research is based on the theoretical knowledge of food security. Food security is a complex phenomenon that encompasses four components – food availability, accessibility, the stability of supply and safe utilization. The term was first used following the events of the mid-1970s – famine, hunger and food crisis. A careful definition was negotiated at the first World Food Summit 1974 in Rome, Italy and later again in November 1996 and then in June 2002. To understand the diversity of the concept, as far back as 2002, over 200 definitions of food security had been published (Maxwell and Smith, cited in FAO, 2003, p. 21). The most accepted definition, however, is by the Food and Agriculture Organization (FAO).

The FAO defines food security as a situation that exists when all people, always, have physical and social access to enough, safe and nutritious foods. Such foods meet their dietary needs for active and healthy life (FAO, 2003, p. 21). Four key pillars of general food security can be identified from the definition, and they are the critical factors in this study. These are:

- Availability – connotes storage occasioned by large production volume during harvest season;
- Accessibility – implies economic opportunities for the farmers in the form of accessible markets and access to stakeholders for mutual benefits;
- Stability of supply – connotes storage occasioned by adequate storage systems for use during off-season periods;
- Safe food utilization – Connotes safe food for both local and global consumers.

These Four Pillars can be lost and gained at the household, community, regional, national or at the global level. The four pillars are the strategic points at which the food security concept is usually measured (Naylor, 2014).

Considering that there was limited knowledge in the critical areas of the research in the research location in literature, the study began as exploratory research, therefore relying on research questions to navigate through.

1.6 Research questions

A research question indicates the direction of inquiry in the research and must be answerable (Andrews, 2003, p. 2), or have the potential for being answered during the study. The following questions were considered:

Research Question 1: Is the current grain post-harvest activities, and grain storage systems among rice and maize farmers in Kogi State sufficient to cut down waste and improve food safety?

- What are the post-harvest grain processing platforms available among maize and rice farmers in rural communities?
- What is the typology of storage systems among rice and maize farmers in rural communities?

Research Question 2: To what extent do the post-harvest platforms and storage systems encourages grain waste, losses or improved food safety in Kogi State, Nigeria?

Research Question 3: How can an alternative model improve rural economic institutions in Kogi State, Nigeria?

While the research questions must usually be answerable, it may be possible for research questions not to have clear answers, but a reasonable attempt to answer the questions is generally acceptable (Andrews 2003, p. 3). The rationale behind these questions, therefore, is to provide a guide into the exploratory research.

1.7 Research hypothesis

A hypothesis is a research statement that can be proved or disproved based on data obtained from the study. According to Andrew (2003), it is possible in some cases, for a hypothesis to emerge from research questions, especially in exploratory research. Thus, the following null and alternative hypothesis were considered:

(Null): Processing and storage systems adopted by the rural farmers in Kogi State do not influence the farmers' income.

(Alternative): Processing and storage systems adopted by the rural farmers in Kogi State influence the farmers' income.

1.8 Research approach

Research can take one or more forms of strategy to create an argument, formulate judgement and then draw conclusions. The baseline of every research is reasoning in a certain way. Therefore, the research approach could be inductive or deductive or a combination of these. Inductive reasoning works from 'specific observations to broader generalisations and theories' (William, 2006, p. 1). Deductive reasoning involves scientific reasoning from one or more statements (premises) to reach a logically inevitable conclusion (Sternberg, 2009); that is, from general theory to a specific outcome. Both inductive and deductive methods of reasoning have a very different pattern of approach in research. This research, however, adopts both the inductive and deductive strategy as applicable in each stage of the research – data gathering and model development, respectively.

1.9 Methodology and methods

This exploratory study employed the survey methodology and case study. The survey methodology was used to gather primary data from the field. The case study was used to obtain information on best practices in case study countries with the aim of utilising the knowledge to develop a food system in Kogi State, Nigeria for the economic development of the rural farmers. A mixed-method approach was used – that is, the combination of both quantitative and qualitative methods targeted at gathering data to answer the research questions and addressing the research objectives. The methods employed were questionnaire (quantitate), on-site observation (qualitative) and survey interaction (qualitative).

1.10 Connecting the dots

Leathers and Foster (2017, pp. 145, 283, 303, 351) established explicit connections between low incomes in any region, having a direct relationship with the menace of poverty, hunger/undernutrition, food, wealth distribution, life expectancy and quality of lives of the people. Technically, however, 'we produce enough food in the world to feed everyone base on average calories required by each person (FAO, 2014a, p. 1). However, inadequate storage, poor access and poor distribution are the challenges (Naylor, 2014; FAO, 2013; Mittal, 2002, p. 304) that encourages wastes, losses and threatening food security in the research location.

Therefore, the research objectives imbibe the combined recommendation of the Food and Agriculture Organization (FAO), the International Fund for Agricultural Development (IFAD) and the World Food Programme of the United Nations, that poverty and undernourishment could be tackled through an all-inclusive economic growth that provides opportunities and well-functioning markets for the poor (FAO, IFAD and WFP, 2015, p. 12). This would be possible when solutions are provided to the concern of food safety, access to weak market as a result of inadequate market structure and also by ensuring that products from the rural areas meet the demand of consumers. This is where the research models come in.

1.11 Research ethical considerations

The fact that the research involved interactions with several people, many of whom may be vulnerable, it became inherently essential to observe the ethics of surrounding research of this nature. At all times, therefore, this research adhered to the ethics of the University of Gloucestershire, United Kingdom.

1.12 Thesis structure

The table below provides the structure of the thesis. The first chapter introduces the research in general terms. Chapter two focuses on global food security while the third chapter delves into the case study countries. Dynamics of food security in Nigeria was covered in chapter four, and chapter five focused on the research philosophy. The empirical results are presented in chapter six. Chapters seven, eight and nine included the global farm assurance/food safety standards, alternative model development and research conclusion respectively.

Table 1.1: Thesis Structure

Chapter Numbers	Content
1	Research Background – Importance of grains in food security
2	Global food security
3	Dynamics of food security in THE United Kingdom (UK), united states of America (US), CHINA and INDONESIA
4	Dynamics of Food Security in Nigeria
5	Research philosophy, Methodology and Methods
6	Results and analysis
7	Farm assurance (GLOBALGAP) and BRC global food safety standard requirements
8	Alternative model development
9	Conclusion and recommendations

CHAPTER TWO

GLOBAL FOOD SECURITY

2.0 Introduction

The purpose of this chapter is to analyse the concepts of global food security and the indicators. The role of grains in food security and the place of post-harvest waste and losses to the idea of food security is also reviewed. This chapter provides comprehensive literature on global food security.

2.1 What is Global Food Security?

Food security is a concept that encompasses four key elements: food availability, accessibility, the stability of supply and safe utilisation (The Economist Intelligence Unit, 2018; Naylor, 2014, p. 7). These four elements can be lost and gained at the household, community, regional, national or global scales - the strategic points at which the concept can be measured. Therefore, in its purest form , global food security is food availability, accessibility, the stability of supply and safe utilisation for the worldwide population. However, this definition could be more complicated.

To understand the complexity and the diversity of definitions that exist, as far back as 2002, over 200 descriptions of Food Security had been published (Maxwell and Smith, cited in FAO, 2003, p. 21). Explicitly, people are food secure when they have the availability and adequate access always, to sufficient, safe, nutritious food to maintain a healthy and active life (WFP, 2017, par. 1).

The Food and Agriculture Organization - FAO (FAO, 2003, p. 21) define food security as a situation that exists when all people, always, have physical, social and economic access to enough, safe and nutritious foods. Such foods meet their dietary needs for an active and healthy life. The (FAO) food security definition is based on the 1996 UN-FAO “Declaration on World Food Security and World’s Summit Plan for Action” definition, which was then further expanded in 2001 (Gibson, 2012, p. 7). The United States Department of Agriculture (USDA) defines food security as access by all people always to enough food for active, healthy life. Lack of access to enough food is termed as food insecurity (Haruna and Bashir, 2011, p. 66); which means access to enough food is food security.

From the perspective of this research, food security connotes availability, accessibility, stability and utilisation of safe foods at all times, in a system that guarantees optimal welfare of food producers at all times. The emphasis is on the welfare of the farmers because of the vital role they play in maintaining the components of food security.

Availability entails the physical supply of the food (Naylor, 2014), and this can be through income to purchase products or via food aid and donations. Access to food could also be through income to buy, or via barter, or having the opportunity to make a living through production. Stability of food means there are availability and access to food always, irrespective of weather, season, location and time. The utilization entails full maximisation of food nutrients, which can only be possible if the people are healthy to eat the food and the food itself is safe and healthy. Food security can be lost or gained at any level, from family to global scales. Gibson (2012, p. 8) had identified these components of food security as the four *pillars* of food security.

2.2 The implication of global population increases on food security

With the world population hitting about 7.6 billion, 10.7 per cent (815 million people) are living in extreme poverty (FAO, 2017). The poverty line is defined based on the monetary value of a person’s consumption power, adjusted to be $1.9 per day in 2015, below which a person is defined as living in poverty (Max and Ortiz, 2018, par. 1; WHES, 2016; FAO, 2017). In this measurement, the purchasing power parity determines what each currency could buy in the local markets, compared to what a US dollar could buy in the United States of America. It is the most valid way of measuring the real poverty line for each country. The capacity to purchase food could be significantly hindered by poverty.

More so that between 35 and 122 million people could be added to the world's population by 2030 relative to a future without climate change. With negative impacts of climate change on incomes in the agricultural sector, the situation could be worse, such that between 97 million (low impact) and over 165 million (high impact) people could be added (FAO, 2016). The implication of this increase is that food must be made available for each and every one of the population in order to sustain the global food security pursuit of the United Nations. The increase in the number of poor people would be most prominent in sub-Saharan Africa, partly because its population relies on agriculture than any other region (FAO, 2016, p 13). With African community standing at about 1.26 billion in 2018, about a quarter of which are malnourished, the impact of food shortage will be severe there than in any other region.

2.3 Global food security indicators

Analysts and experts measure food security by taking into consideration its availability, accessibility, supply, quality/safety and recently, the preservation of natural resources and resilience in the course of growing crops and manufacturing foods. Where any one of these pillars is lacking, the tendency for hunger, malnutrition, poverty and low life expectancy becomes significant. Two leading indices that estimate the global food security using various indicators are the Global Food Security Index (GFSI) and the Global Hunger Index (GHI).

2.3.1 Global Food Security Index

The Global Food Security Index (GFSI), is published by The Economist Intelligence Unit. Using various pre-determined indicators, the GFSI measures the food security of 113 countries by evaluating access to affordable and nutritious food. The 113 countries in the index were selected based on regional diversity, economic importance, population size (countries with larger populations were chosen so that a more significant share of the global community is represented) and the goal of including regions around the globe. Many countries that have made progress in fighting hunger are countries that have enjoyed stable political conditions and overall economic growth, as well as expanding primary sectors, mainly agriculture, fisheries and forestry. Many had policies in place aimed at promoting and protecting access to food. The Global Food Security Index is a dynamic quantitative and qualitative benchmarking model, constructed from several unique indicators, which measures these drivers of food security across both developing and developed countries. This index is the first to examine food security comprehensively across the three internationally established dimensions (The Economist Intelligence Unit, 2016).

According to the 2017 index report, the categories and indicators are as summarised in Figure 2.1. The report recommended that governments would need to invest in the development and implementation of new technologies to make countries more resilient to changing weather patterns and narrow the gap between low-income and middle-income countries. Also, sustained investment, primarily by the private sector, is critical if countries are to develop the infrastructural capacity necessary to produce and transport sufficient quantities of food in the future (The Economist Intelligence Unit, 2017).

Tables 2.1 shows the overall rankings of the Global Food Security Index from the year of inception (2012) to 2018.

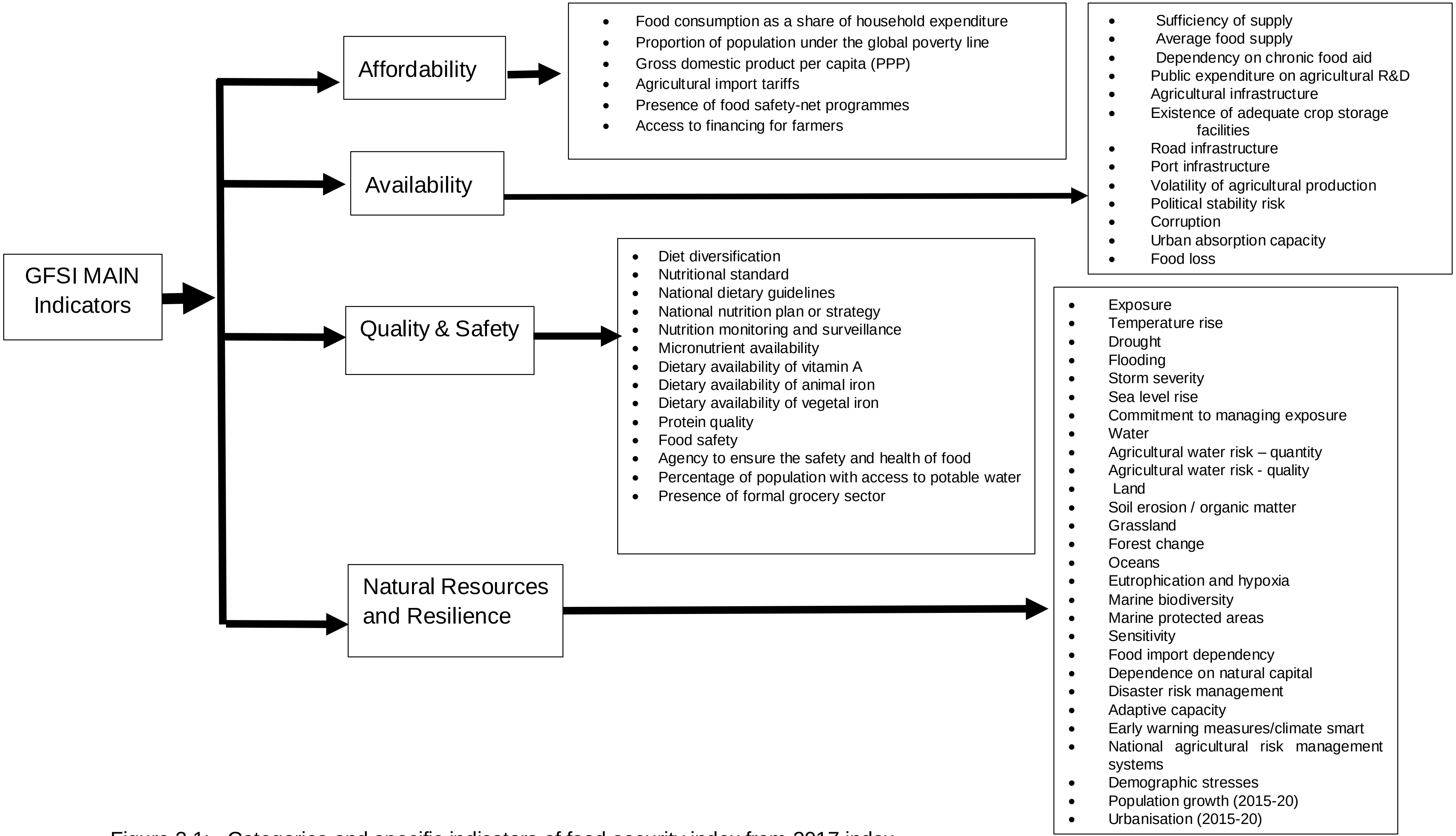


Figure 2.1: Categories and specific indicators of food security index from 2017 index.
Source: The Economist Intelligence Unit, 2017.

Table 2.1: GFSI country comparison from 2012 (year of inception) to 2018

		Overall GFSI ranking in the indicated years						
S/N	**COUNTRY**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
1	Ireland	-	11	7	3	2	1	2
2	Austria	6	4	2	4	16	2	14
3	France	4	3	10	9	6	3	10
4	United States of America	1	1	1	1	1	4	3
5	Germany	10	11	8	8	6	5	11
6	Switzerland	7	5	6	6	13	5	7
7	United Kingdom	20	20	16	15	8	5	3
8	Canada	8	8	8	7	8	8	9
9	Denmark	2	10	11	14	14	9	16
10	Sweden	17	14	12	12	10	10	12
11	Netherland	5	5	3	5	4	11	5
12	New Zealand	11	9	13	13	11	12	15
13	Finland	9	13	19	17	17	13	8
14	Australia	14	15	15	9	4	14	6
15	Norway	3	2	3	9	12	15	12
16	Belgium	12	7	14	18	21	16	17
17	Japan	16	18	21	21	22	17	18
18	Portugal	15	21	18	16	14	18	19
19	Singapore	-	16	5	2	3	19	1
20	Spain	13	19	20	19	19	20	21
21	Czech Republic	23	23	23	25	25	21	24
22	Italy	19	22	22	22	22	22	23
23	Poland	24	27	26	28	29	23	26
24	Israel	22	17	17	19	17	24	20
25	Hungary	25	28	29	31	34	25	30
26	Chile	26	26	27	27	24	26	27
27	Greece	18	25	24	29	31	27	33
28	Slovakia	27	37	31	32	40	28	35
29	South Korea	21	24	25	26	28	29	25
30	Kuwait	-	-	28	24	27	30	28
31	Uruguay	33	32	38	33	36	31	34
32	Oman	-	-	-	-	26	32	29
33	Qatar	-	-	-	-	20	33	22
34	Romania	38	33	44	45	32	34	38
35	Costa Rica	35	36	36	38	37	35	36
36	Saudi Arabia	28	31	32	30	32	36	32
37	Russian	29	40	40	43	48	37	42
38	Argentina	32	35	37	37	37	38	37
39	Brazil	31	29	33	36	41	39	39
40	Bahrain	-	-	-	-	33	40	41
41	United Arab Emirates	-	-	30	23	30	41	31
42	Bulgaria	46	51	50	50	50	42	47
43	Malaysia	33	34	34	34	35	43	40
44	Mexico	30	30	35	35	39	43	43
45	China	38	41	42	42	42	45	46
46	South Africa	40	39	46	41	47	46	45
47	Belarus	43	46	47	44	46	47	44
48	Turkey	36	38	39	39	45	48	48
49	Serbia	37	49	43	49	52	49	53
50	Panama	42	44	45	40	44	50	50
51	Botswana	47	43	48	46	54	51	52
52	Colombia	51	52	51	53	49	52	49
53	Thailand	45	45	49	52	51	53	54
54	Jordan	54	54	59	55	60	54	60
55	Tunisia	50	47	54	51	53	55	51

56	Azerbaijan	67	71	62	58	57	56	56
57	Paraguay	49	53	58	61	67	57	58
58	Kazakhstan	53	58	57	56	68	58	57
59	Peru	48	50	53	54	55	59	55
60	Egypt	52	56	66	47	57	60	61
61	Ecuador	57	57	56	60	56	61	65
62	Dominican Republic	61	55	55	56	64	62	58
63	Ukraine	44	47	52	59	63	62	63
64	Vietnam	55	60	67	65	57	64	62
65	El Salvador	56	63	68	66	69	65	68
66	Sri Lanka	62	60	60	63	65	66	67
67	Morocco	59	59	63	62	62	67	64
68	Bolivia	65	65	61	67	70	68	74
69	Algeria	73	68	70	68	66	69	69
70	Venezuela	41	41	41	48	60	70	78
71	Nicaragua	69	72	74	70	75	71	72
72	Guatemala	60	68	71	70	73	72	71
73	Indonesia	64	66	72	74	71	73	65
74	Honduras	57	62	63	73	77	74	74
75	Pakistan	75	75	77	77	78	75	77
76	India	66	70	69	68	75	76	76
77	Ghana	68	67	78	75	78	77	73
78	Uzbekistan	72	73	73	64	72	78	80
79	Philippines	63	64	65	72	74	79	70
80	Myanmar	78	74	86	78	80	80	82
81	Uganda	71	77	74	79	81	81	89
82	Senegal	93	82	82	80	86	82	87
83	Nepal	76	84	85	85	82	83	79
84	Cambodia	89	89	96	96	89	84	85
85	Cote d’Ivoire	76	76	76	76	84	84	81
86	Kenya	77	80	80	83	83	86	87
87	Cameroon	74	78	84	82	85	87	84
88	Rwanda	90	96	93	94	87	88	93
89	Mali	87	102	95	86	91	89	86
90	Bangladesh	81	81	88	89	95	90	83
91	Benin	82	85	82	80	88	91	90
92	Nigeria	80	-	87	91	90	92	96
93	Togo	97	105	106	101	93	93	93
94	Tanzania	99	95	104	98	94	94	98
95	Tajikistan	-	83	81	88	92	95	91
96	Sudan	96	104	97	92	98	96	99
97	Burkina Faso	88	92	100	99	106	97	97
98	Laos	-	-	-	-	103	98	95
99	Guinea	85	87	99	97	97	99	102
100	Ethiopia	100	90	89	86	98	100	100
101	Mozambique	91	93	101	103	108	101	101
102	Zambia	95	100	98	102	102	101	104
103	Angola	86	88	92	102	101	103	92
104	Syria	70	79	79	84	96	104	103
105	Malawi	98	99	94	93	105	105	107
106	Niger	91	91	102	99	110	106	104
107	Haiti	102	101	103	104	108	107	106
108	Sierra Leone	94	98	89	106	112	108	109
109	Chad	104	106	108	108	111	109	108
110	Yemen	83	93	91	90	100	110	110
111	Madagascar	101	96	107	107	104	111	111
112	Burundi	103	103	105	109	113	112	113
113	Congo (Dem. Rep.)	105	107	109	105	107	113	112

Credit: Compiled from the annual reports of the Economics Intelligence Unit (2012 – 2018)

From the table, most European countries are at the top, having scored high in the various indicators employed in the measurement. In contrast, African and Asian countries are at the bottom of the table and are densely populated, thereby bringing into focus the place of population and food security.

The population of some of the countries does not correspond with or is not in tandem with their food production. This could be one of the reasons for food insecurity situation. It could also mean that more investment is required to sustain the land carefully and to prevent wastage and loss of food produced. With Asia and Africa's continents amounting to nearly 77 per cent of the world's population, no other continents require keen investment in agriculture and land management as much as they do at this point in time.

The Republic of Ireland had gracefully moved from a fair ranking in the past few years to the top of the table, becoming the most food secured country in the world, displacing the United States of America in 2017, until 2018 when it ranked second. The UK made a tremendous improvement, ranking third with the USA in 2018. However, in the availability category, the UK tops the entire countries, meaning that food is available more in the UK than the USA, which ranked 10th position in that category. Both the UK and the USA ranked third in the 2018 overall ranking, having considered other indicators. The global food security index reflects the actual performance of each country in the various indicators used.

2.3.2 Global Hunger Index

Poverty and hunger are two sides of the same coin. The roles of poverty and hunger in food insecurity of any region cannot be overemphasised. The Global Hunger Index (GHI) is designed to measure and track hunger globally. Calculated each year by the International Food Policy Research Institute (IFPRI), Concern Worldwide, and Welthungerhilfe, the GHI highlights successes and failures in hunger reduction and provides insights into the drivers of hunger. By raising awareness and understanding of regional and country differences in hunger, the GHI aims to trigger actions to reduce hunger (Grebmer, *et al.* 2015, p. 7).

Hunger, according to the Oxford *Living* Dictionary (2016a), is a feeling of discomfort or weakness caused by lack of food, coupled with the desire to eat. To prevent instances of hunger is the fundamental focus of every human. Though hunger and undernutrition have declined globally since year 2000, the state of hunger is still severe (Grebmer, *et al.* 2018, p. 3) considering the number of people still going hungry. As much as 72 developing nations out of 129 have reached the Millennium Development Goals (MDG) hunger target, most of these enjoyed stable political conditions and economic growth, along with sound social protection policies aimed at assisting the most vulnerable (FAO, IFAD and WFP, 2015, p. 13). Sadly, the current figure of over 800 million hungry people around the world is more than the population of Europe, comprising of about 44 countries and territories. It is an equivalent population of Europe and Australia combined, plus the small population of the continent of Antarctica. In other words, the hunger situation is still pretty much dangerous. Much of hunger situations are in the continents of Asia and Africa, however.

Therefore, much needs to be done to contain this menace and the continued population growth, to which the Food and Agriculture Organization has contributed significantly, proposing a grassroots development for the most vulnerable. The 2016 GHI was compiled for 118 countries, excluding highly developed countries where the incidence of hunger is low and where the measurement indicators are not appropriate because of the low tendency for hunger. Figure 2.2 shows the composition and indicators. Tables 2.2 and 2.3, shows the index values/interpretation and GHI ranking of the examined countries over the years, respectively.

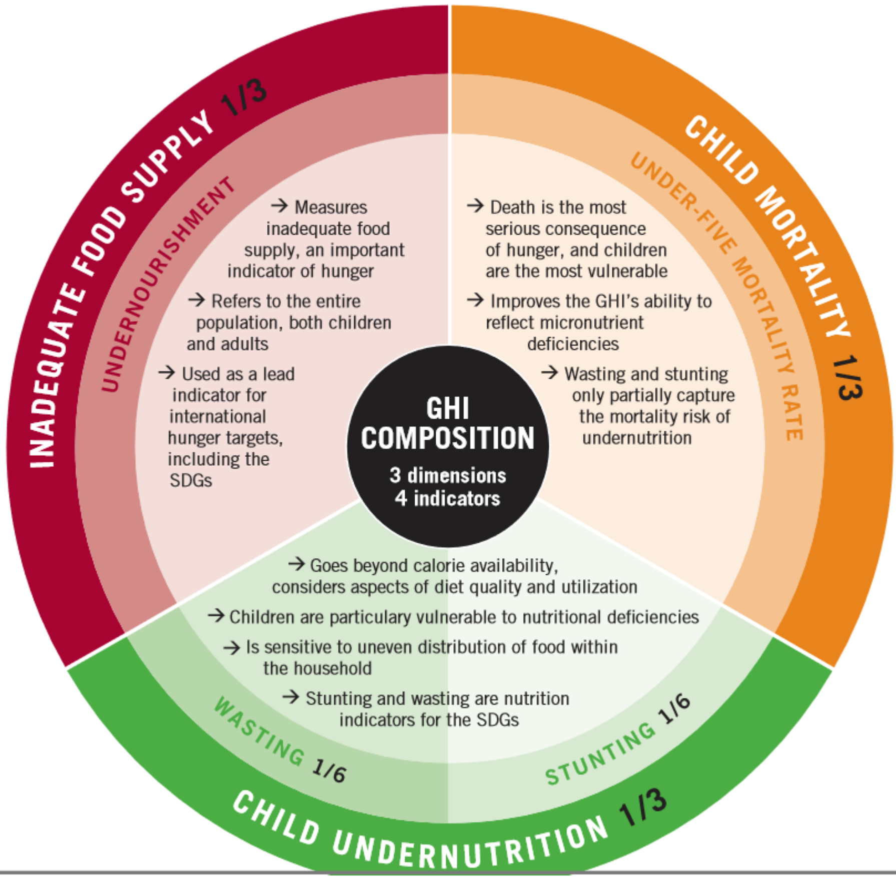


Figure 2.2: GHI indicators

Credit: Grebmer *et al.,* 2017, p. 8).

Table 2.2: Indices for GHI values and interpretation

GHI Value	Interpretation	Remarks: Country's Case
<= 9.9	Low	Kuwait, Turkey
10.0 – 19.9	Moderate	Ghana, Senegal
20.0 – 34.9	Serious	Indonesia, Nigeria
35.0 – 49.9	Alarming	Zambia, and Central African Republic's case
>= 50	Extremely alarming	The Central African Republic

Credit: Grebmer *et al.* (2015, p. 9, 2017, p. 9; 2018, p. 9).

Table 2.3: Comparing Global Hunger Index Scores over the years for participating countries

Rank[1]	Country	2000	2005	2010	2018
2018 GHI scores less than 5, collectively ranked 1–15[2]	Belarus	5.0	<5	<5	<5
	Bosnia & Herzegovina	9.8	7.2	5.1	<5
	Chile	<5	<5	<5	<5
	Costa Rica	6.1	5.6	5.0	<5
	Croatia	6.2	<5	<5	<5
	Cuba	5.3	<5	<5	<5
	Estonia	6.7	5.4	<5	<5
	Kuwait	<5	<5	<5	<5
	Latvia	6.9	5.0	<5	<5
	Lithuania	5.0	<5	<5	<5
	Montenegro	—	—	<5	<5
	Romania	8.3	6.8	6.1	<5
	Turkey	10.3	7.3	5.3	<5
	Ukraine	13.6	5.0	<5	<5
	Uruguay	7.7	8.1	5.4	<5
16	Bulgaria	8.2	7.8	7.0	5.0
16	Slovak Republic	7.2	6.8	5.8	5.0
18	Argentina	6.7	6.2	5.9	5.3
19	Kazakhstan	11.3	12.4	8.8	5.5
20	Macedonia, FYR	7.7	8.5	7.0	5.9
21	Russian Federation	10.1	7.7	7.0	6.1
22	Mexico	10.8	9.1	7.7	6.5
22	Serbia	—	—	6.7	6.5
24	Iran	13.5	9.4	8.1	7.3
25	Armenia	18.4	12.8	11.3	7.6
25	China	15.8	13.0	10.0	7.6
27	Colombia	11.3	10.8	10.0	7.7
28	Tunisia	10.7	8.6	7.6	7.9
29	Trinidad & Tobago	11.7	12.2	12.2	8.0
30	Georgia	14.6	10.5	8.4	8.1
31	Brazil	13.0	7.0	6.6	8.5
31	Paraguay	13.9	12.5	11.4	8.5
31	Saudi Arabia	11.5	13.8	9.7	8.5
34	Jamaica	8.4	8.2	8.5	8.6
35	Peru	20.9	18.4	12.5	8.8
36	Fiji	9.8	9.3	8.6	9.0
37	Panama	19.8	17.7	12.6	9.1
38	Kyrgyz Republic	18.8	14.0	12.4	9.3
39	Algeria	15.6	12.9	10.6	9.4
40	Azerbaijan	27.4	17.4	12.3	9.5
41	El Salvador	16.3	13.3	12.8	10.1
42	Suriname	16.0	12.5	10.5	10.2
43	Dominican Republic	18.4	17.2	13.0	10.3
44	Morocco	15.7	17.8	10.2	10.4
44	Thailand	18.3	13.3	12.9	10.4
46	Oman	13.7	14.7	9.8	10.8
47	Mauritius	15.9	15.2	14.1	11.0
48	Jordan	12.2	8.5	8.3	11.2
49	Venezuela	15.2	12.7	8.4	11.4
50	Lebanon	9.1	10.3	8.0	11.7
51	Ecuador	20.6	17.6	14.1	11.8
52	Uzbekistan	23.7	17.9	15.6	12.1
53	Albania	21.6	16.9	15.4	12.2
53	Turkmenistan	22.0	17.4	15.3	12.2
55	Guyana	17.8	16.9	15.9	12.6
55	Mongolia	31.7	24.9	15.8	12.6
57	Malaysia	15.5	13.0	11.9	13.3
58	Nicaragua	24.7	17.8	16.4	13.6
59	Honduras	20.6	17.7	14.7	14.4
60	South Africa	18.1	20.8	16.1	14.5
61	Egypt	16.4	14.3	16.3	14.8
62	Ghana	29.0	22.2	18.2	15.2
63	Gabon	21.1	19.0	16.7	15.4
64	Viet Nam	28.2	23.8	18.8	16.0
65	Bolivia	30.3	27.1	21.8	16.7
66	Senegal	37.3	27.8	24.1	17.2

Rank[1]	Country	2000	2005	2010	2018
67	Sri Lanka	22.3	21.2	17.9	17.9
68	Myanmar	44.4	36.4	25.9	20.1
69	Philippines	25.9	21.6	20.6	20.2
70	Guatemala	27.5	23.8	22.0	20.8
71	Camer[illegible]	41.2	33.7	26.1	21.1
72	Nepal	36.8	31.4	24.5	21.2
73	Indon[illegible]	25.5	26.5	24.5	21.9
74	Iraq	26.5	24.9	24.4	22.1
75	Gamb[illegible]	27.3	26.2	22.3	22.3
76	Swazi[illegible]	28.9	27.6	26.7	22.5
77	Kenya	36.5	33.5	28.0	23.2
78	Cambodia	43.5	29.6	27.8	23.7
78	Lesotho	32.5	29.7	26.3	23.7
80	Benin	37.5	33.5	28.1	24.3
80	Namibia	30.6	28.4	30.9	24.3
80	Togo	39.1	36.4	27.1	24.3
83	Lao PDR	48.0	35.8	30.3	25.3
84	Botswana	33.1	31.2	28.4	25.5
85	Côte d'Ivoire	33.7	34.7	31.0	25.9
86	Bangladesh	36.0	30.8	30.3	26.1
87	Malawi	44.7	37.8	31.4	26.5
88	Mauritania	33.5	29.7	24.8	27.3
89	Burkina Faso	47.4	48.8	36.8	27.7
90	Mali	44.2	38.7	27.5	27.8
91	Rwanda	58.1	44.8	32.9	28.7
92	Guinea	43.7	36.8	30.9	28.9
93	Ethiopia	55.9	45.9	37.2	29.1
93	Guinea-Bissau	42.4	40.3	31.0	29.1
95	Angola	65.6	50.2	39.7	29.5
95	Tanzania	42.4	35.8	34.1	29.5
97	Papua New Guinea	30.9	28.2	34.3	29.7
98	Djibouti	46.7	44.1	36.5	30.1
99	Congo, Rep.	37.8	37.2	32.2	30.4
99	Niger	52.5	42.6	36.5	30.4
101	Comoros	38.0	33.6	30.4	30.8
102	Mozambique	49.1	42.4	35.8	30.9
103	India	38.8	38.8	32.2	31.1
103	Nigeria	40.9	34.8	29.2	31.1
105	Uganda	41.2	34.2	31.3	31.2
106	Pakistan	38.3	37.0	36.0	32.6
107	Zimbabwe	38.7	39.7	36.0	32.9
108	Liberia	48.4	42.0	35.2	33.3
109	North Korea	40.3	32.9	30.9	34.0
110	Timor-Leste	—	41.8	42.4	34.2
111	Afghanistan	52.3	43.2	35.0	34.3
112	Sudan	—	—	—	34.8
113	Haiti	42.7	45.2	48.5	35.4
114	Sierra Leone	54.4	51.7	40.4	35.7
115	Zambia	52.0	45.8	42.8	37.6
116	Madagascar	43.5	43.4	36.1	38.0
117	Yemen	43.2	41.7	34.5	39.7
118	Chad	51.4	52.0	48.9	45.4
119	Central African Republic	50.5	49.6	41.3	53.7

— = Data are not available or not presented. Some countries did not exist in their present borders in the given year or reference period.

Note: Rankings and index scores from this table cannot be accurately compared with rankings and index scores from previous GHI reports (see Chapter 1).

[1] Ranked according to 2018 GHI scores. Countries that have identical 2018 scores are given the same ranking (for example, Bulgaria and the Slovak Republic are both ranked 16th). The following countries could not be included because of lack of data: Bahrain, Bhutan, Burundi, Democratic Republic of Congo, Equatorial Guinea, Eritrea, Libya, Moldova, Qatar, Somalia, South Sudan, the Syrian Arab Republic, and Tajikistan.

[2] The 15 countries with 2018 GHI scores of less than 5 are not assigned individual ranks, but rather are collectively ranked 1–15. Differences between their scores are minimal.

Credit: Compiled from the Global Hunger Index by Grebmer *et al.* (2018).

Note: The lower the number, the better.

2.4 Regional food security

The focus of this section is on the region of Africa, basically because this research's empirical study is stationed in the African continent. The most prosperous region in Africa for reducing hunger was Western Africa, where the number of undernourished people has fallen by 24.5 per cent since 1990–92 (FAO, IFAD and WFP, 2015, p. 13). This success happened despite limiting factors such as rapid population growth, drought in the Sahel and high food prices experienced in recent years. A total of 18 countries in sub-Saharan Africa have reached the MDG 1c [reduce by half the percentage of persons who suffer from malnutrition] hunger target (Ibid.). However, the situation is still far from expectation in Africa, especially with the highest-ranked African country on the 47th position on the global food security scale. Table 2.4 below shows the region-wise summary of the 2016 Global Food Security Index (GFSI).

Table 2.4: Global Food Security Index (GFSI) region-wise for 2016 (reproduced)

Regions	**Countries within the region**
Africa Region	South Africa is the highest-ranked African country in 47th place overall, followed by Tunisia (53), Botswana (54), Egypt (57) and Morocco (62). Nigeria (90)
Asia Region	Singapore is the highest-ranked country in Asia (3rd place overall), followed by Japan (22), South Korea (28), Malaysia (35) and China (42).
South America Region	Chile is the highest-ranked country in South America (24th place overall) followed by Uruguay (36), Argentina (37), Brazil (41) and Colombia (49).
Central America	Costa Rica is the highest ranked Central American country (37th place overall), followed by Mexico (39), Panama (44), El Salvador (69) and Guatemala (73).
North America Region	The US in the first place (Overall) and Canada 8th.
Europe Region	The highest-ranked European country is Ireland (2nd place overall), followed by the Netherlands (4), France and Germany (joint 6) and the UK (8).
Middle East	Qatar is the highest-ranked Middle Eastern country (20 overall), followed by Oman in (26), Kuwait (27), the UAE (30) and Saudi Arabia (32).
Oceania	Australia (4 overall) and New Zealand (11)
The Caribbean	Two Caribbean countries were included in the index with the Dominican Republic in (64), and Haiti (108)

Credit: The Economist Intelligence Unit, 2016.

In terms of hunger, Europe and North America has little problems. However, African and Asian countries still have a lot more to do to combat hunger and poverty.

2.5 Household and national food security in Nigeria

In the 2018 ranking, over 70% of countries included in the food security index recorded higher scores compare to the previous year. However, Nigeria further slipped down. Low- and mid-income countries made the most substantial gains because of improvement in agricultural infrastructure (e.g., road networks and crop storage facilities) and improved capacity to feed rapidly growing urban populations. Again, Nigeria, through a mid-income country, slipped within the same period. Nigeria further moved in terms of food safety and quality in 2017 because of cases of contamination along the global food supply chain.

Rural households are most vulnerable in Nigeria for various reasons bothering inadequate storage facilities and post-harvest wastes and losses. According to the Global Hunger Index, hunger situation in Nigeria is severe, especially in the northern part where terrorism (Boko Haram Islamic Group) has killed many in their thousands. Hunger in the slums of the major cities is a direct result of a lack of economic opportunities.

According to FAO (2018), the agricultural sector in Nigeria faces many challenges. Notably, among them are an outdated land tenure system that constrains access to land (1.8 ha/farming household) and a shallow level of irrigation development (less than 1 per cent of cropped land under irrigation). Others are limited adoption of research findings and technologies, high cost of farm inputs, poor access to credit, inefficient fertilizer procurement and distribution, inadequate storage facilities and poor access to markets have all combined to keep agricultural productivity low (average of 1.2 metric tons of cereals/ha) with high postharvest losses and waste.

About two-thirds of the population of Nigeria are in poverty and on very low income, especially those at the provincial level (NBS, 2012).

However, because of the country's massive size and diversity, different regions may face various constraints because of a decentralised approach to designing industrial policies and initiatives that may not be in sync with the agricultural systems (IFPRI, 2012).

The root causes of food loss and spoilage are complex and interlinked, and include, but are not limited, to insufficient post-harvest and on-farm storage technologies, dated practices for handling, processing and packaging; and limited market information and access, decreasing farmers' abilities to sell products at a reasonable price before they deteriorate. The United Nation had indicated the need "to shift the focus of development economics from national income accounting to people-centred policies" (UNDP, 2018a) as the critical solution.

2.6 Importance of grains in food and nutrition

Grains are small, hard, dry seeds, with or without attached hulls or fruit layers, harvested for human or animal consumption (Babcock, 1976, p. 1). 'Any grain or edible seed of the grass family which may be used as food; e.g. wheat, rice, oats are called cereal. All cereal crops (except the so-called pseudo-cereals such as buckwheat and quinoa,) are members of the grass family Poaceae (Gramineae). The pseudo-cereals are plants grown for the seed (actually fruits) of the somewhat similar nutrient composition to the cereals but not belonging to the grass family' (Vaughan *et al.,* 1997, pp. 22, 29 and 30).

Grains are generally divided into three groups; cereals (such as wheat, millet, rice and maize), oilseeds (soybeans, sunflower, linseed) and pulses (beans, peas, cowpeas). According to FAO (2002, p. 32), cereals are still by far the world's most important sources of food, both for direct human consumption and indirectly, as inputs to livestock production. It means, therefore, that grains are the most important crops grown around the world.

In addition, 'cereal-based foods are a major source of energy, protein, B vitamins and minerals for the world population' (McKevith, 2004, p. 114). Also 'wheat, maize, rice, barley, rye, oat, triticale, millet and sorghum are the cereal crops most regularly grown in different parts of the world' (Shewry, 2007, p. 240). Similarly, 'as an essential part of a balanced diet (i.e. one that provides all the food groups in the nutrition education pyramid or plate and all the recommended dietary intakes) the cereal group provides necessary amounts of most nutrients —but not all' (Truswell, 2002, p. 2). Table 2.5, below, shows the proximate composition of some cereal grains.

Table 2.5: Proximate composition of cereal grains

Cereal	Crude protein	Crude fat	Ash	Crude fibre	Available carbohydrate
Brown rice	7,3	2,2	1,4	0,8	64,3
Sorghum	8,3	3,9	2,6	4,1	62,9
Rye	8,7	1,5	1,8	2,2	7108
Oats	9,3	5,9	2,3	2,3	62,9
Maize	9,8	4,9	1,4	2,0	63,6
Wheat	10,6	1,9	1,4	1,0	69,7
Barley	11,0	3,4	1,9	3,7	55,8
Pearl mil	11,5	4,7	1,5	1,5	63,4

Credit: FAO (2014b, p. 10)

2.7 Nutritional composition of grains

Table 2.6 shows the nutritional composition of different whole grain and refined grains, per 100 g, according to the European Food Information Council – EUFID.

Table 2.6: Nutritional composition of different whole grain and refined grains, per 100 g

	Whole wheat flour	White, wheat flour, 75% extraction	Rye flour	Rye flour, 60% extraction	Brown rice (raw)	White rice (raw)	Barley (whole grain raw)	Pearl barley	Oatmeal
Carbohydrates, g (% of energy)	62 (75.6)	71 (80.6)	59.2(71.4)	73 (85)	73.5 (82.4)	78 (87)	60.8 (72.8)	67 (79)	60.7 (63.9)
Protein, g (% of energy)	10 (12.2)	12.6 (14.3)	10 (13)	8 (9.3)	8.3 (9.3)	7 (8)	10.6 (12.7)	9 (10.6)	12.8 (13.2)
Fat, g (% of energy)	2 (5.5)	1.1 (2.8)	2 (5.8)	1 (2.6)	2.6 (6.6)	1 (2.6)	2.1 (5.7)	2 (5.3)	7.3 (18.1)
Dietary fibre, g	11	4	15	5	3	1.3	14.8	8.6	7.3
Vitamins									
Vitamin B^1(Thiamine), mg	0.4	0.07	0.4	0.15	0.34	0.04	0.31	0.03	0.60
Vitamin B^2(Riboflavin), mg	0.15	0.04	0.2	0.07	0.03	0.03	0.10	0.03	0.05
Vitamin B^3(Niacin), mg	5.7	1	1.7	1	6.1	1	5.2	3	1
Vitamin B^6(pyridoxine), mg	0.35	0.12	0.22	0.23	0.25	0.12	0.56	0.25	0.12
Vitamin B^9(Folate), µg	37	22	78	28	49	20	50	20	60
Minerals									
Iron, mg	*4*	*0.8*	*4*	*1.5*	*1.3*	*0.4*	*6.0*	*2*	*4.0*
Zinc, mg	*2.9*	*0.64*	*3*	*1.3*	*0.8*	*1.8*	*3.3*	*2*	*3.02*
Magnesium, mg	*124*	*20*	*92*	*51*	*157*	*13*	*91*	*44*	*128*
Sodium, mg	*5*	*2*	*5*	*10*	*1*	*2*	*4*	*5*	*7*

Credit: European Food Information Council – EUFID (2015, p. 3).

2.8 Grain anatomy

Most of the grain used for human food is milled to remove the outer layer (pericarp) called the bran, besides the germ. This milling process removes some essential nutrients beneficial to health, including dietary fibre, phenolic, vitamins and minerals (Wilder, 2010). The process strips the grain the “whole” status. It is common with the three most consumed food crops in the world – rice, wheat and maize.

A whole-grain kernel — or seed — is composed of three parts: the bran, the endosperm, and the germ. The bran is the outer shell that protects the grain. It provides fibre, B vitamins, and trace minerals. The germ provides nourishment for the seed, containing antioxidants, vitamin E, B vitamins, protein, minerals, and oils. The endosperm provides energy for the seed in the form of carbohydrates (primarily) and protein (Wilder, 2010, p. 1). Figure 2.3 shows the anatomy of a whole grain kernel.

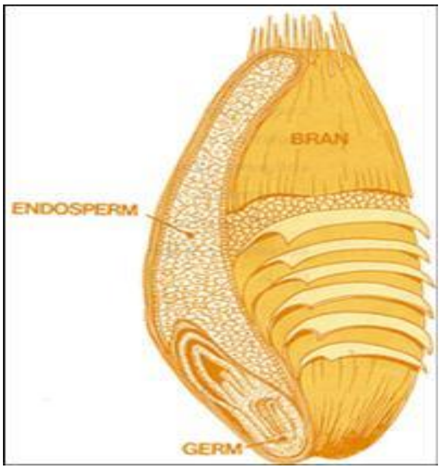


Figure 2.3 A whole grain kernel
Source: Wilder (2010, p. 1).

2.9 Grain storage parameters

Grain storage is one of the common ways to deal with the problem of food insecurity. The versatility of grains requires that specialised storage systems be adopted to reduce waste and losses. Several environmental factors are generally considered within the grain storage environment. The cause of grain losing its optimum value (losses) and quantity (wastes) depends on the way the grain is dried, the conditions of the storage environment and the materials it is stored. The primary factors to consider are:

- Temperature,

- Relative humidity of the surrounding;
- The moisture content of the grains to be stored.

Grain temperature has a significant effect on the grains in storage. Generally, warm grains would relatively be ideal for insect breeding and activity, therefore must be cooled immediately for an extended grain storage life. It reduces germination loss, maintains baking qualities and protects against infestation and permits grain to be stored at higher moisture contents. Lowering the temperature lowers the relative humidity in equilibrium with the moisture content. It effectively increases storage time (HGCA, 2003).

Storage length varied considerably for various cereal crops. Presence of foreign materials, including insects, fungi can increase the deterioration rate. Moisture content must be kept within the allowable storage limit and checked regularly to avoid build-up. Table 2.7 shows the optimum temperature and possible length of storage at the indicated storage temperatures for principal grain crops.

Table 2.7: Optimum moisture content and time for storage of grains.

Crop	Storage temperature (^{o}C) up to 6 Months	Storage temperature (^{o}C) More than 6 Months
Wheat	18	10
Corn	15	13
Soybeans	13	11
Canola	15	13
Edible beans	15	13
Small Grains	14	13
Sunflower (oil)	10	8
Rough rice	12-14	12
Sorghum	12-15	12

Credit: William and Gary (2002, p. 1).

Grains are hygroscopic and will lose or gain moisture until an equilibrium is reached with the surrounding air. The equilibrium moisture content (EMC) is dependent on the relative humidity and the temperature of the atmosphere (FAO, 1994), and this has been compiled by Brooker *et al.* (1974) as in Table 2.8.

Table 2.8: Grain equilibrium moisture content for range of grains

	Relative Humidity (%)							
Grain	30	40	50	60	70	80	90	100
	Equilibrium Moisture Content (% wet basis) at 25 ^{o}C							
Barley	8.5	9.7	10.8	12.1	13.5	15.8	19.5	26.8
Shelled maize	8.3	9.8	11.2	12.9	14.0	15.6	19.6	23.8
Paddy	7.9	9.4	10.8	12.2	13.4	14.8	16.7	-
Milled rice	9.0	10.3	11.5	12.6	12.8	15.4	18.1	23.6
Sorghum	8.6	9.8	11.0	12.0	13.8	15.8	18.8	21.9
Wheat	8.6	9.7	10.9	11.9	13.6	15.7	19.7	25.6

Credit: Brooker, Bakker-Arkema and Hall (1974).

2.10 The techniques of grain storage

The primary purpose of grain conditioning is to preserve its quality, which has been reported to favour low moisture content and temperature (these are important for successful storage over an extended period).

When warm air from the centre of a bulk or silo meets raw grain at the surface, condensation may occur. Moisture at the surface or in damp pockets in bulk will encourage moulds, heating and sprouting. Developing grain weevils may also generate heat. Therefore, grain should be aerated immediately after post-harvest to even out temperatures. The temperatures should be checked regularly across the bulk – particularly areas furthest away from the duct in a blown aeration system or closest in a suction system and cool intermittently, even when grain temperature has fallen, to counteract 'hot-spots' developing (HGCA, 2003, pp. p, 13).

Before storage or further processing, cereal grains need to be dried. The most cost-effective method is to spread them out in the sun to dry. In other regions (like the humid climates), the use of artificial dryers is necessary, as a simple grain dryer.

Simple grain dryers can be made from a large rectangular box or tray with a perforated base. The grain is spread over the bottom of the box, and hot air is blown up through a lower chamber by a fan. The fan can be powered by diesel or electricity and the heat supplied by kerosene, electricity, and gas or burning biomass, to evaporate moisture from the grains.

There are two underlying mechanisms in the drying procedure: (1) moisture movement from the interior of each grain in bulk and (2) evaporation of the moisture from the surface of the grains or the storage medium to the surrounding. The rate of drying is determined by the moisture content of the grain, the temperature of the grain, relative humidity of the environment and the velocity of the air in contact with the grains (FAO, 1994).

Cereal grains should be dried to 10-15% moisture before storage. Dried grains are stored in bulk until required for processing. The grains should regularly be inspected for signs of spoilage, and the moisture content testing. If the grain has picked up moisture, it should be re-dried. Grains are often protected with insecticides and must be stored in rodent-proof containers (FAO, 2015b).

For rice grain, for instance, RKB (2017), opined that extended period safe storage of rice is possible if the grain moisture content is less than 14%, and stored away from insects, rodents and birds.

According to the FAO (1994), the drying of grains in thin layers where each and every kernel is fully exposed to the drying air can be represented in the form:

MR = f(T, h, t);

$$MR = \frac{MC - MC_e}{MC_0 - MC_e}$$

Where,

MR represents the moisture ratio (a ratio that compares the mass or volume of air to the mass or volume of moisture contained in that air).

MC is the moisture content of the grain at any level and at any time, % dry basis or % db);

MC_e is the equilibrium moisture content (%db);

MC_o is the initial moisture content of the wet grain (%db);

T is the air temperature (°C);

h is the air relative humidity; and

t is the drying time.

Empirical data have been used to determine mathematical approximations of the relationship between drying rate and air conditions.

The key to successful storage is to move the drying zone through the top of the grain mass within the allowable storage time (Alberta Agriculture and Forestry, 2001). As shown in Figure 2.4, the permissible time for drying is reduced at high grain temperature and moisture content. It means a higher airflow requirement to accomplish drying within the proper storage for wetter grain. Similarly, at higher temperatures, high airflow rates are required to complete drying before grain spoils. Figure 2.5 shows the various zones in a storage structure such as a bin or silo.

Table 2.9 shows the general recommended moisture content for safe storage.

Table 2.9: Recommended moisture content for safe storage

Storage Duration	Recommended MC for safe storage	Potential problems
Weeks to a few months' storages	14% or less	Moulds, discolouration, respiration loss, insect damage, moisture adsorption
Storage for 8 to 12 months	13% or less	Insect damage
Storage of farmers' seeds	12% or less	Loss of germination
Storage for more than a year	9% or less	Loss of germination

Credit: RKB (2017).

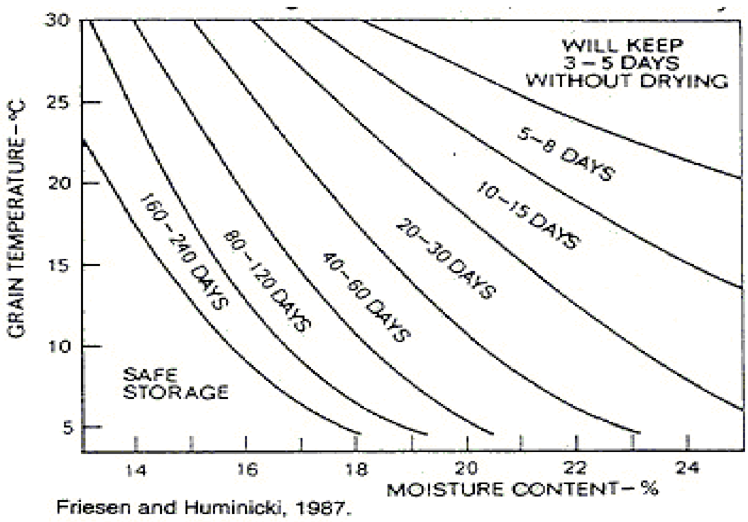


Figure 2.4: Safe Grain Storage temperatures and Moisture Content

Credit: Friesen and Huminicki (1987) *in* Alberta University of Agriculture and Forestry (2001, p. 2).

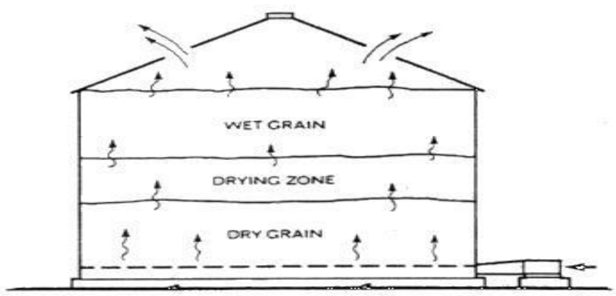


Figure 2.5: Drying zones of a grain storage bin or silo

Credit: Credit: Friesen and Huminicki (1987) *in* Alberta University of Agriculture and Forestry (2001, p. 2).

2.11 Impacts of food security and hunger indices on human development

Though the human development index is a complex concept that goes beyond food, the place of food in this concept cannot go unnoticed. The human development index summarises the average achievement in vital human development areas such as long and healthy life, knowledge and a decent standard of living or well-being. Human development index literarily shifted the focus of determining the performance of any region or country on the economy to a concept that emphasises on the people and their capacities.

Elimination of hunger and security of food of the people is fundamental to what the people can achieve with their capacities. Based on the discussion of global food security and global hunger indices, it is clear that human development can only hold when there is food security and hunger is at the lowest level possible. This, therefore, justifies the fundamental reasons for the discussion of food security and hunger security indices.

2.12 Chapter summary

This chapter focused on the food security at the global, national and household levels, including the vital role that grains play against global, national and family food insecurity. This was followed by a discussion on the indices for estimating food security – in this case, the global food security index and the global hunger index were discussed. Food security at the household and national levels in Nigeria were also discussed in relation to the importance that grains play in food and nutrition in Nigeria. The chapter concluded by suggesting the implication of global food security index and global hunger indices on human development. In the next chapter, food security is discussed purposively in case study countries.

CHAPTER THREE

DYNAMICS OF FOOD SECURITY IN THE UNITED KINGDOM (UK), UNITED STATES OF AMERICA (US), CHINA AND INDONESIA

3.0 Introduction: why the UK, US, China and Indonesia as case-study countries?

There are fundamental reasons why the United Kingdom (UK), the United States of America (USA), China and Indonesia were chosen as case study countries. First, the agricultural sector in each of these countries is unique. Secondly, there is a need to examine these countries in terms of the components of food security (availability, accessibility/affordability, the stability of supply and safe utilisation) as outlined in the theoretical underpin proposed in Chapter One.

The UK was considered as a case country because it has globally recognised independent food safety standards and regulations. There is also an insignificant chance of food insecurity or hunger. The USA was considered because it is the highest producer of maize (corn) in the world, and maize is the most cultivated crop in Kogi State and one of the most cultivated in Nigeria. The USA was also considered because there is a heavy reliance on the government's food safety standards and low level of hunger situation. Both the UK and the USA has an efficient international network of markets for selling agricultural produce, hence creating economic opportunities for their farmers.

China was considered a case country because despite having the largest population in the world, the country has one of the largest grain reserves in the world. The country has small arable land too, but it produces more than 20 per cent of the world's foods grown on just seven per cent (7%) arable lands. China's food reserve was 356 kg grain in storage per person per year as at 2002 (Ministry of Agriculture of the People's Republic of China, 2004) despite limited arable land (CIA, 2016), above the FAO’s minimum recommendation of 80 kg per person per year for food emergencies (AIT, 2014).

The key reason why the research considered Indonesia is that the country has a population that is about the same size as that of Nigeria with similar challenges that bother on poverty among the farmers, undernourishment among children and political leadership challenges. However, Indonesia has achieved impressive growth economically and even became the largest economy in Southeast Asia in the 1990s (FAO, 2017) and then the fourth in the east after China, Japan and South Korea (Elias and Noone, 2011). Cases of hunger and child-stunting still existing, but the government is pushing for up to 95 % food sufficiency.

The fundamental fact is that agriculture occupies an essential place in every nation of the world, and its contribution in terms of food supplies, employment and national growth and development cannot be over-emphasised. Agriculture can help reduce poverty, raise incomes and improve food security for 80% of the world's poor, who live in rural areas and work mainly in farming (World Bank, 2018b). The situation in third world country like Nigeria differs significantly from that of the developed countries because of some fundamental issues, and thus it is best to study what the developed countries are doing and delivering the same strategy or modify for the local situations in the developing countries. It may help to know why on the world scale, the wealthiest twenty-four [24] nations of the world have about ten per cent of the population but produce 45 per cent of the world’s [foods]. The poorest fifty [50] accommodates one-third of the world’s population but grows just 5 per cent of the world’s foods (Leathers and Foster, 2017, p. 141).

In this chapter, the research analytically looked at the dynamics of agriculture in these countries, what they are doing in their agricultural sector to ensure that the four components of food security are sustained, including the performance of their farmers. The focus is on what can be learnt from these countries.

3.1 Food security in the UK

The 2018 Global Food Security Index (GFSI) report placed the United Kingdom as the third most food secured land in the world, just behind Singapore and the Republic of Ireland respectively but there are still some short-term household food insecurities (Lambie-Mumford *et al.,* 2014). Also, in terms of the components of food security, the UK ranked differently in each element. For example, in terms of food availability and accessibility, the GFSI ranked the UK first in the world. The UK was ranked 11th in affordability, 18th in quality and safety of food and 45th in the management of natural resources and resilience. Food supply is stable, and significant disruptions in terms of food supply are unlikely. Overall, the UK ranked 3rd worldwide in food security base on the 2018 GFSI report.

While the UK is considered as one of the countries that place great emphasis on food safety, it still has some work to do in food safety, and it has had a poor outcome in some quarters, which is reflected in the ranking. However, consistent efforts are being made by retailers and manufacturers to adhere to the regulatory requirements on food safety, leading to the reliance on private food safety institutions.

In a study by Lambie-Mumford *et al.* (2014), to understand the *food aid landscape in the UK, those who use food aid and why* they researchers found out that the number of people seeking the support of food aid was on the increase. It also found out that low-income households, those who just lost their jobs, and those with health challenges are those who are most likely to use aid but as their last resort. The users of food aid employ different strategies to obtain their own food before they consider food aid. Some of the plans are cutting back and changing eating and shopping habits, juggling budgets and turning to family and friends.

One of the conclusions of the study is that food aid does not reduce the overall household food insecurity because it does not remove the cause of the food insecurity. However, food aid can be used as formidable relieve for short-term food insecurity as been experienced by households in the UK if appropriately tailored to the needs of the users (Lambie-Mumford *et al.* 2014; Poppendieck, 1994).

In the following sections, other vital statistics relating to the UK's agriculture is reviewed.

3.1.1 Key agricultural statistics of the UK

The population of the United Kingdom has been estimated to be 66.7 million (Worldometers, 2018) on December 31 2018, of which about 126, 000 are farmers (Statista, 2018). The country produces about 60 per cent of its food and importing the rest (National Statistics, 2015). Farm sizes vary significantly from less than 20 to over 100 hectares per farm. There were about 212,000 farm holdings in the UK in 2016 (National Statistics, 2016). Therefore, based on these statistical facts, the farmer-to-population ratio in the UK is 1:317; which means, a farmer in the UK produces as much food for at least 317 others in the country, assuming the 40 per cent import is equivalent of 40 per cent less of the total population. This is one of the most robust efficiencies of a farmer in any country in terms of the ratio of the total farmers to the total population of the country.

According to the Home-Grown Cereal Authority (HGCA), and the Agriculture and Horticulture Development Board (AHDB) of the UK, wheat is the most widely grown arable crop, covering an expanse of about two million hectares and produces approximately 15 million tons of wheat yearly. Export takes around four million tons and generally goes to about 20 nations around the world. Wheat is a multipurpose crop and is used primarily for milling into flour which is the raw material for bread and biscuits. Wheat is also used for animal feed (HGCA and AHDB, 2015, p. 3). Other cereals are grown in the United Kingdom (mostly for local consumption only) are barley, oats and a smaller quantity of triticale, linseed and rye.

Agriculture uses 69% of the expanse of land in the United Kingdom, and it employs 1.5% of its workforce (about 476,000 people). It contributes 0.62% of it is Gross Value Added – that is, the contribution of part of the economy, minus any costs incurred (Development Economics, 2017, p. 2; National Statistics, 2015; Rhodes, 2016, p. 5). Though agricultural related activities occur in most rural locations, it is concentrated in East Anglia (crops) and the South West (livestock), according to the Office of the National Statistics (2016).

In recent times, organic farming is becoming common, as farmers make an effort to sustain profits. Some farmers complement their income by diversifying activities away from pure agriculture – for example, biofuels present new chances for farmers in the UK as fossil fuels continue to be seen as an unfriendly fuel to the environment and encouraging climate change. The prices for biofuels is still on the increase. Hence farmers have an essential role to play in terms of preserving the countryside (Brown, 1999) and the environment.

Farmers earnings are relatively low, high technology, fertile soil and subsidies, notwithstanding. For this reason, a large number of young people are still not interested in agriculture or farming, bringing the average age of a typical British farm holder to 59 in 2015 (National Statistics, 2015).

The research observes, however, that the use of technology is intensive and farms are heavily mechanised. Access to finance is vital to the system, enabling farmers to access credit or facilities/equipment and pay over a specified period. According to Laughton (2017), small farms fair better (twice) than big farms in terms of profit; skilled entrepreneurs prefer dealing with small farms. For the small farms, sales are mostly through local supply (short) chains, hence providing benefits to the farmers and even the environment.

3.1.2 Grain production

Table 3.1 and 3.2 shows the production volume of wheat and barley on UK agricultural holdings between 2010 and 2014, and 2013 to 2017 respectively. The provisional 2017 wheat harvest for the UK is 15.2 million tonnes, an increase of 5.4% in 2016. It is above the five years average 2012 - 2016 of 14.5 million tonnes. The provisional barley production figure for the UK increased by 10.6% to 7.4 million tonnes in 2017. It is above the five years average (2012 – 2016) of 6.7 million tonnes (National Statistics, 2015).

Table 3.1: Production of Wheat and Barley on UK agricultural holdings 2010-2014

						Thousand Tons
	2010	2011	2012	2013	2014	% Change between 2013 & 2014
Wheat	14,878	15,257	13,261	11,921	16,621	39
Barley	5,252	5,494	5,522	7,092	7,027	-1

Credit: DEFRA (2017, p. 1).

Table 3.2: Production of Wheat and Barley on UK agricultural holdings 2013-2017

						Thousand Tons
	2013	2014	2015	2016	2017	% Change between 2017/2016
Wheat	11,921	16,606	16,444	14,383	15,163	+5.4
Barley	7,092	6,911	7,370	6,655	7,360	+10.6

DEFRA (2017, p. 1).

3.1.3 Grain storage systems in the UK

Safe, adequate grain storage is key to assuring crop quality and helping prevent loss of premiums through claims and rejections. Store hygiene is essential for eliminating sources of contamination from storage fungi, insects and mites (which are considered the three leading causes of grain spoilage in the United Kingdom) – and are most likely to be introduced from the store structure and equipment (HGCA, 2011).

There are options available to farmers regarding the storage of grains in the United Kingdom, according to Fengrain, (2016). On-farm storage facilities which require the farmers to build and maintain the facilities, sharing the gains as well as the losses. Another option is the use of the central storage facilities which are available to farmers to pay for "storage spaces" and the maintenance of such spaces while their grain is in store. Flexible storage hire is also becoming popular on a pay-as-you-go basis. There is also a co-operative option, which involves buying membership of a cooperative and space at the Cooperative Stores. Additional services such as cleaning, haulage, drying, marketing expertise and others aimed at adding value to the grains are also provided by the cooperatives.

Storing grains at a central store has many benefits (Ibid.), some of which includes full-grain management service as the management of the stores takes care of the logistics involved in the drying and long-term storage. Other benefits are:

- Cost-effective management of grain;
- Better utilisation of existing facilities and cash flow;
- Low-cost, long-term asset.

The purpose of having the best storage systems in place is to ensure that the grains are dried and dressed for premium markets. Therefore, safe and clean dried grains add value to the grains. Storage is necessary when the prices are down. There are excellent grain storage structures all over the UK. Based on interaction with a few farmers, it could be cheaper (and perhaps, more convenient) to store grains with rental stores than building individual storage systems.

Proper storage minimises risk throughout the supply chain, ensuring food safety. Most UK grain enters the human food chain, either as food, drink or animal feed.

Drying is done in two ways, according to the HGCA (2011, p. 1): high temperature drying at about 40 ^{o}C or near-ambient temperature of about 5 ^{o}C above the grain temperature. Crop drying and storage systems are designed to follow the Hazard Analysis and Critical Control Points (HACCP) system, which is a mandatory food safety system in the UK. Figure 3.1 shows a pattern of grain drying/storage systems.

Figure 3.1: Crop drying/storage systems in the UK

Credit: REBL (2018) (left), RAU grain dryer/storage (right).

3.1.4 Food safety regulations in the UK

Private food safety organisations take food safety regulations seriously in the UK's food supply chain. It is so comprehensive that any food manufacturer, wholesaler, supplier and the retailer would either be at its best or be out of business. Several standards operate in the UK and Europe. The European Union's (EU's) food safety policy aims to ensure that EU citizens enjoy safe and nutritious food produced from healthy plants and animals (EUFIC, 2015, p. 3). However, there are independent, private food safety organisations that further takes the issue of food safety to another level by providing strict standards at all stages along the food supply chain.

Some of the available standards in the UK and Europe for crop, feed and primary producers are Red Tractor, Linking Environment and Farming (LEAF), GLOBALGAP and organic certifications. Others are manufacturer schemes, and they include Global Food Safety Initiative - (which covers BRC Global Food Safety, Dutch HACCP, IFS, SQF, FSSC 22000, GlobalG.A.P., CanadaGAP, Global Market Programmes, Best Aquaculture Practices (BAP)), Good Manufacturing Practice, Good Distribution Practice, HACCP and ISO 9001 and ISO 22000. Table 3.3 below shows some of the standards in play in the UK and USA.

Table 3.3: Some notable food standard certification bodies in the UK, USA and Europe

Notable Standards	**Owners**	**Mode of Standard Development**
BRC Global	British Retail Consortium – UK	Members
International Food Standard	Germany, France, Italy, Switzerland, Austria, Asia, Spain and America	All Stakeholders – wholesales and retails
ISO 22000	162-member countries including the UK (British Standard Institution, BSI), USA (America National Standard Institute) South Africa (South African Bureau of Standards) and Nigeria (Standard Organization of Nigeria, SON)	Technical Committees
SQF 2000 and 1000	Food Marketing Institute – USA and Australia	Member Committees
Food Safety Modernization Act (FMSA)	Government Institution	Department of Health and Human Services - Committees

The Global Food Safety Initiative requirements consist of three key elements: food management systems, good practices and hazard analysis and a critical control point (HACCP) and specify for the recognition of food safety certification programmes in its Benchmarking Requirements. It is done by bringing together food safety experts within a global network and driving global change through multi-stakeholder projects on strategic issues (e.g. auditor competence, regulatory affairs, food safety for small suppliers) (The Economics Intelligence Unit, 2018; Julien, 2010, pp. 62-83).

Generally, to operate as a food manufacturer or retailer or merely want to export foods to the UK and Europe, there are fundamental self-assessment criteria that must be deemed adequate by the internal management of the company or country that want to export to the UK or Europe. Focus areas for food safety self-assessment questionnaires are in the areas of foreign body control, transport, traceability records, HACCP documentation, and product recall procedures are but just a few of the requirements.

The objectives, benefits and coverage are similar among the standard certification bodies, except that some are applicable at the primary production stage (farm level) and others are suited for secondary manufacturers, wholesalers and retailers (industry level) (Julien, 2010, p. 75; Baines, 2010, p. 310). For example, figure 3.2 shows some key certification bodies that operate at the primary and secondary production stages in the UK and Europe.

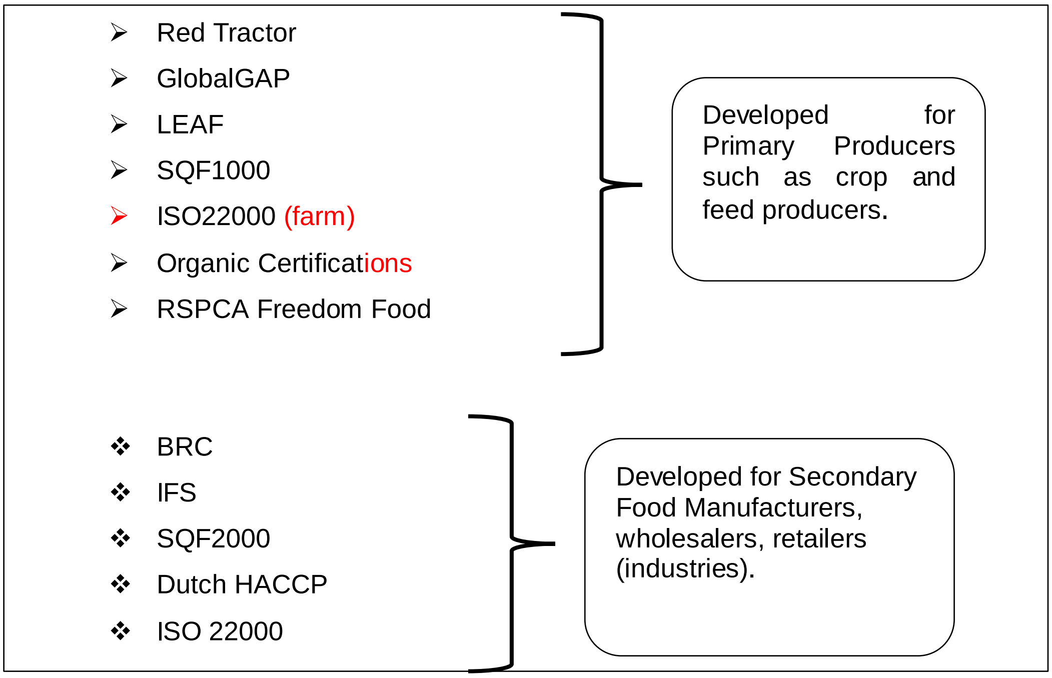


Figure 3.2: Food certifications at primary and secondary production stages

Standard certification can offer several crucial benefits to companies or producers. Some of the benefits include improved confidence in suppliers and products, reduced time spent on supplier screening, less time spent reworking and returning products outside specification. Due diligence defence, expert witness, and the ability to reduce individual inspection costs by combining a variety of different inspections at the same time are other benefits. In addition, there are also marketing benefits such as improved business reputation as a supplier of the high-quality product, ability to trade with customers insisting on independent inspection, use of the logo of the Certification Body and certificate to demonstrate compliance with the standard requirements (SAI Global, 2018).

Each of the standard schemes has their specific requirements, but the conditions are about the same - strong need for management commitment, application of HACCP and good practices in manufacturing, storage and distribution procedures.

3.2 Food security in the USA

In the past few years, the United States of America has been ranked favourably by the Global Food Security Index report. For example, from 2012 to 2016, it ranked first globally as the most food secured country. In 2018, food availability and accessibility ranked 10th, affordability ranked 5th, safety and utilization were 4th , and the adherence to the protection of the environment, natural resources and resilience ranked 44th (poorly).

In 2017, 1 out of every 8 Americans was reported as being in the state of food insecurity (Coleman-Jensen *et al.,* 2018). However, food supply remains stable, and the country has many food export destinations around the world for agricultural produce. Overall, the Global Food Security Index ranked the USA third, along with the United Kingdom in the 2018 global ranking.

Parameters for the Global Hunger Index such as child-wasting and undernourishment, does not apply generally. Food insecurity at the household level is usually temporal, similar to that of the UK and Canada (Lambie-Mumford *et al.* 2014), occasioned by low-income, sudden loss of job and health issues. The food aid in the USA is robust and well able to provide temporal relieve to the temporal households food insecurities.

3.2.1 Key agricultural statistics in the USA

The United States of America is the largest producer of corn (maize) in the world. In 2015, a total of 361.0 million metric tons was produced by the country - a production value that is more than three times the entire production volume of the 27 countries in the European Union. The countries in the European Union had a combined production of just 75.8 million metric tons about the same period.

In 1870, almost 50 per cent of the US population was employed in agriculture (Patricia, 1981). As of 2008, however, less than 2 per cent of the population was directly engaged in agriculture (U.S. Bureau of Labour Statistics, 2015). In 2012 alone, there were an estimated 3.2 million farmers, ranchers and other agricultural managers in the USA. The ratio of the number of farmers to the population of the USA in 2017 (325 million), means a single farmer is producing enough food for at least 101 other people in the country. There was also an estimated 757,900 people who were legally engaged as agricultural workers in the US at this period. Agriculture in the United States is dynamic, covering the major staple crops around the world and a large animal production sector (U.S. Census of Agriculture, 2015).

Among the various hazardous industries, agriculture ranks higher than them all, due to the use of chemicals and risk of injury (NIOSH and CDC, 2007). Agriculture in the US makes up approximately 75% of the country's pesticide use, and the agricultural workers are at high risk of being exposed to dangerous levels of pesticides, whether they are directly working with the chemicals or not (Calvert *et al.*, 2008).

Agriculture is a significant industry in the United States, which is a nett exporter of food (Stephen, 2013). In 2007, about 2.2 million farms existed and were covering an area near a billion acres (3,730,000 km^2). The land size means that a farm averaged 418 acres (1.69 km^2) (U.S. Census of Agriculture, 2007). Although agricultural activity occurs in all states, it is primarily concentrated in the Great Plains of the United States. The Great Plains are plain arable lands. Agricultural businesses also happen in the region around the Great Lakes, which is known as the Corn Belt (Hatfield, 2012). Seed improvement or hybridisation are areas the USA still leads in agricultural innovation, including the development of bio-plastics and bio-fuels (U.S. Census of Agriculture, 2007).

However, for food safety issues, one in six people fall sick each year, and 3,000 deaths are recorded because of foodborne disease (FDA, 2018).

3.2.2 Grain production in the USA

For grains, the United State has been at the forefront of research, production and export. The monetary value of grains in the United States of America is as presented in Table 3.4, below. The comparison is made between the 1997 value and that of 2014 (summarised and tabulated). The United States remain the largest producer of corn in the world, doubling the amount of corn production more than twice within two decades, as shown in Table 3.5. It is evident that the grain market is a vast market, considering its monetary value.

At 361 million metric tons in 2014, the country's production was the largest worldwide. The reason for this success is the fact that the yield per hectare for this crop is one of the highest in the world. Similarly, the robust market structure, the information available to the US farmers on the potential market for this versatile crop is enormous. It gives the farmers, and the country, leverage over other corn (maize) producing countries.

Table 3.4: Value of grain crops in the United States of America

Major Crops	1997 (US$ Billions)	2014 (US$ Billions)
Corn	24.4	52.4
Soybeans	17.7	40.3
Wheat	8.6	11.9
Rice	1.7	3.1
Sorghum	1.4	1.7
Barley	0.9	0.9

Credit: USDA-NASS Report (1997, p. 1); USDA-NASS Report (2015) – as summarized and tabulated.

Table 3.5: Major agricultural produce of the United States of America

S/N	Agricultural Products	2003 total quantity (Million Tons)	2013 total quantity (Million Tons)	2014 Major Grains	Remarks
1	Corn	256.0	354.0	361.0	Increased
2	Cattle meat	12.0	11.7		Decreased
3	Cow's Milk, Whole Fresh	77.0	91.0		Increased
4	Chicken Meat	14.7	17.4		Increased
5	Soybeans	67.0	89.0	108.01	Increased
6	Pigmeat	9.1	10.5		Increased
7	Wheat	64.0	58.0	55.4	Decreased
8	Cotton lint	4.0	2.8		Decreased
9	Hen eggs	5.2	5.6		Increased
10	Turkey meat	2.5	2.6		Increased
11	Tomatoes	11.4	12.6		Increased
12	Potatoes	20.8	19.8		Decreased
13	Grapes	5.9	7.7		Increased
14	Oranges	10.4	7.6		Decreased
15	Rice, paddy	9.1	8.6	10.0	Increased
16	Apples	3.9	4.1		Increased
17	Sorghum	10.4	9.9	10.9	Increased
18	Lettuce	4.7	3.6		Decreased
19	Cotton seed	6.0	5.6		Decreased
20	Sugar beets	30.7	29.8		Decreased

Credit: Summarized from statistics provided by FAO (2015b).

3.2.3 Grain storage systems in the USA

After harvesting their plots, the next step for growers (farmers) is to store the grain adequately. According to Joanie (2013), many farmers have on-farm silos to store grain, equipped with heating and drying systems to take the grain to the appropriate moisture content. Some silos, separate from those with dry-down capabilities, are strictly for long-term storage of the grain. It is not unusual for farmers to use more than one method to store grain.

There are three main methods of storing grains in the United States:

1. Using grain bins - bins are vented, corrugated steel structures larger in diameter than silos and have varying heights. They generally store dry corn and soybeans, which meet the domestic or export market demand for feed, food and fuel use (Joanie, 2013). Figure 3.3 shows a typical bin.
2. Silos – They are usually built with concrete or steel and used for storing grains and other bulk materials. They traditionally store silage, which is grass or other fodder harvested green and wet, primarily to feed dairy cattle. Figure 3.4 shows a picture of grain silos.
3. Giant sausage-shaped storage bags -These allow farmers to store millions of bushels of corn and soybeans at a fraction the cost of conventional grain silos and far more efficiently than leaving grain in the open air.

The bags, which are about 300-foot (91-m) long and 10 feet in diameter reduces costs. Many growers have been left to store their wheat on-farm, using sturdy white plastic bags holding around 250 tonnes of wheat (Byrne, 2012). Figure 3.5 shows the giant sausage-shaped storage bags.

Figure 3.3 - Grain Storage Bins

Credit: Ackerman, 2018.

Figure 3.4 – Grain Silos, California, USA.

Credit: Luong, 2004.

Figure 3.5: Giant Sausage-shaped Storage Bags

Credit: Byrne (2012, p. 1).

The US government appear to have passed the burden of grain storage to the farmers, with no government reserve to cushion food emergencies. Historically, the Grain Reserve project was an initiative of President Franklin D. Roosevelt, to help stabilise the price of wheat and protect American farms during the depression. However, in the ’70s the project was revamped into Farmer-Owned Grain Reserve, which encouraged farmers to store grain in government facilities at low-cost and even no-interest cost of storage. In 2008, the stores were gradually depleted until 2008, when the USDA decided to liquidate them (Snyder, 2015, p. 1; Kaufman, 2012, p. 1). The US government has found an alternative to reserves in that the efficiency of the farmers each year could sustain the country even in the unlikely event that production is halted.

3.2.4 Food safety regulations in the USA

Globalization of food supply chains, combined with industrialization and urbanization, has changed the dietary habits of people around the world (FAO, 2017). Like in many advanced countries in Europe, importers of food products into the United States of America are solely responsible for ensuring that the products comply with the requirements of the law of the United States Federal Food, Drug and Cosmetic Act (FDA, 2018). The Food and Drug Administration (FDA) itself does not approve or certify, license or sanctions, but importers must have registered with the body and agreed beforehand to comply with the requirements. However, the FDA can inspect food items to ensure they comply with the requirements of the law.

It was not until 1906 that food laws were given the attention it surely required. Two Acts were signed into law following the aftermath of the accounts of lack of food quality: The Pure Food and Drug Act and the Federal Meat Inspection Act. These were geared towards the prevention of food-borne illnesses (NDSU, 2018; Jackson, 2009; NCSL, 2009).

According to the NDSU (2018) and NCSL (2009), the chronicle of food legislation in the USA is as shown in Table 3.6.

Table 3.6: the chronicle of food legislations in the USA

The year 1900 – 1950	**The year 1951 – 2000**	**The Year 2001-present**
1906: Pure Food and Drugs Act 1906: Federal Meat Inspection Act 1913: Gould Amendment 1930: McNary-Mapes Amendment 1938: Federal Food, Drug, and Cosmetic Act 1948: Miller Amendment 1950: Oleomargarine Act	1953: Factory Inspection Amendment 1954: Miller Pesticide Amendment 1957: Poultry Products Inspection Act 1958: Food Additives Amendment 1960: Color Additive Amendment 1962: Talmidge/Aujeb Act 1966: Fair Packaging and Labelling Act 1967: Wholesome Meat Act 1968: Wholesome Poultry Products Act 1968: Animal Drug Amendments 1970: Egg Products Inspection Act 1976: Vitamins and Minerals Amendment 1980: Instant Formula Act 1990: Nutrition Labelling and Education Act 1990: Organic Foods Production Act 1994: Dietary Supplement Health and Education Act 1996: Federal Tea Tasters Repeal Act 1996: Food Quality Protection Act 1997: FDA Modernization Act 1997: National Economic Crossroads Transportation Efficiency Act	2002: Public Health Security and Bioterrorism Preparedness and Response Act 2002: Farm Security and Rural Investment Act 2003: Animal Drug User Fee Act 2004: Passage of the Food Allergy Labelling and Consumer Protection Act 2005: Sanitary Food Transportation Act 2011: Food Safety Modernization Act 2016: Agriculture Marketing Act

Four agencies play significant roles in carrying out food safety regulatory activities in the United States at 1198: the Food and Drug Administration (FDA), which is part of the Department of Health and Human Services (DHHS); the Food Safety and Inspection Service (FSIS) of the US Department of Agriculture (USDA); the Environmental Protection Agency (EPA); and the National Marine Fisheries Service (NMFS) of the Department of Commerce. More than 50 interagency agreements have been developed to tie the activities of the various agencies together (NAP, 1998).

The US food safety system has been adjudged to have many of the attributes of an effective system., though complex and interrelated activity involving government at all levels, the food industry from farm and sea to table, universities, the media, and the consumer. The food system is also moving toward a more science-based approach with HACCP and with risk-based assessment, and it is fragmented by having 12 primary federal agencies involved in crucial functions of safety: monitoring, surveillance, inspection, enforcement, outbreak management, research, and education (NAC, 1998).

The widespread of foodborne diseases in the USA led to some stricter food safety regulations. For reasons like these, Food and Drug Administration - FDA in the USA (FDA, 2019) had suggested a shift in focus from responding to foodborne illness to preventing it. Such related food safety concerns led to the establishment of the Food Safety Modernization Act (FSMA) in the United States (Zhang and Seale, 2017, pp. 175, 176). The FSMA became public law, as Public Law 111–353—JAN. 4, 2011. The FDA has seven significant rules to implement FSMA, recognizing that ensuring the safety of the food supply is a shared responsibility among many different points in the global supply chain for both human and animal food. The FSMA rules are designed to make clear specific actions that must be taken at each of these points to prevent (FDA, 2019).

Food safety is government-driven in the USA. Most of the independent food certifications operating in Europe are recognised in the USA as long as they comply with the US regulations. Private food safety institutions in the USA are not as convenient as it is in the UK and Europe.

3.3 Food security in China

In China's grain production sector, the inputs and outputs are factors that are considered seriously along with the need of the consumers and their locations. Indiscriminate use of inputs in the past is currently affecting the outputs (the environment and food safety); however, future improvement in grain production will focus on technology adaptation rather than increasing resource inputs (NPJ, 2018).

Food security in China is ranked fair by the Global Food Security Index report. With global food availability/accessibility ranked 44th in 2018, China still requires more investment in agriculture amidst very scarce resources, especially land. Food affordability is ranked 49th globally, 37th in food safety and food utilisation. The 65th ranking in defence of the environment, natural resources and resilience (The Economic Intelligence Unit, 2018) is weak. Though China is 95 per cent self-sufficient in wheat, rice and corn [maize], its soybean need depends on importation up to the tune of 80% (NPJ, 2018).

In terms of safety of food, China has had severe food safety scandals in recent years, however. Stability of supply is excellent. Severe hunger is low base on the Global Hunger Index in 2017. Overall, China is in a good food security situation at the household level. There is a robust national grain reserve, however.

3.3.1 Key agricultural statistics in China

China is one of the success stories of countries that have transformed from being a poor country to an economic superpower over a few decades, and its prospects are still rising (Gulati and Fan, 2007). In addition to land reforms, there have been human, social and agricultural investments, creating growth and income for the people. Others areas of compelling interest are public investment, irrigation and the water sector, domestic agricultural marketing, World Trade Organization and agricultural trade liberalization, rural diversification, the rural non-farm sector, antipoverty programs and safety nets.

Since 1949, China has been making a tremendous effort towards food sufficiency, using various social experiments called reforms. The reforms of the 1980s brought the agricultural sector into a new dimension of growth. Before the 1980s, most agrarian activities were organised according to the three-tier commune system. By 1984, the contract responsibility system was adopted by almost the entire agricultural production system. In 1985, 63 per cent of the population of China lived in rural areas.

China's investment in rural infrastructure (especially roads), agricultural research and development, rural education were some of the investments that brought the growth in agriculture and rural incomes (Gulati and Fan, 2007).

Agriculture in China employs about 300 million farmers, out of the approximately 1.404 billion people, representing about 21.4 per cent of the population and 17.51 per cent of total employment (Trading Economics, 2018; United Nations, 2017; National Bureau of Statistics of China, 2008).

3.3.2 Grain production in China

China ranks first worldwide in terms of farm output, producing potatoes, sorghum, peanuts, rice, wheat, tea, millet, oilseed, soybeans, barley and cotton. It ranks second for maize production after the United States. Even though it accounted for only 10 per cent of arable land worldwide, it produces food for about 20 per cent of the world's population (National Bureau of Statistics of China, 2008).

The world grain production was 2.849 billion metric tons in 2016, out of which, China produced 580.8 million metric tons, amounting to 20.3 per cent of the world’s output. China achieved the production capacity owing to the sound management of arable lands, having an arable land just about one-third of that of Nigeria (CIA, 2016).

Until the 1949 revolution, land ownership in China was outdated, with 70 to 80 per cent of agricultural land held by 10 per cent of the landlords (Ministry of Agriculture China, 2004). Most farmers were landless peasants who rented land from the landowners, usually at exorbitant rates. Between 1949 and 1952, the land was confiscated by the government without compensation and redistributed equally among the farmers (Gulati and Fan, 2007, p. 11).

Moreover, the government exercised complete control over production by enforcing centrally set targets related to the area, yield and output for each crop. Agricultural produce was subject to the fulfilment of compulsory quotas at fixed procurement prices. Farmers could sell any surplus at the higher above-quota prices (for grains, these were about 30 per cent higher than the in-quota price). State agencies monopolised trade, and private business was limited to the county level and a few commodities such as tea, tobacco, sugar, eggs and hogs (Sicular, 1988 *in* Gulati and Fan, 2007).

3.3.3 Grain storage systems in China

Local creativeness exists in terms of grain storage systems among the farmers in China, though with the collaboration and support of international organisations. Lorini *et al.* (2006, p. 48) reported that since 1995, some granaries for farm storage had been built in China with the support of the Food and Agriculture Organization (FAO). There have been significant achievements. The authors, however, suggested that farm grain storage should only aim at the storage of grains for family consumption since farm grain storage facilities are limited regarding storage condition and technology. The residue grains should go to specialised grain storage enterprises for ample storage, which can also reduce the cost of storage significantly. Models such as the development and establishment of some Grain Accepting Storehouses for farm grain storage and 'Grain Bank' was suggested.

The place of local content in the revolution of agriculture in China cannot be over-emphasised. At a tough time, government intervention was multifaceted. Apart from supports from international organisations like the Food and Agriculture organisations, the development of local innovations, the management of the external supports, blended well with the use of local materials, techniques and the people, to bring about the necessary improvement in the food storage systems. There were, however, several food safety scandals.

There is a clear difference between *government reserve* and *storage for profit* or better market. This is lacking in the context of Nigeria's grain reserve programmes and other agricultural policies that targeted food security. Figures 3.6 through 3.10, below show the various methods of grain storage in China as reported by the authors.

Figure 3.6: Metal grain silo in China
Credit: Lorini *et al.*, 2006, p. 49

Figure 3.7: Airtight storage with double PVC surface
Credit: Lorini *et al.*, 2006, p. 49

Figure 3.8: Concrete grain storage in China.
Credit: Lorini *et al.*, 2006, p. 49

Figure 3.9: Grain storage under stair
Credit: Lorini *et al.,* 2006, p. 50

Figure 3.10: Steel net grain storage
Credit: Lorini *et al.*, 2006, p. 50

3.3.4 Food safety regulations in China

Perhaps, the most widespread food industry incident in China to date is that of 2008 Melamine Milk Scandal, that led to the death of many children (Handford, Campbell and Elliot, 2016). There were also significant issues in 2004 with infant formula, including the oil drained from the gutter, toxic bean sprouts and multiple kinds of meat products that are considered unsafe. These incidences have had negative impacts on the confidence of Chinese consumers on Chinese foods (Jiang, Stigter and Monnikhof, 2018, p. 3).

These food safety occurrences and others shook most of the world where food safety is of importance, such that even the Chinese consumers distrust the willingness of Chinese government to control the situations using any measure (Wang *et al.,* 2015). The distrust on the government having the political and structural will to solve the food safety problems led many of the Chinese consumers prepared to pay more for safer foods, even those foods from foreign countries, so long that the safety was guaranteed (Liu and Niyongira, 2017).

At this point, the old Chinese food law was reviewed. Before the 2008 melamine milk powder scandal, the most up-to-date Chinese Food Law then was from 1995 called the Food and Hygiene Law, which was concerned just with the clean condition at the food manufacturing environment. In 2009, the 1995 Food Law was updated to include safety; this was updated again in 2015, and the focus shifted to risk prevention and risk assessment, traceability and supervision in the whole food chain, and strict penalties for those who do not comply (Jiang, Stigter and Monnikhof, 2018, p. 6).

Punitive damages up to ten times the value of the food products would be done to the food producers or manufacturers, where the food products fail to meet food safety standards (Sim and Yang, 2016). There are other rigorous conditions placed on baby foods and milk. Same food regulations apply irrespective on the platform where the food was purchased – directly or through e-commerce.

According to Sim and Yang, the 2015 food law places more prominence on the supervision and control of every step of food production, distribution, sale and recall. It is claimed to be the strictest food safety law in Chinese history, showing proactiveness and attitude required to curb unsafe foods and boost consumer confidence in domestic products.

Jiang, Stigter and Monnikhof (2018) affirmed that the China food legislation is provided by the State Council and its direct and regional institutions like the China Food and Drug Administrations (CFDA), Administration of Quality Supervisory, Inspection and Quarantine (AQSIQ) and the National Health and Family Planning Commission (NHFPC) respectively. The NHFPC and CFDA provide food safety assessment while implementation is by CFDA and AQSIQ (import) and CFDA now have more enforcement powers in addressing food safety issues (Sim and Yang, 2016).

The impact of having weak food institutions, scandals and red alert from consumers around the world is long-lasting. Once the trust in a food system is in doubt, it takes years and even decades for the confidence to be regained, no matter the amount spent in advertising the products.

In the next section, the research looks at the situation with Indonesia. As previously indicated, China is one success story of countries that have transformed from developing countries into an economic hub, and the prospects are still high. Indonesia is on the same path too. What can the researcher learn from Indonesia?

3.4 Food security in Indonesia

Food security in Indonesia has improved over the last decade (Piesse, 2016), but with the 2018 Global Food Security Index report (The Economic Intelligence Unit, 2018), a lot more is still required. Food availability/accessibility was ranked 58th globally, affordability was poor at 63rd and safety, and utilization was ranked 84th. The 111th ranking out of 113th on natural resource protection and resilience points to the fact that the country's food production process is detrimental to the environment.

Indonesia has long sought to restore its self-sufficiency in essential agricultural commodities, such as rice, as successive Indonesian governments have connected self-sufficiency to enhanced food security. Indonesian food security has continued to improve, but the focus on autonomy, however, has led to worse food security outcomes in the past. Indonesia was once self-sufficient in rice and sugar but, as the population increased, production failed to keep up with demand. Rates of malnutrition remain high throughout. Stunting in children also remains a significant health challenge. Between 2005 and 2015, after steadily declining for decades, the rate of stunting in children under the age of five increased from 28.6 per cent to 36.4 per cent (Piesse, 2016).

Hunger situation was rated “severe” according to the 2018 Global Hunger Index report, which means the stability of food supply is weak. There has been a tremendous improvement in creating opportunities for the farmers; however, these opportunities are not enough to meet the growing population.

3.4.1 Key agricultural statistics in Indonesia

While agriculture makes up less of Indonesia’s gross domestic product than in the past, its labour force is still predominantly engaged in the sector. Currently, about 40 per cent of the workforce is employed in some form of agricultural activity. The farming of more profitable crops, such as palm oil, which is not a food crop and does nothing to further food security, also made the importation of produce more likely. Competition for land from industry and housing also pushed many farmers out of the market, further reducing the country’s ability to produce its own food (Piesse, 2016).

Indonesia is a foremost producer of palm oil, and a key global producer of copra (dried meat), cocoa, rubber and coffee but about 68 per cent of the farmer population are smallholder farmers on less than a hectare (FAO, 2017). Though children malnourishment and poverty among the populace has unsteadily improved over the years, this could be attributed to the actions of the government, as the government's policy has also shaped the country economic performance through its trade openness along with industrialisation and young workforce (Elias and Noone, 2011).

The agricultural sector contributed 13.4 per cent to national GDP (down from 15.2% in 2013), and it remains one of the significant sources for domestic economic growth, and at the same time critical in contributing towards the eradication of hunger, poverty and malnutrition; the occurrence of undernourishment in Indonesia dropped from 19.7% in 1990-1992, to 7.6% in 2014-2016. (FAO, 2018b).

According to Suasih and Yasa (2017), the price disparity between the farmers and the consumers is a significant problem created by middlemen and benefitted only by the middlemen to the detriment of the farmers and the consumers. The disparity is because of the power of the intermediary traders or other supply chain actors within a very long chain, leading to inefficiency of the system, low price for the farmers and high price for the consumers. The authors recognised the challenges facing Indonesian smallholder farmers to include land size being too small, non-competitiveness among the middlemen or supply chain actors, the farmers lacking the structure that allows them to bargain and the problem of storage systems.

3.4.2 Grain production in Indonesia

According to the International Grains Council (IGC), Indonesia's total grains production in 2017-18 comes to 11.2 million tonnes, up from 10.9 million the previous year (Lyddon, 2018). However, wheat must be imported to meet the local demand, mainly from Australia (48%), Canada (17%), Ukraine (16%), and the United States (11%) (the total volume of import is as shown in Figure 3.11). In 2018, Indonesia became the highest importer of wheat from the United States of America, displacing Egypt (USDA – FAS, 2018). However, the government is pushing for greater self-sufficiency in corn (Lyddon, 2018) and in rice.

Figure 3.11: Indonesia wheat import from 2010 to 2018
Credit: USDA -FAS, 2018

3.4.3 Grain storage systems in Indonesia

Rural farmers rarely store harvested grains for long, a situation that often affects farmers. Suasih and Yasa (2017) had suggested that the critical thing is that if the farmers could store their grains for at least, 3 to 4 months after harvest, they would have a high chance of earning more. There is an extreme shortage of literature on rural storage systems in Indonesia.

Like in many rural areas of developing countries, markets are often poorly serviced, and smallholders are unable to take advantage of market opportunities. They pay high costs to overcome market imperfections, trouble accessing credit, obtaining information on market opportunities or new technologies, purchasing specific inputs and accessing product markets. When markets are accessible, farmers may be subject to price fluctuations or inequitable prices. Such difficulties are barriers to their development and represent a ‘bottleneck’ in the development process.

One possible mechanism for improving the livelihood of rural smallholders and providing them with the benefits of economic liberalisation is contract farming (Patrick, 2003). The author had explained, that through contractual arrangements, agro-industry can assist smallholders in shifting from subsistence or traditional agriculture to the production of export-orientated, high-value products. This not only has the potential to increase incomes of contracting smallholders but also to have multiplicative effects in the rural and broader economy. For smallholders, contract farming is potentially a way of overcoming market imperfections, minimising transaction costs and gaining market access. This approach, which has been implemented in other developing countries, according to the author, may also provide benefits for smallholders in Indonesia and deserves priority in development research.

Grain processing in rural communities is basic, lacking any sophistication of the developed countries and typical of the developing countries. Figures 3.12 and 3.13 shows corn harvesting in rural areas and winnowing operations, respectively.

Farmers harvest corn in Kretek farming fields in Bantul, Yogyakarta
Credit: Amindoni (2017)

Winnowing in Bali, Indonesia
Credit: Dreamstime, 2013.

3.4.4 Food safety regulations in Indonesia

Food safety in Indonesia is regulated by the government. Regulations such as those based on Law No. 18/2012 on food (The Food Law), Government Regulation No. 28/2004 on food safety, quality and nutrition (GR 28), Government Regulations No. 69/1999 on food labelling and advertisement, Regulation of Minister of Health with No. 33/2012 and other technical regulations are in force in the country (Baker and McKenzie, 2018; Sihombing, 2016).

Others are Law. 33/2014 on Halal Assurance (Halal Assurance Law) which require halal certification for consumer products including foods and beverages, President Regulation No. 74/2013 on the Alcoholic Beverages Control and Supervision (Alcohol Regulation), Law No. 8/199 (Consumer Protection Law), Law No. 7/2014 that bothers on trade (Baker and McKenzie, 2018). According to the authors, medicine/therapeutic goods are regulated separately to food, under Law No. 36/2009 on Health; a single agency supervises both: The Food & Drugs Supervisory

Agency (BPOM). These were, however, harmonised through the National Food Safety Committee.

Despite the various regulations, Indonesia has had many food scandals, some of which were said to be malicious. However, the country has many export destinations. The food law recognises that food is a fundamental human right; the availability, affordability of safe and nutritious foods is the responsibility of the State and the quest for total food independence.

3.5 Chapter summary – areas of good practice in case study countries

The chapter has shown the performance of the case countries on food security situations. From the robust food security situations of the UK and USA to the fair but significantly improved China down to the severe hunger situations in Indonesia, there are lessons to learn. First, temporal food insecurity situations in the UK and the USA can be relieved via food aid, but the food aid does not and cannot solve the underlying problems that led to households seeking the assistance of food aid. Secondly, China's future food security is being built around technology adaptations rather than increased resource inputs. Indonesia's self-sufficiency pursuit is functional but not sustainable as population growth outshoot food production. In a nutshell, the strategy of China to maximise food production via the adoption of technology instead of pushing for more resources into food production is sustainable. A positive mass balance or a mass imbalance in favour of output is sustainable. This is possible where fewer inputs produce higher outputs. Post-harvest waste reduction, as well as reuse, recycle, and reduction of agricultural wastes will favour more outputs. The use of food aid can help with temporal household food insecurity.

CHAPTER FOUR

DYNAMICS OF FOOD SECURITY IN NIGERIA

4.0 Introduction

In chapter two, the concept of food security and the importance of food security were highlighted using global indices. In chapter three, the dynamics of food security in the case study countries were highlighted along with key statistics in the agricultural sector. In this chapter, the dynamics of food security in Nigeria is examined with the global lenses and with the perspective obtained from the evaluation of the case study countries.

4.1 Food security at the federal level in Nigeria

The Federal Government bears the burden of the entire States in Nigeria. For example, every month, the federal government shares allocations from the earnings in crude sales and taxes to all the State governments to run their respective States and improve security. The same way, the Federal Government is at the forefront of defending food security in Nigeria. However, because of the poor economic situation of many of the States (Kogi State and all the States in the North inclusive, totalling over 25 States), the allocation from the federal government is the lifeline at the State level. Therefore, national statistics typically reflects a milder situation in the States.

When the Global Food Security Index began in 2012, Nigeria was ranked 80th in the world in terms of food security. As more indicators were introduced, the ranking further slipped. In 2017, the need to protect the environment, the resources and the resilience in doing so, was added. This also worsens the ranking of Nigeria to 96th out of 113 countries.

In terms of food affordability and availability, Nigeria ranked 101st and 100th out of 113 respectively. The ranking for food quality/safety and the vital indicator of protecting the environment was 77th and 68th, respectively. From all indications, there is food insecurity in Nigeria. How does this reflect at the national and local levels? Apparently, various unrest within the regions of the country such as Boko Haram terrorism in the North East, the Herdsmen-Farmers conflicts in the middle belt and the Kidnappings in the South East and South-South, prevents farmers from their farms, partly leading to the food insecurity. The social unrests could also be pointing to the food insecurity in the country.

Incidence of food shortages and price instability is common. This is reflected in the food affordability rating. Nigeria is an import-dependent country for many staple foods, especially rice, wheat, maize and tomato paste. According to DeRose, Messer and Millman (1998, p. 53), food shortage happens when there is not enough food supply to provide the required energy and vitality. The causes of food shortage could include natural disasters (like drought, flood, or in-store fungus and Mycotoxins), political disasters (like civil conflict, terrorism) and also some misguided economic policies such as (price controls, hoarding) – all of which discourage the production of essential foods.

4.1.1 Food security in Kogi State and its local communities

At the State and community levels in Kogi State, hunger is severe among the people, especially during conflicts and natural disasters. This is reflected in the Global Hunger Index in 2018, as there were incidences of the inadequate food supply in the State, child undernutrition, and child mortality. Though human wasting is not common, children stunting exist in their numbers. Considering these, the Global Hunger Index rated the hunger situation in Nigeria as severe. Comparing the hunger index of Nigeria to the case study countries, there are contrasts than similarities. First, no hunger cases are were recorded for the UK and USA because the indicators used does not and could not produce data from those countries.

Secondly, when compared with China and Indonesia, Nigeria and Indonesia have some significant similarities in child undernourishment, stunting and mortality. However, Indonesia has improved over the years, and China is in fair state of food security, but recent reports of the trade war with its allies like the USA, especially on agricultural products means the food security issues could worsen or be tending towards the case of the UK and the USA in the event that they strike a better deal.

4.1.2 Contrast and similarities between food security and hunger situations in case study countries and Nigeria

Table 4.1 shows the performance of the case study countries and Nigeria in terms of food security from 2012 40 2018. Nigeria is in direct contrast to the case study countries. It appears that every year beginning from 2012, when the Global Food Security report began, the case of food insecurity in Nigeria has been worsening. Recently, cases of severe food shortage in the North East required the assistance of the international community, including the Red Cross, the World Bank and others who indirectly or directly support in other ways, like the Department for International Development (UK).

Except for Indonesia that shows some mild similarity with Nigeria, Indonesia appear to have loosely maintained a stable food security system since 2012. Also, China has maintained a fairer position, basically because of more considerable improvement in other participating countries. For example, the United Kingdom had from the onset of the food security index, been consistently improving. Other countries in Europe had shown such improvements too. This improvements in food security may have affected the performance of China, which, in recent years, has invested tremendously in its agricultural sector.

Table 4.1: Food security in case study countries and Nigeria from 2012 - 2018

COUNTRY	2012	2013	2014	2015	2016	2017	2018
United States of America	1	1	1	1	1	4	3
United Kingdom	20	20	16	15	8	5	3
China	38	41	42	42	42	45	46
Indonesia	64	66	72	74	71	73	65
Nigeria	80	-	87	91	90	92	96

Credit: Compiled from 2018 Global Food Security Index.

In terms of hunger index, the UK and USA do not fit into the parameters or indictors used. Therefore, there are no similarities with Nigeria where most of the settings are applicable and measurable. Hunger cases in China as at 2018 was rated low by the Global Hunger Index – which means hunger, resulting from inadequate food supply and causing child mortality and child undernutrition, is not common. The Global Hunger index rated the hunger situation in Indonesia as “moderate” – which means, hunger cases are mild. In contrast to the case study countries, Nigeria’s hunger situation as in 2018 was rated “severe”. This means the case of food shortages and hunger is typical. In Kogi State, over 2 million of the population received aid from the international donors during the 2012 flooding. There were no grains in Nigeria’s food reserve to help the situation.

4.2 Key agricultural statistics in Nigeria

4.2.1 Grain production in Nigeria

Between 60 to 90 % of farm outputs from seed crops in Nigeria constitute grains of different types. The remaining production is tubers, especially cassava and yams. In Kogi State, up to 85 per cent, farm outputs are maize and rice. However, agricultural practices in Nigeria are majorly traditional; therefore, there are many militating factors affecting production. Most of the production process - land clearing operations to its development, through planting, weeding, and harvesting, every step of the farming operation is carried out manually with crude instruments. The manual activities are not without their backbreaking effect on the local farmers, as expected of such jobs that require heavy lifting of the soil, standing under the scorching sun over a prolonged period.

Similarly, harvesting is a difficult task, that requires a large number of people. For example, to harvest maize or rice crops, agricultural workers would cut down the plants through the stems, with a long-handled cutting tool, such as a scythe or sickle [or bend the plants downward and then plug off the matured cobs, in the case of maize]. Next, they would separate the edible grain from the inedible chaff, then beating the cobs with a wooden stick or the cut stalks of rice against a log (in case of rice). This operation is known as threshing. Then they would clean any remaining debris away from the seeds [through a manual winnowing process using trays] to make them suitable for use in a mill. All these take much time and many people and create rooms for post-harvest waste. Modern combine harvesters do the actual harvesting (cutting), threshing, cleaning and loading operations almost at a go. A combine harvester is merely driven through a field of crops, and it cut, thresh, and clean the grains all by itself using rotating blades, wheels, sieves, and elevators. The grain collects in a tank inside the combine harvester (which is periodically emptied into carts pulled by tractors that drive alongside), while the chaff spurts from a big exit pipe at the back and falls back down onto the field.

In Nigeria, only a few farms exist with modern technology, like the Obasanjo Farm in Ogun State. The rural farmers rely on hoes and cutlasses and manual workforce. The manual workforce is usually the children of the farmers. One of the reasons why some African families are believed to celebrate male children than females at birth is not far-fetched. They need more workforce on their farm. Figure 4.1 below shows a farmer weeding a maize farm with a hoe.

Figure 4.1: A farmer in a maize farm
Credit: The Business Day (2017).

There is no data on the number of agricultural machines and equipment in use in each State of Nigeria, probably because of the low numbers or lack of existence of it. However, the best estimate had it that there were 30,000 tractors in the year 2000 (World Resource Institute, 2003) for a population of 124 million as at then, with more than half being farmers. It was very different from the 4.8 million tractors available in the USA in the same year for a population of 281.5 million. Most of the tractors in Nigeria were purchased by the government as some “interventions” for farmers, but maintenance issues meant that nearly 90 per cent of them are non-functional. However, rural farmers were not in the picture because they do not have private farmlands vast enough for tractors to cultivate. There is a need for a strategy for farmers to have combine access to technology, not just to produce grains, but to maximise every grain production, which can lead to their economic improvement.

4.2.2 Community livelihoods in Kogi State - Food security at the State and community levels in Nigeria

Lack of data on the performance of each State in Nigeria on food security is a big challenge owing to the fact that there are no structures to help capture the data accurately. However, food insecurity can be measured using suitable and applicable indicators such as the income of the people, food affordability, presence of economic opportunities, access to education and the state of hunger. However, foreign bodies like the United Nations through the Multidimensional Poverty Index (MPI) provides reliable data on this. In the 2019 report, 51.4 per cent of Nigerians (about 98 million people) and 57.5 per cent of people across Sub-Saharan Africa, were reported to be multidimensionally poor. The MPI use three indicators: access to health, education and standard of living. The standard of living is directly related to income, and income is directly related to the capacity to purchase food, therefore associated with food security (Leathers and Foster, 2017; Gibson, 2012, p. 8). The report attributed rapid population growth in African countries like the Democratic Republic of the Congo, Ethiopia and Nigeria, as the factor that led to the multidimensionally poor people (UNDP and OPHI, 2019).

Even though Nigeria has been recognised as having one of the world's most underutilised agricultural lands (Smith and Naylor, 2014, p. 202) and rich in alluvial soils, yet cases of food insecurity, occasion by poverty abound. Also, the vegetation of Nigeria is in three unique folds - tropical/mangrove in the South, Guinea Savannah at the middle belt and then the Sahel/Sudan Savannah towards the extreme north, hence allowing cultivation of diverse crops. Rainfall is sufficient for most plants, supported by Fadama (drying season irrigation farms) in some communities in Nigeria. Unlike some other African countries that are always under threat of drought, desert encroachment and other natural challenges, occasioned by reduced rainfall, Nigeria's case are institutional. The fertile soils do produce crops, but post-harvest wastes caused by inadequate storage systems have been reported across the country. Table 4.2 shows the multidimensional poverty rate for the Nigerian States in 2014.

Table 4.2: Multidimensional poverty rate (%) in 2014

S/N	State in Nigeria	Multidimensional poverty rate (%)
1	Abia	21.0
2	Abuja	23.5
3	Adamawa	59.0
4	Akwa Ibom	23.8
5	Anambra	11.2
6	Bauchi	86.6
7	Bayelsa	29.0
8	Benue	59.2
9	Borno	70.1
10	Cross Rivers	33.1
11	Delta	25.1
12	Ebonyi	56.0
13	Edo	19.2
14	Ekiti	12.9
15	Enugu	28.8
16	Gombe	76.9
17	Imo	19.8
18	Jigawa	88.4
19	Kaduna	56.5
20	Kano	76.4
21	Katsina	82.2
22	Kebbi	86.0
23	Kogi	26.4
24	Kwara	23.7
25	Lagos	8.5
26	Nasarawa	52.4
27	Niger	61.2
28	Ogun	26.1
29	Ondo	27.9
30	Osun	10.9
31	Oyo	29.4
32	Plateau	51.6
33	Rivers	21.1
34	Sokoto	85.3
35	Taraba	77.7
36	Yobe	90.2

Credit: UNDP, 2015

4.2.3 Initiatives for improving rural community livelihoods in Nigeria

When it comes to agricultural policies, Nigeria could be among the top countries with excellent policy documents – but on paper! Nigeria is a complex country no doubt, and the complexity is the reason why specific solutions should be provided for people in a particular location and not a top-down approach where a generic solution is provided for the people. A good example is the Strategic Grain Reserve complex in Kogi State, which was approved by the Nigerian Government in 1987 and the actual construction began in 1994. The government's aim for building the silos was to buy off about five per cent of the farmers' produce at low prices during the harvest periods, then store them for emergencies. The focus of the government was to strike a bargain on a large percentage of its people, not on improving their welfare from farming. In other words, the silo project was not people-centred. The safety of the raw grains was of no consideration, only the price. While the government tries to proffer solutions to rural challenges, it is also a part of the problem confronting the rural farmers.

In the following sections, the current structure of agricultural and rural developments in Nigeria is analysed, along with other various initiatives, projects, programmes and schemes since independence are presented. The aim is to understand why some succeeded and why many others failed and how the lessons learnt can be used to design a model.

The federal ministry of agriculture and rural development is the central ministry that oversees all agricultural and rural development projects in Nigeria. However, the ministry is so large that most of the funding, either from budgetary allocations or from donor agencies, are used to feed logistics from the "top". When the federal ministry provides the fund to the States' departments of agriculture, the funding is further subjected to logistic expenses. By the time the funds get to the target beneficiaries, most of it may have been expended on logistics, and also, the infrastructural deficiencies at the bottom would not allow the funding to have a long-lasting impact on the rural farmers. The same way, policies, projects and programmes adopt the top-bottom approach in implementation (Daneji, 2011).

The federal ministry of agriculture and rural development has 17 service and technical departments. The service departments include finance and accounts, planning & policy coordination, human resources, general services, procurement, reform coordination & service improvement. The technical departments are agribusiness & marketing, agricultural land and climate change management services, federal department of agriculture, farm input service, fisheries and aquaculture, animal husbandry services, rural development, agricultural extension, cooperatives, food and strategic reserve, veterinary and pest control services.

Table 4.3 below shows the key projects, programmes, schemes or policies from 1960 till date; however, the list is non-exhaustive. a Few of some of the projects/schemes/initiatives is discussed below.

Table 4.3: Agricultural projects/policies/programmes/schemes in Nigeria from 1960 to date

S/N	Year	Policy	Remarks
1	1972	Agricultural Development Projects (ADPs)	Agency-based
2	1973	National Accelerated Food Production Programme (NAFPP)	Policy-based - Ended
3	1973 1978 2000 2010	Nigerian Agricultural Bank (NAB) Nigerian Agricultural and Cooperative Bank (NACB) Nigerian Agricultural Cooperative and Rural Development Bank Limited (NACRDB) Bank of Agriculture (BoA)	NACB merged with Peoples Bank of Nigeria (PBN) and Family Economic Advancement Programme (FEAP) to form NACRDB
4	1975	National Grains Reserve Programme (NGRP)	Silo projects still ongoing in many places since the early 90s.
5	1976	Operation Feed the Nation (OFN)	Policy-based - Ended
6	1977	The River Basin Development Authorities	Agency-based Epileptic, not active.

7	1977	Agricultural Credit Guarantee Scheme	Ended
8	1979	Green Revolution	Policy-based - Ended
9	1986	Structural Adjustment Programme (Sap)	Policy-based - Ended
10	1992	National Agricultural Land Development Authority (NALDA)	Agency-based - Ended
11	1192	Directorate of Food, Road and Rural Infrastructure (DFRRI)	Agency-based - Ended
12	1999	Agricultural Policy Thrust	Policy-based - Ended
13	2005	Millennium Development Goals	World bank initiated – Ended in 2015.
14	2013	Agricultural Transformation Agenda (ATA) – with divisions:	Modified/Ended - Became epileptic after a change of government
15	2012	Growth Enhancement Support Scheme (GESS)	
16	2011	Staple Crop Processing Zones	
17	2011	The Nigeria Incentive-Based Risk-Sharing System for Agricultural Lending (NIRSAL)	Not active, no precise operation
18	2016	The Agriculture Promotion Policy (APP) 2016-2020 document, "The Green Alternative."	To take off because of various logistics required and government administrative bottlenecks.

4.2.3.1 Agricultural Development Projects (ADPs)

Launched in 1972 shortly after the end of Nigeria's civil war, the Agricultural Development Project (ADP) had two main objectives: to increase food production and to raise the income of small-scale farmers (Auta and Dafwang, 2010, p. 138). The ADP was a World Bank project via a tripartite agreement involving the World Bank (66%), the Federal Government of Nigeria (20%) and the State Governments of Nigeria (14%). The State governments were responsible for the payments of salaries of local staff. With over 100 million USD spent on the project, the ADP is now unlike its former glory when the funding was active.

Also, similar agricultural projects, like the ADP, cease to exist with the ending of the government regime that created them or with the withdrawal of funding from the donor organisations – mainly the World Bank, USAID, and the British Government through the Department for International Development (DFID). In some cases, while the projects or programmes still exist, they become ghosts of themselves. For example, Auta and Dafwang (2010, p. 139) described the Agricultural Development Projects in Nigeria as "symbols of past glory". The Independent Evaluation Group of the World Bank opined that the ADP has become a permanent institution for rural infrastructural development and agricultural services, but advocated for a change in roles, like the regular State Departments needed a review (The World Bank Group – IEG, 2012, p. 1) because people are still on a payroll for a project that is not functional. The moment the funding from the World Bank ended, the projects ceased to function as it should. In other words, the sustainability of the project was questionable.

4.2.3.2 National Grain Reserve Programme (NGRP)

In 1987, taking a pragmatic approach, the Federal Government of Nigeria launched what it called the National Agricultural Food Storage Programme (NAFSP) with a vision to maintain and manage an adequate and quality food reserve for national food security (FMARD, 2016b). The NAFSP had three tiers: The Strategic Grains Reserve (SGR), the Buffer Stock Storage (BSS) and the On-farm Adaptive Storage (OAS) programmes.

The SGR has the objectives of decreasing post-harvest losses, to provide the first line of food relief both internally and to friendly countries in times of disaster, either natural or man-caused. It is also to make food available at other times at affordable prices. The BSS is to reduce inter-seasonal variations in the food supply, thus guaranteeing price stabilisation to both the consumer and the producer. Also, the SGR is managed by the federal government while the BSS is under the management of the state government. The On-farm Adaptive Storage (OAS) Programme was to promote the development and propagation through States and Local Government extension services of suitably designed storage structures for use by farmers to minimise post-harvest losses at farm level (FMARD, 2016b).

However, in Kogi State, the State's managed BSS and OAS, including the federal government grain silos located in the State, have not had the required impact on the people. There is no known report of its performance and effects in the literature, apart from the mention on a government website that a silo complex exists in the State under a federal government programme. Also, while an unimpressive report about the other silo complexes spread across the various States of Nigeria (Abbah *et al*., 2012) abounds, that of Kogi State has remained perpetually elusive. There are indications that the silos are not being used even though the construction started in the early 90s.

Similarly, the Buffer Stock Storage (BSS) programme aimed at buying grains from the local farmers during harvest periods and at cheaper rates, has not taken off. In the same circumstance, the On-farm Adaptive Storage (OAS) was planned such that adaptive storages would be built for each farmer; this also has not taken off. The BSS and OAS remain vague in literature, as no records exist of any Buffer Stock grain releases in times of food shock, such as, during the flood disaster in 2012 that left about half of the population of the State without access to adequate food for several months. There was no adaptive storage built for farmers either.

About three decades down the line, the National Agricultural Food Storage Programme has not lived up to expectations in Nigeria. The initial policy objective was to buffer five per cent of the food grain produced in the country. This five per cent cannot sustain the reserves extensively anymore, with the current population and population growth even if the silos are functional and stocked to full capacity. More so, the problem of post-harvest waste and losses among the farmers would be a setback to the quantity and quality of grains that would be available in the open markets.

Similarly, part of the initial policy objective was also to stabilise commodity prices during scarcity and periods of surplus. However, as the grains are not getting into the storage, claims and counterclaims about this objective ever being met have been reported. Although the programme had the vision of operating in a manner devoid of a bureaucratic bottleneck (FMARD, 2016b), records show that this has not been the case. The programme appeared to have been overshadowed by corruption and lack of a working model and stifled by a bureaucratic bottleneck. Olajide and Oyelade (2002) reported that at the inception of the programme, funding for the construction of the grain silos was through extra-budgetary allocations. Nevertheless, by late 1992, when the government stopped extra-budgetary expenses, funding became grossly inadequate, resulting in the abandonment of the then 25 on-going sites by the construction contractors, at various levels of completion. However, the programme recorded significant extra-budgetary funding from 2008 through 2010. About 280 billion Naira (approximately USD 800 million) was reported to have been spent on the grain silos construction across the six geopolitical zones of Nigeria by the federal government of Nigeria (Sina, 2017; Business Highlights, 2017.). In all, there were 33-grain silos across the country with a total capacity of 1.3 million metric tons. Considering the spending from the previous administrations, an estimate of over one billion dollars may have gone down on the project.

Putting the infrastructures together to meet the policy objectives was a significant challenge, leading to the setbacks that follow. As at 2001 (24 years after the launching of NAFSP), only four hectares of the acquired 10 hectares of land for the development of the grain silos were developed, leaving behind six hectares for future development (Olajide and Oyelade, 2002). In Kogi State, the situation is not in any way different, as literature had a few reports on the state of the grain silos there.

From 1999 up to 2001, the capacity utilisation of the old grain silos (about 3 – 6 of them constructed in the late and early 90s) was 3 per cent and was improved to 50 per cent as at 2003 (FMARD, 2016b). However, recent reports on some of the grain silos and the grain reserve programme generally seem to suggest otherwise in terms of meaningful utilisation. For instance, the flood disaster in 2012 in Nigeria led many researchers to question the economic usefulness of those silos completed between 2009 and 2014, with one researcher describing the grain silos as being in a state of "perpetual emptiness" (Ibraheem, 2014, p. 2).

Abbah *et al.* (2012) reported that the grain silos in Kaduna and Bauchi States of Nigeria had been without grains since 2009. As at this time, the government planned massive importation to salvage the flood disaster in 2012 that wiped away many farmlands. Ibraheem (2014, p. 2) confirmed the state of grain silos in Kaduna State, Nigeria describing them as, "sorry sight, storing emptiness, tall weeds and scurrying reptiles rather than storing grains".

A report by Abbah *et al.* (2012) asserted that government officials at the Federal Ministry of Agriculture and Rural Department (the ministry given the responsibility of managing the grain silos) consistently failed to provide any useful information whatsoever on the state of the multimillion-dollar grain silo complexes. However, recent advertorial by the said Ministry, in conjunction with the Federal Ministry of Finance requesting an expression of interest for the concession of the 33-grain silos across the country (FMARD, 2016c) may be an indicator that pointed to management failure.

For research manageability and control; however, the focus of this research lies with storage systems in rural communities in Kogi State, as a case study for Nigeria. The reasons are that in Nigeria, Kogi State is one of the most central States of the federation. The State is also a confluence State, having the two major rivers in Nigeria (River Niger and River Benue) merging there. The rivers create enormous potential for all-year-round agricultural production via irrigation. It boasts of mostly agricultural land size with high soil fertility for various crops, especially rice and maize crops. Kogi State has a full agricultural identity.

If storage is to be profitable, however, then the farmers must break even economically. Grain farmers or storers can only break even if the cost of storage is less than the revenue generated from the sales and expenditure of the storage activity. The cost of storage includes but not limited to labour and supervision, pest control, storage and spillage losses and the cost of capital invested in the grain (FAO, 1994, p. 1). In practice, the costs of storage depending on the commodity stored, varied basically on the type of storage system and random/variable factors such as pest incidence and conditions. However, no evidence exists that this aspect of cost recovery and profit were included in the planning, which led to the construction of the grain silos, and even the overall grain storage programme in Kogi State. Therefore, part of the objective of this research is to provide a strategy for maximum utilisation of the silos in Kogi State with cost recovery in focus, to allow its sustainability.

The primary function of a reserve in any economy is to smooth out price fluctuations in the market. It is the reason governments around the world try to store grains (Ibid.). The problem of inadequate storage systems is one of the crucial causes of food insecurity in Nigeria. Oyebanji (1996, p. 67) in Alabadan (2006, p. 1) suggested, particularly for Nigeria, that '…the only way to arrest the increasing food insecurity in Nigeria is to develop efficient storage structures or buildings that will minimise wastes and maintain the quality of stored produce'.

However, storage for the wellbeing of the people of a country, or price stabilisation, is not the responsibility of the farmers; it is the responsibility of the government. Farmer's store grains for the purpose of making some profits and therefore must operate base on a business model.

4.2.3.3 Growth Enhancement Support Schemes (GESS)

In recent times, the most reported scheme as being impactful of all the agricultural programmes in Nigeria is the Growth Enhancement Support Scheme (GESS). Its agenda was to increase inputs for rural farmers. The GEES was a branch of Agricultural Transformation Agenda. It was opined as "creating an enabling environment for private sector investment that will modernise and industrialise agriculture in Nigeria (GrowAfrica, 2015, p. 4), such that agriculture could become a business venture rather than an "intervention" or to "help" the rural farmers.

However, identification of real farmers was and has been the primary challenge, creating rooms for corruption, embezzlement and diversion of agricultural funds for personal use. Access to the scheme by the rural farmers is difficult because of technological constraint on the part of the farmers and the cumbersome processes or logistics on the part of the government. Though the government of Nigeria was reported to have purchased mobile phones for the farmers on which they were to receive information about the subsidy on fertilisers or improved seedlings, the effectiveness and sustainability of such model are questionable. Even at that, the low education of the farmers, inadequate network coverage, difficulty in using mobile technology among the farmers are other related issues that would need reconsideration. One of the procedural failures is that it is not tricky for non-farmers to register as farmers, and thereafter benefits from the subsidised products.

4.2.3.4 **Nigerian Incentive-based risk-sharing system for Agricultural Lending (NIRSAL)**

The establishment of a risk-sharing facility by the Central Bank of Nigeria in 2011, through the Nigeria Incentive-Based Risk Sharing System, was to de-risk bank lending to farmers. It also aimed at increasing agricultural produce outputs (GrowAfrica, 2015). NIRSAL was designed to create an enabling environment for affordable agricultural financing along entire agricultural value chains. It lessens the risks of financing institutions while granting agricultural loans by building the capacities of both banks and value chain actors on good practices in agricultural financing, loans utilisation and repayment (NIRSAL, 2018).

However, a 10-year study as reported by Ahiaba (2019) showed that credit repayment in some rural communities, particularly in Kogi State, require a more localised financing system with an option for farmers to repay credit with both cash or an agreed per cent of their harvests in raw form. The study concluded that most farmers who were to repay with money for the loan granted, defaulted more than those who were asked to repay with a part of their harvests. It is a shortfall for NIRSAL's mode of operation, which is too conventional. The rural farmers require a localised system, providing inputs required instead of raw cash.

4.2.3.5 The Millennium Development Goals (MDGs)

The MDG was a World Bank project and had eight objectives, one of which was to exterminate poverty in the rural areas. However, 15 years after the programme

(2000 to 2015), the End-Point Report – Nigeria in 2015, agreed that considerable effort was made on this objective, but the target was not met. The report concluded that the challenge to effective poverty reduction in the country was the insufficient poverty reduction effect of economic growth. Thus, whereas the country recorded mostly impressive growth rates in the 2000s and in more recent times, this was not entirely inclusive and neither did it reduce poverty or even generate employment (OSSAP-MDGs, 2015, p. 2; UN, 2015).

The Millennium Development Goals (MDGs) End-Point Report for Nigeria (2015) agreed that the reason Nigeria was unable to meet the poverty eradication goal of the MDGs was that the economic strategies employed were not entirely inclusive nor people-centred in implementation. However, some progress was made in the other core objectives, like the reduction of maternal deaths.

4.2.3.6 The Livelihood Improvement Family Enterprise (LIFE)

LIFE was designed in response to the limited readily available options for the "disadvantaged" (youth and women) in the rural and suburban communities to improve their livelihood. LIFE promotes community-based on-farm and off-farm business activities along with critical agricultural value chain as a mechanism for job and wealth creation amongst unemployed youths and women. The initiative has the objective to sponsor community-based farming. It acts as a business to create on-farm and off-farm jobs. The scheme's intentions were also to encourage import substitution through enhancing production and productivity of competitive crops focusing on communities with ecological advantage, and equally endorse value addition through the setup of private sector operated cottage industries processing and packaging of produce with an organized link to market at competitive prices and to improve family livelihood through the development of agricultural enterprises and to reduce rural-urban migration among the youth. However, record rural farmers benefiting from this initiative does not exist.

4.2.3.7 Agro-Processing, Agricultural Productivity Enhancement and Livelihood Improvement Support (APPEALS)

The development objective of the APPEALS Project for Nigeria is to enhance the agricultural productivity of small and medium-scale farmers and improve value addition along priority value chains in the participating States.

The initiative has five components, as follows:

(1) Production and productivity enhancement. It was designed to increase the total supply of the targeted priority value chains with a purpose to ensure a consistent, reliable and timely stream of products to the markets.

(2) To promote primary processing, value addition, post-harvest management and women and youth empowerment. It is to support the reduction of post-harvest losses, facilitate the consolidation of production and primary processing by farmers' cooperative societies and small and medium-scale enterprises in project intervention areas, focusing on gender-sensitive activities. It covers along the core segment of the value chains (production, processing, marketing) and ancillary businesses (agro-dealership, haulage, packaging and business management);

(3) Infrastructure Support to agri-Business Clusters aimed at improving the physical environment (last-mile connection to roads and utilities) for agro-industrial and cottage processing units, located in agri-business clusters with significant potential for agro-processing and greater inclusion of small to medium size farmers into the agri-business supply chains through the business alliances;

(4) Technical assistance, Knowledge Management and Communication were designed to build the capacity of the project staff and partner in the relevant areas of the value chain development, harness the knowledge acquired and generated under the project.

(5) Project management and coordination are to ensure effective management and coordination of the project for the proper accomplishment of project-related goals.

4.2.3.8 The “Zero Reject” Initiative

The principal objective of the Quality Control and Standardization mandate of Zero Reject was to entrench best practices in the food handling chain and linking stakeholders and farmers for quality consumption, export drive and for Agricultural Development Action Plan. It was targeted at dealing with the issue of food rejections at the international markets - a reaction to the various rejection of agricultural products that originated from Nigeria, attempting to penetrate the global markets. However, this initiative was a substantial failure, lacking a clear insight of preventing contamination rather than remediating contaminated agricultural produces.

4.2.4 Contribution of agriculture to the Gross Domestic Products (GDP)

Before the discovery of oil and gas in large quantity in the southern part of Nigeria, agriculture occupied a vital role in the contribution to the economy of Nigeria. Over the years, the situation has changed from bad to worse. One of the reasons for the decline in the contribution of agriculture to the GDP is the poor access to a competitive market by the farmers. Figure 4.2 below summarised the contribution of agriculture to Nigeria’s economy from 1960 to 2017. It is clear from the figure that agriculture is losing its place as a one-time economic backbone of Nigeria, especially in the era of groundnut pyramids in the north. A sharp drop in agricultural contribution to the GDP between 1960 and 1970 was because of petroleum discovery in the south of the country in the 1950s. It led to the age of oil booms in the 70s.

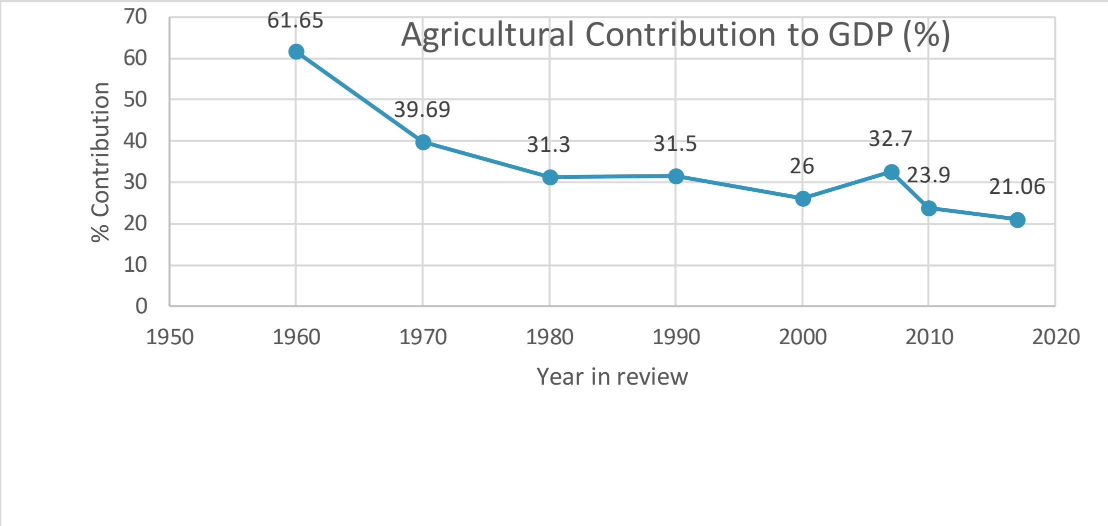


Figure 4.2: Line graph showing the agricultural contribution to GDP in Nigeria
Credit: NBS, 2017; Ahungwa, Haruna & Rakiya (2014)

The oil boom hit agriculture badly, as many people began to migrate from rural communities to cities, in search of opportunities in the oil sector. Farming became the last option for many people, only to be considered when all else fails. Nigeria became a net importer of essential foods almost immediately. The quest to recovery from the oil-dependency was what led to various agricultural policies, programmes and projects. However, there have been calls for diversification to go back to agriculture.

4.2.5 Exportable agricultural commodity in Nigeria

The exportable agricultural product is defined as crops which are currently grown in Nigeria which have export potential (NBS, 2014). The Agricultural Exportable Commodity Statistics Survey is an annual survey which has helped to expose areas of comparative advantage of all 36 States of Nigeria and Federal Capital Territory (FCT) that cultivate the fourteen identified crops.

It also serves as a pointer to States where these crops can easily be found in case of future surveys in the country (Ibid.). The survey covered the following fourteen crops: Cashew, Cocoa, Coffee, Cotton, Garlic, Ginger, Gum Arabic, Kola nut, Oil Palm, Rubber, Sesame seed (Beni seed), Shea nut, Sugarcane and Tea.

The primary agricultural produce from Nigeria can be divided into two main groups: food crops, produced mainly for the use of the family and as staples for majority of the population of Nigeria, and cash crops: The food crops include beans, sesame, groundnuts, kola nut, maize (corn), melon, millet, palm kernels, palm oil, plantains, rice, sorghum, soybeans and yams. While the cash crops, which are mainly for export (mostly in their raw forms because of lack of processing facilities) includes cashew nuts, cassava, cocoa beans, gum Arabic, rubber and kola nut. Of all the crops, rice, maize, yams and cassava are the most valuable, and the most consumed. Cocoa is a leading foreign earner, followed closely by rubber (these are obtainable in the south and south-west of Nigeria) and sorghum, beans, and millet in the north (NBS, 2014). Figure 4.3 below, shows the map of Nigeria's agriculture, resources and industries. The facilities required to process the cash crops are not standard; otherwise, the farmers stand to benefit more if the processing is carried out at the local level near the production of these products. It would help the rural economy only if the products are produced to the global standard.

To access the global market, the control of food safety issues at the raw material level (production stage) is key to the production of standard finished products because the safety and quality of the finished products are dependent on the entire chain from the farm to the fork (Julien, 2010, p. 62). Moreover, the food supply chain is now a global process with massive private participation and governments playing regulatory and hygiene control roles (Baines, 2010, p. 303). With many organisations currently sourcing for [raw] materials beyond traditional boundaries to remain competitive' and to cut cost (Julien, 2010, p. 63), there is no better time for third world countries to begin to handle, for instance, food safety issues more appropriately. They need to do this to remain relevant, competitive and to attract patronage from global firms or consumers, and to initiate food trade agreements with developed countries. Failure to meet these global food safety standards means that Nigeria, for example, could become excluded from other countries regarding food trade.

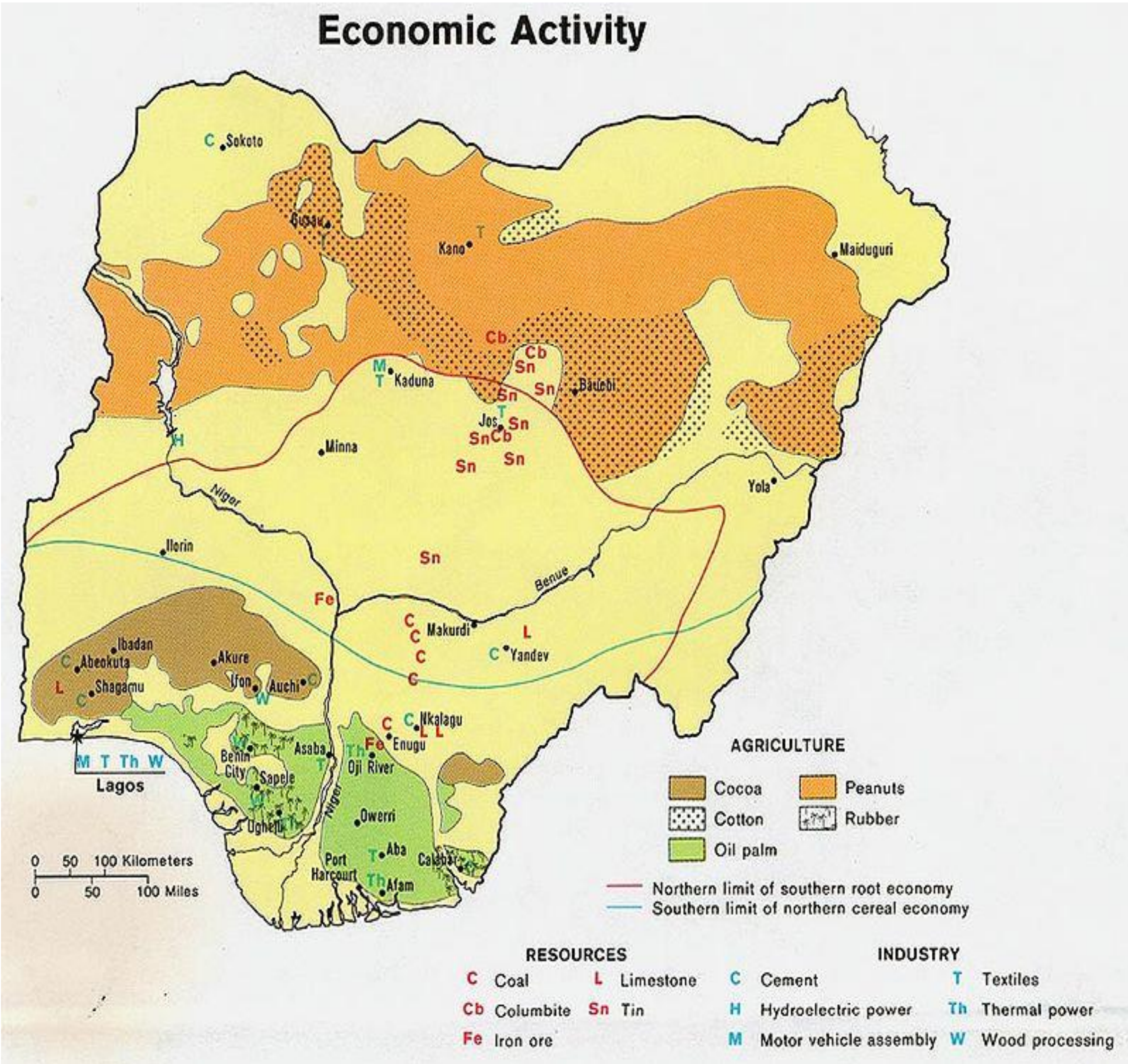


Figure 4.3: Map of Nigeria's agriculture, resources and industries.
Source: University of Texas Libraries (2016).

4.2.6 Prospects and challenges of rural economic livelihoods in villages

Despite the shortfalls of the various agricultural policies, programmes and projects, there are prospects. There have been some successes in the past, like the ADP and the GEES, but a whole lot needs to be done, especially within the prospects of raising the rural farmers from poverty and the context of the changing food standards around the world. Marketing of rural agricultural produce requires a more robust strategy than merely displaying raw grains in the open market.

In his visit to the expanded National Economic Council in 2018, Premium Times (2018) reported that Bill Gates had initiated research into the challenges confronting Nigeria as a nation. It concluded that “the majority of Nigerian smallholder farmers lack access to the seeds, fertiliser, and training they need to be more productive, and they lack access to the markets they need to profit from their labour.” Gates was reported to have added, that “one of the barriers that continue to bedevil the rural farmers is lack of access to finance. Finance connects farmers to opportunities just the way roads connects people”. Sadly, only about 4 per cent of Nigerian farmers can access agricultural loans (Ibid.). Investment in the people via the creation of opportunities to markets, to good health and education, was the core requirements.

Moreover, and sadly too, the farmers are also not creditworthy, because of lack of data about their activities. As reported by the Bank of Agriculture, Nigeria, some farmers would collect agricultural credits from the bank and would relocate elsewhere or change their addresses (BOA, 2018). Some were even reported to have faked their deaths to avoid repayment. Similarly, one of the challenges of the Growth Enhancement Support Scheme (GEES) programme of the government in 2012 was the inability of the plan to “verify whether a farmer is indeed a farmer”

(GrowAfrica, 2015, p. 16). This research, therefore, is to develop a processing and storage model across communities in Kogi State, to help produce world-class grains and to reduce or eliminate food waste, losses, improve food safety, improve general food security and improved income for the rural farmers. The well-being of the farmers is a consequence of the market their farm produce can reach.

4.2.7 Locations of strategic national grain silos in Nigeria

To contribute to the body of knowledge, Table 4.4 shows the location of the grain silos belonging to the Federal Republic of Nigeria, together with their various capacities.

Table 4.4: Location of grain silo complexes belonging to the Nigeria Government

S/No	Location	State	Capacity MT
1	Jahun	Jigawa	25,000
2	Kaduna	Kaduna	25,000
3	Gombe	Gombe	25,000
4	Jos	Plateau	25,000
5	Minna	Niger	25,000
6	Ilorin	Kwara	25,000
7	Lafiaji	Kwara	11,000
8	Makurdi	Benue	25,000
9	Ibadan	Oyo	25,000
10	Akure	Ondo	25,000
11	Irrua	Edo	25,000
12	Ogoja	Cross-River	25,000
13	Ezillo	Ebonyi	25,000
14	Dutsin-ma	Katsina	25,000
15	Sokoto	Sokoto	25,000
16	Bulasa	Kebbi	100,000
17	Gwagwalada	FCT - Abuja	100,000
18	Ilesha	Osun	25,000
19	Gusau	Zamfara	100,000
20	Gaya	Kano	25,000
21	Bauchi	Bauchi	25,000
22	Jalingo	Taraba	25,000
23	Maiduguri	Borno	100,000
24	Lafia	Nasarawa	25,000
25	Ikenne	Ogun	25,000
26	Ado-Ekiti	Ekiti	100,000
27	Zango Village – Lokoja	Kogi	25,000
28	Igbariam	Anambra	25,000
29	Uyo	Akwa-Ibom	25,000
30	Damaturu	Yobe	25,000
31	Yenagoa	Bayelsa	100,000
32	Okigwe	Imo	100,000
33	Yola	Adamawa	25,000
TOTAL CAPACITY			**1.3 million MT**

Credit: FMARD (2016b).

4.3 Grain Storage systems in Nigeria

Waste and losses have been identified as a significant challenge confronting the volume of food production in rural areas. Up to 40 per cent of grain harvests are lost to poor grain handling and storage. Parfitt, Barthel and Macnaughton (2010) posit that food losses take place at the various stages of production through the supply chains. In a nutshell, storage structures play vital roles in the preservation of grain stock and raw materials, finished product, equipment and livestock (Steffen, 2001). Significant emphasis has been advised so that the efficiency of the structures can preserve the stored produce (Pedersen, 1978; Furtick, 1978).

4.3.1 The role of wastage in food security and rural livelihoods in Nigeria

A significant factor in food security and rural economic debate relates to waste. Waste happens at different points in the food production system, especially at the following: Local farm level which may be due to inappropriate or inadequate harvesting, processing, storage systems and at the point of sales, especially in areas where grains are sold in the open without packaging. Waste can also happen during transportation from, for example, the location of production to the point of consumption or to where it could be used as raw materials. Food waste can happen at the point of preparation, where good foods could end up at the waste site. Finally, wastes occur at the point of consumption, or shortly after, especially in places where people order for prepared food they usually cannot consume.

The reduction of Food Loss and Waste (FLW) is of importance to policymakers and the media and there have been several publications in this regard by researchers and organizations (Koester, 2017, p. 276), including European Parliaments, The United Nations Environment Program (UNEP), the Food & Agriculture Organizations, Koester, (2013, p. 63-64) and Parlitt, Barthel and Macnaughton (2010, pp. 3065-3081). The High-Level Panel of Experts on Food Security and

Nutrition defined FLW as an economic, social and environmental foe (HLPE, 2014, pp. 12, 31). Koester (2017, p. 286) however, suggested a more meaningful definition of FLW, as the various estimations available are likely to result in overestimation. The critical factor is that even grains that may have lost value are not wasted as long as there are other ways of utilising them.

Globally, Gustavsson *et al.,* (2011, p. v) estimated that global food waste, amounting to about 1.3 billion tonnes, occurs yearly. Ironically, developed countries waste almost as much food as the total amount of food production in sub-Saharan Africa, equivalent to about 222 million tonnes. Sub-Saharan Africa produces about 230 million tonnes on average. In 2012 for instance, the African continent produced 172 million tons (Mt) of cereals, 16 Mt of pulses, and 16 Mt of oilseeds, with the most important being maize, cowpeas, common beans, and peanuts (Taylor, 2016, pp. 80, 111).

4.3.2 National livelihoods: the role of storage systems in food safety, food security and rural livelihoods in Nigeria

In Nigeria, previous studies had consistently identified inadequate storage systems, as the leading cause of post-harvest waste and loss – the factors militating grain production and utilisation in developing countries like Nigeria (Odulami, 2016; Essiet, 2014; Adeoye, *et al. 2011;* Adepoju, 2014; Olayemi, *et al.* 2012; Okuneye, 2001). Inadequate investments in storage or poor transportation for agricultural produce could be because of lack of access to credit (Koester, 2017, p. 275).

The waste and in-store losses occur mainly among rural/smallholder farmers because they lack storage facilities. Meanwhile, the rural/smallholder farmers have been identified to play a pivotal role in food security of Nigeria and create up to 60 per cent of employment, contributing to Gross National Income (GNI) (Dan-Azumi, 2011). Similarly, a different percentage of waste problems has been reported for various crops and in various States in Nigeria, ranging between 40 to 80 percent (Adepoju, 2014, p. 8; FMARD, 2016a, p. 22, Adeoye et al. 2011, p. 432; Olayemi, et al. 2012, p. 13). In general, the government of Nigeria placed the average wastes for various crops at 60 per cent (FMARD, 2016a, p. 22). However, grain losses are difficult to estimate, as it relates to a loss in the quality and value of the crops while in-store, and the interpretation of "value loss" depends on the final use. The actual wastes are in the form of residues that occur during processing plus loss of value during storage which may result in total loss of value, hence considered wasted.

There is a significant chance for food safety-related issues, waste and food insecurity in areas where storage systems are inappropriate or inadequate, which can result in health risks. Hazards are also possible where records of raw material producers are not known or kept and where there are no safety regulations to control potential dangers and threats as they relate to pesticide use, as identified by FMARD (2016a, pp. 5, 19-20 and 23). Risk, as defined by Soon and Baines (2014, p. 4) has two parts: the likelihood that a hazard will affect food consumers and the second part deals with the severity of the consequences of the risk if it does occur.

The possibility for the three pillars of sustainable agriculture (economy, ecology and sociology) which Hayashi (2011, pp. 3, 14) referred to, may suffer huge setbacks in an unsafe food situation. The author also clearly opined that the era of sustainable agricultural model or approach takes into consideration people, planet and profit, unlike the conventional agricultural model that focuses on yield and profit.

Therefore, there are factual gaps in the current literature regarding the role of storage systems in safe crop production, processing and storage systems at the provincial level in Kogi State – Nigeria; and *the people* aspect of modern agriculture, which stipulates that farmers (employees of agriculture) should also prosper economically. Meanwhile, more than 80 per cent of foods that are produced in Kogi State is done at the rural farms (KSMRD, 2015), which compares with the estimate for Africa and Asia (FAO, 2014a, p. 4).

The rate of post-harvest losses in Nigeria as compared with other countries is as shown in Figure 4.4, below. The post-harvest waste in Nigeria is clearly above the different countries and about twice that of Indonesia, and three times that of India, El Salvador and Vietnam. The losses in rice alone have been estimated at 56.7 Billion Nigerian Naira (the equivalent of USD 162 million) on a yearly basis, the maximum amount of damages occurs during the storage of crops because of poor or inadequate infrastructure (Kumar and Kalita, 2017). The author classified loses into two categories: direct losses, due to physical damage of commodities [waste]; and indirect losses, due to loss in quality and nutrition, caused by biotic factors (insect, rodents, fungi and mycotoxins) and abiotic factors (moisture content, temperature, humidity), as reported by Abedin, *et al*. (2012). Losses of up to 60 per cent have been reported (Costa, 2014).

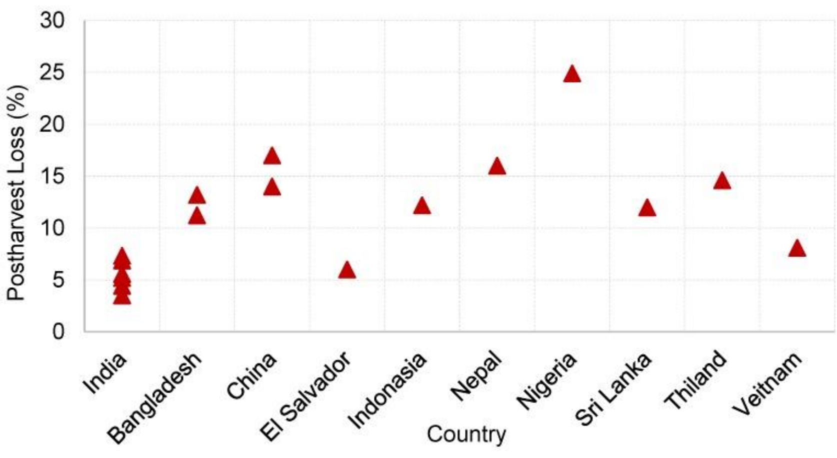


Figure 4.4: Post-harvest losses in the rice value chain in some countries
Credit: (Kumar and Kalita, 2017).

4.3.3 Typology of storage systems in some communities in Nigeria

In a study by Bankole, Taninola and Adesina (2013) on the evaluation of agricultural storage structures utilisation in Lagos State, Nigeria, improvised and traditional storage still accounted for 15 to 70 per cent of storage structures in Lagos State, depending on the location. Some farmers were even found to store their harvests in their living rooms and under the beds. It could encourage waste and losses and make grains unsuitable for global markets because of possible contamination. Figures 4.5 and 4.6 below shows some of the storage structures obtainable in some communities, south-west of Nigeria. In this region, the modern and traditional method still dominate the grain store types, and this is understandable. Lagos is one of the major commercial hubs of Nigeria, and areas like the Lagos Mainland and Lagos Island are developed. Therefore it was expected that modern facilities be found for grain storage in these areas.

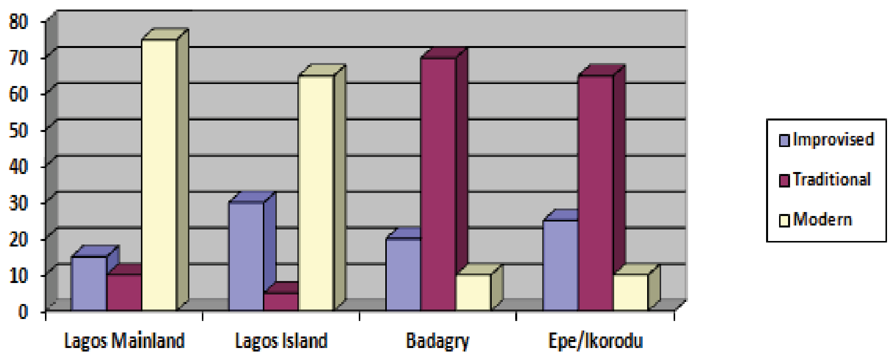


Figure 4.5: Representation of farmers using improvised, traditional and modern storage structures in Lagos State

Credit: Bankole, Taninola and Adesina (2013)

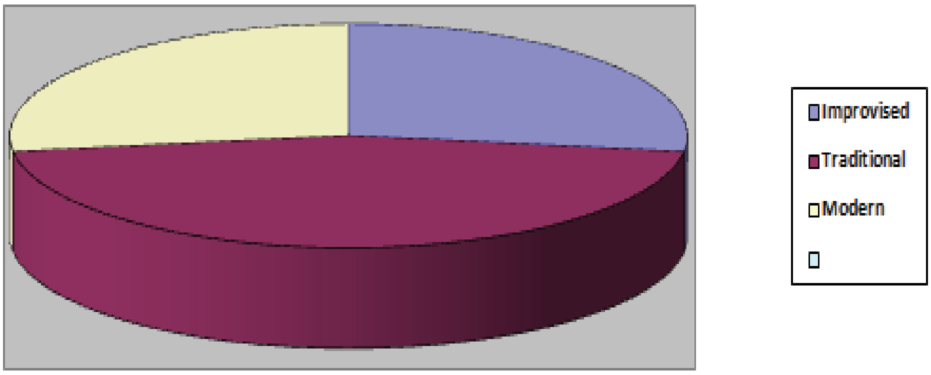


Figure 4.6: Pie Chart showing Representation of farmers using improvised, traditional and modern storage structures in Lagos State

Credit: Bankole, Taninola and Adesina (2013, p. 36)

In a related study, Adejumo and Raji (2007, p. 1), reported on technical appraisal of grain storage systems in the Nigerian Sudan savannah of the north, and pointed out that the common grain storage structures existing in this zone are the mud rhombus, thatched rhombus, underground pit, an earthen pot and warehouse storage. The author opined that most of the structures were not moisture-proof, rodent-proof and were not airtight. The common structural defects occur mainly in the roof, walls and columns of the storage structures. Some of the conventional storage structures in this zone are shown in Figures 4.7 through 4.10, below.

Figure 4.7: Mud Rhombus with a thatched roof

Credit: Adejumo and Raji (2007, p. 5)

Figure 4.8: Thatched Rhombus with tree stem columns, showing tree stem external support

Credit: Adejumo and Raji (2007, p. 7)

Figure 4.9: Failed Thatched Rhombus after eight years of use

Credit: Adejumo and Raji (2007, p. 8)

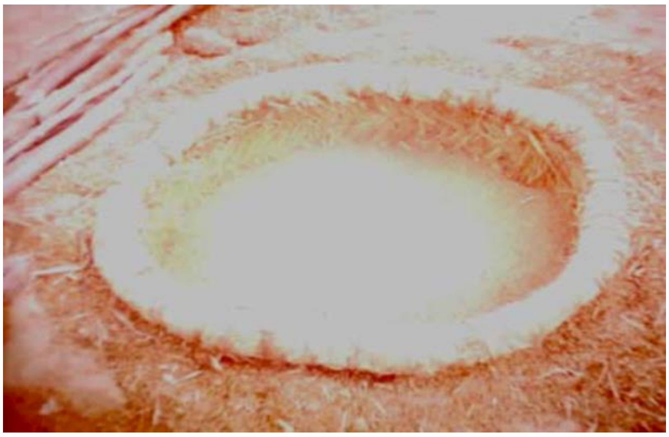


Figure 4.10: Underground pit, showing woven grass stem lining used for storing millet in Borno state, Northern Nigeria.

Credit: Adejumo and Raji (2007, p. 9).

4.4 Food safety regulations in Nigeria

According to the World Bank report, US$ 110 billion in lost productivity and medical expenses each year are incurred because of unsafe foods in low- and middle-income economies (World Bank, 2018c). For this reason, food safety must be observed from the moment the seeds hit the soil. It is because it has become pertinent to begin to search for more causes of food allergy as early as at the production levels (GLOBALG.A.P., 2017, p. 33), and as the harvested products move to the bulk stores.

Food safety regulations in Nigeria is the responsibility of the National Agency for Food & Drug Administration and Control (NAFDAC). It is the agency that issues the certification number for semi-processed and processed foods. Other agencies and departments are saddled with related responsibilities and issue certificates for goods meant for export. Some of the agencies are;

- The Nigeria Agricultural Quarantine Service (NAQS) – this agency issues phytosanitary certificate for agricultural commodities; NAQS is a regulatory agency under the Federal Ministry of Agriculture and Rural Development, with the primary objective being to prevent the introduction, establishment and spread of animal and zoonotic diseases as well as pests of plants and fisheries including their products. The body performs other functions such as emergency protocol of new pest incursion or disease outbreak in collaboration with key stakeholders. It ensures that agricultural exports meet with international standards in line with the International Plant Protection Convention (IPPC) and to meet the conditions imposed by importing countries (NAQS, 2014).

- International Veterinary Certificate for Animals and Animal Products – this certificate is issued by the Department of Veterinary and Pest Control Services (DVPCS). The Department functions as the policy adviser to the Government on all animal health, safety and wholesomeness of food of animal origin for human consumption and pest control services. It is involved in the prevention, control and eradication of trans-boundary animal diseases and pests. It deals with the control of vector-borne diseases, zoo-sanitary certification services, provision of veterinary public health services, food safety services and zoonotic diseases control. It is to guarantee healthy national herd, the wholesomeness of foods of animal origin, international trade in livestock and livestock products and the general economic well-being of the populace (FMARD, 2018).
- Fumigation Certificate for Agricultural Commodities is issued by Federal Ministry of Industry, Trade and Investment. The ministry's roles are to represent the interest of Nigerian exporters in government boards and committees responsible for export development and promotion in Nigeria. The ministry works with other agencies and Committees such as the Nigerian Export Promotion Council (NEPC), Nigeria Export Processing Zones Authority (NEPZA), States' Export Promotion Committees, Nigeria Committee on Trade Procedures (NITPRO), among others (FMITI, 2011).

The other agencies and department play vital roles. However, none of the regulations deals with the grains from the farm to the processing and storage point, until the grains get the food manufacturers or secondary processors.

The NAFDAC areas of focus are processed and semi-processed foods, drugs & medical devices, herbal & cosmetics, vaccine & biologics, chemicals, narcotics, veterinary and other services. The agency's roles also include disclosing food outbreaks and recalls to the public, both from outside and within Nigeria.

Also, the agency also issues guidelines for import and exports for bulk food, animal feed, food raw materials, regulated foods, pre-packaged foods that are not for personal use, as well as the issuance of health certificate for exportation of processed and semi-processed food commodities. There are guidelines also for micro, small scale enterprises, guidelines for facilities for the manufacture of food products, guidelines and requirements for bread manufacturing products and instructions for packaged water facility in Nigeria.

The agency provides regulations for wine, spirit drinks, soft drinks, pre-packaged water, non-nutritive sweeteners in food products, milk and other dairy products, fruit juice and nectars. It regulates the advertisement of food products. There are also regulations for cooking salt, food fortifications, food additives, food irradiation, fats and oils rules as well as rules for cocoa and cocoa products.

The agency has no guidelines and regulations for agricultural products such as grains from the farm to the storage. Recall that the European Commission has a red alert on processed and semi-processed food commodities from Nigeria (RASFF, 2016). For the products to have gotten to the border of Europe, it had received the NAFDAC approvals. The contamination that led to the rejection of Nigeria's products is only possible because, the raw materials were already contaminated from the point of production, through storage, before the firms bought them from the open market, through the middlemen, for processing. The "zero rejection" initiative by the federal ministry of agriculture and rural development was a reaction to the rejection imposed by the European Union markets and other global markets. However, the initiative lacks a concrete model to prevent the contamination of the grains from the source.

4.5 Chapter Summary

This chapter has highlighted Nigeria's food security as measured with various global recognised indicators. The contrasts/similarities/differences in food security situations in Nigeria and the case study countries have been highlighted. More instances of food security cases in Kogi State and the communities, indicating the livelihood of the farmers has also been emphasised. However, critical issues as identified in this chapter must be resolved, and this is only possible when the right methodology is applied, to determine the challenges confronting the beneficiaries and find a model for addressing the issues.

CHAPTER FIVE

RESEARCH PHILOSOPHY, METHODOLOGY AND METHODS

5.0 Introduction

In this chapter, the research aligns with the background that deals with the philosophy of this research, the methodology and the methods employed. Research philosophy deals with a belief system about data collection on a phenomenon, how it should be collected, analysed and used. The methodology of research deals with the learning of the various techniques that can be exercised in the conduct of research. It does not entail the techniques but understands how and where each method fits. The methods are the techniques or tools used in data gathering. In the following sections, more explicit details of the fundamental aspect of any research are expounded as it relates to this research.

5.1 Research philosophy

By way of definition, research philosophy or theory or paradigm is the development of the research background, research knowledge and its nature (Saunders, Lewis and Thornhill, 2009). Cohen, Manion & Morrison (2000) explained that the philosophy of any research marks its birth, its foundation on which all other research processes are built. It deals with the source, nature and development of knowledge (Bajpai, 2011). It is equally seen as a belief about how data about a phenomenon should be gathered, analysed and used (Davison, 1998).

By these definitions, it can be deduced that the philosophy of research determines the research approach, methodology and methods. There are many schools of thoughts on the subject of philosophy of research, and several paradigms are in literature. However, the positivist belief was selected because of its objective views, while interpretivism was because of its subjective opinions. These were chosen basically because of their suitability for this research and were blended together within the mixed-method exploratory study.

5.1.1 Positivism

The school of thought of positivism has a 'long and rich historical tradition…so 'embedded…that knowledge claims not grounded in positivist thoughts were at some point in history dismissed as *ascientific* [unscientific] and, therefore, invalid' (Hirschheim, 2015, p. 12). Technically, positivists believe that reality is constant and can be observed from an objective standpoint without interfering with the phenomena being studied. According to Davison, (1998), they contend that events should be isolated and that observations should be repeatable, involving manipulation of reality, with variations in only a single independent variable to identify uniformities in and to form relationships between some of the constituent elements of the social world.

Positivism is based on the philosophical ideas of the French philosopher Auguste Comte, who emphasised observation as a way of understanding human behaviour. According to him, real knowledge is based on the experience of the senses and can be obtained by observation and experiment. Knowledge is generated this way by the positivist (Dash, 2005).

Knowledge generation should be understood within the framework of the principles and assumptions of science. These assumptions, as Cohen, Manion and Morrison (2000) noted, are determinism, empiricism, parsimony, and generality.

Determinism means that events are caused by other circumstances and, hence, understanding such casual links is necessary for prediction and control. Empiricism means a collection of valid empirical evidence in support of theories or hypotheses. Parsimony refers to the explanation of the phenomena in the most economical way possible. Generality is the process of generalising the observation of the event to the world at large.

With some assumptions, science aims to integrate and systematise findings into a meaningful pattern or theory, which is regarded as tentative and not the ultimate truth. Such arguments are themselves subject to revision or modification as new evidence are discovered. The positivistic paradigm shift is quantitative, dealing with numbers and undergoes the knowledge generation process using various quantification tools. It is done to improve the accuracy of results and to define in clear terms, the relationships that exist among the variables.

5.1.1.1 Adopted branch of positivism and criticism

Generality as a school of thought in positivism makes it possible to generalised data obtained from some randomly selected members of a group, such that their responses could be interpreted to represent the response of the entire group. This is the adopted position of this research. Positivism has been criticised for its disregard for own subjective views, regarding humans as entities controlled passively by external factors. Hence, human beings are dehumanised without their intention, individualism and freedom being considered in viewing and interpreting social reality (Dash, 2005).

Critics of this paradigm believe that objectivity has to be replaced with subjectivity in scientific inquiry, the criticism eventually gave rise to the anti-positivism or naturalistic inquiry.

5.1.2 Interpretivism (Anti-positivism)

Anti-positivism paradigms emphasise on the place of ideological positions. It believes that the individual should interpret social reality according to the ideological positions; such that individuals acquire or experience knowledge personally rather than acquired, or imposed, from outside. The anti-positivists believes that reality is multi-layered and complicated and that a single phenomenon can have multiple interpretations (Cohen, Manion and Morrison, 2000). Anti-positivism is marked by three schools of thought in social science research: *phenomenology*, *ethnomethodology* and *symbolic-interactionism*. These three are means through which interaction with phenomena can be achieved. It suggests a qualitative, rather than quantitative, approach to the social inquiry. According to this theory, it is essential for the researcher, as a social actor, to appreciate differences between people (Saunders, Lewis and Thornhill, 2012) and consider the differences in their many might.

5.1.2.1 Adopted branch of interpretivism and criticism

This research adopted the phenomenological branch for its primary data collection. Phenomenology is a theoretical viewpoint which believes that individual behaviour is determined by the experience gained from one's direct interaction with the phenomena. It rules out any objective external reality (Dash, 2005). It is the philosophical tradition that seeks to understand the world through directly experiencing the phenomena. During interaction with various phenomena, human beings interpret them and attach meanings to different actions and or ideas and, thereby, construct new experiences (Littlejohn & Foss, 2009, p. 47). Phenomenology examines human experiences through the descriptions provided by the people involved. These experiences are called *lived experiences.* The goal of phenomenological studies is to describe the meaning that experiences hold for each subject. This type of research method is used to study areas in which there is little knowledge (Donalek, 2004).The main criticism of interpretivism is the lack of objectivity in its approach.

5.2 Linking the critical research questions and hypotheses to the aims and objectives - The choice of the philosophical position

Recall the key objectives and research questions as set out in Chapter One. The objectives were:

- Identify good practices in case study countries in relation to regulations, private standards and access to markets;
- Evaluate the situation in agriculture in Kogi State - Nigeria with a focus on post-harvest processing and storage systems;
- Appraise the contribution of grains to food security and how the typology of grain storage systems in Kogi State reflects on farmers' income;
- Develop models to support rural economic development while ensuring food safety, food security and waste minimization.

On the other hand, the research questions were:

Research Question 1: Is the current grain post-harvest activities, and grain storage systems among rice and maize farmers in Kogi State sufficient to cut down waste and improve food safety?

Research Question 2: To what extent do the post-harvest platforms and storage systems encourages grain waste, losses or improved food safety in Kogi State, Nigeria?

Research Question 3: How can an alternative model improve rural economic institutions in Kogi State, Nigeria?

Based on the research objectives and questions, this research adopts the scientific nature of positivism theory as an ontological position and the subjective nature of interpretivism (or constructivism or anti-positivism) theory as an epistemological position within a mixed-method approach. Therefore, the nature of reality (ontology) is viewed objectively, with the lense of positivism. There is an implication, though: the subjective views of the people, their tradition or culture could be made immaterial or inconsequential. However, the interpretation of this reality and data required for an efficient model development geared towards farmers' capacity building, was subjective. Therefore, the epistemological position adopts that of anti-positivism (constructivism or interpretivism).

These philosophical positions would be used to prove or disprove the research hypothesis. The null and alternative research hypothesis as expressed in Chapter One is:

(Null): Processing and storage systems adopted by the rural farmers in Kogi State do not influence the farmers' income.

(Alternative): Processing and storage systems adopted by the rural farmers in Kogi State influence the farmers' income.

5.3 Research Methodology and approach

A methodology is not the same as a method; it, however, provides the supports and theories to understand which method to apply at any point in the course of research (Irny and Rose, 2005). In its simplest term, the methodology is the study or description of methods (Baskerville, 1991). Research philosophy, strategy, and the instruments used are connected as the research seek to answer the research questions (Davison, 1998).

This research adopted survey methodology (usually quantitative) and case studies (mixed methods). The reason being that exploratory research requires qualitative, as well as quantitative data, to improve the result validity. As defined by Irny and Rose (2005), the methodology is the systematic, theoretical analysis of the methods applied to a field of study. It encompasses the theoretical analysis of the body of methods and principles associated with a branch of knowledge.

5.3.1 Survey methodology

Survey methodology studies the sampling of discrete units from a population. The associated survey data collection techniques or methods are questionnaire and interview, whereby questions are put forward to the participants, expecting their response. However, such questions may, or may not, be answered (Beam, 2012). The essential requirements are samples, methods and questions, which are then analysed statistically (Davison, 1998). The survey was a suitable methodology for the research at hand.

5.3.2 Case study research

Case studies can be considered from both the quantitive and qualitative angle. It is, however, intensive, observing a single point in time or over some delimited period (Gerring, 2004, p. 342). In a case study, a single person, group can be considered as *the case* to be studied over time (Baškarada, 2014). In multiple cases, cases are considered by crossing the boundaries, digging into differences and similarities (Cohen and Crabtree, 2006). Stake (1994, p. 236), opined that the case study is about the individual cases and not by the methods used.

Considering the complexity and significant geographical boundaries of Nigeria, the case study was a suitable method to be able to have firm control over data gathering and analysis. However, the size of the data to be collected if each community in

Nigeria is treated as an individual case was way beyond this research time and hence was considered unsuitable to consider the entire communities in Nigeria. Kogi State was therefore selected as the case for Nigeria. The target is to understand the boundaries of the situation (person, situation) and the complexity of the behavioural patterns.

It is sometimes considered weak because its results cannot be generalised easily since it usually concentrates on a single organisation or participant (Davison, 1998, pp. 3-5). However, sometimes, a case study is about a group, describing the behaviour of the group, not the behaviour of everyone in the group – This is considered a weakness too and does not represent specific cases of the individuals in the group.

5.4 Research Approach

Every research can take on one or more approaches to create an argument, formulate judgement and then draw conclusions. The baseline of every research is the ability to reason in a particularly logical way. The Merriam-Webster Dictionary (2016) gives a simple definition of reasoning as the drawing of inferences or conclusion from a reason. It is a logical way to form a conclusion or judgement. The focus of the research is the people and their situation, attitudes, trends and patterns. Also, research can be conducted informally for the researchers' benefit, through asking questions, watching, counting or reading and, formally, for medical or academic purposes, as a marketing strategy, to inform and influence politics and policy (University of Surrey, 2016).

This research was both inductive or deductive.

5.4.1 Inductive

Inductive research approach works from ‘specific observations to broader generalisations and theories; this is informally referred to as a "bottom-up" approach’ (William, 2006, p. 1). It is such that the premises are viewed as supplying strong indication in favour of truth and conclusion, while in the deductive argument, the truth of the conclusion of an inductive argument is not absolute’ (Copi, Cohen, and Flage, 2006).

5.4.2 Deductive

The deductive research approach is a scientific inference made from one or more statements (premises) to reach a logically inevitable conclusion (Sternberg, 2009, p. 578). It works from general theory to a specific conclusion, informally referred to as a ‘’top-down’’ approach (Williams, 2006). It usually begins with a theory and narrows down to confirmation of the hypothesis. Figure 5.1 shows the representation of these approaches and the point they apply in this research.

Both inductive and deductive methods of reasoning have a very different "feel" to them when in research. Inductive is open-ended/exploratory, while deductive is narrower and is concerned with testing or confirming hypotheses (Ibid.).

This research was both inductive and deductive in approach. It is inductive from the exploratory part of the research, leading up to the data collection to support the general situation of the farmers in the rural communities. It is deductive in approach in the development of the model to improve food safety, food security and development of rural communities in Kogi State, Nigeria.

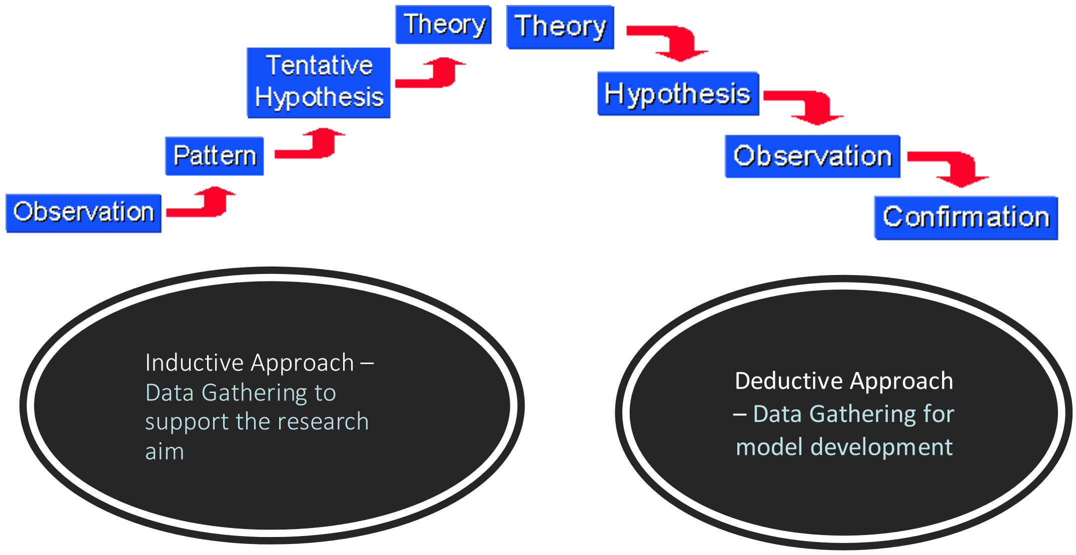


Figure 5.1: Representation of the deductive reasoning process.

Credit: William (2006, p. 1), modified by the author.

5.5 Research methods

This research adopted mixed methods. The following sections detail the various methods adopted and the rationale behind their adoption in this research.

5.5.1 On-site observation

An observation tool is employed when the nature of the research question to be answered focused on answering a ‘how’ or ‘what’ type of questions. One of these research questions is to know the types of storage systems that were available to the rural farmers in Kogi state. The “observation” here, however, was not about the people, but about the nature of storage systems found within the farming communities in Nigeria, it was about how the post-harvest systems for grains and the kind of pesticides are commonly available in these communities.

A great deal of photography was necessary here. Cohen and Crabtree (2006) had suggested even the use of video or audio recording and a field note in addition to taking photos with a camera. In this case, this method was used to obtain data that could be used to classify storage methods used by the farmers in Kogi state. There are several reasons for, and benefits of, using a camera and a field note. The benefits to include fostering a good relationship with the participants, which may lead to an in-depth understanding of the situation or phenomenon in its natural setting. The benefits could also be that a good foundation for a theory or hypothesis could be developed from observation research.

5.5.1.1 Covert observation

Covert Participant observation involves a researcher joining the group he or she is studying, with the researcher's status not made known to the group. The covert observation was to generate five critical data from the location, which are the methods of harvesting, de-husking, shelling, drying and ease of access to pesticides and type of pesticides in use. It was not used to directly observe the people themselves, only the post-harvest processing methods.

5.5.1.2 Overt observation

Overt observations refer to the researchers revealing the intention of the interaction with a group or community he or she is studying, right from the onset of the observation. In other words, the participants were aware of the researcher's intentions from the onset of the interaction. This method has an advantage, as it connotes honesty on the part of the researcher, eventually helpful where cultural taboos exist that could limit what the researcher could do. This method was used to gain access to the farmers' storages and farms, with full permission. Where photographs are required, they are taken at this point (where permitted of course).

5.5.2 Survey questionnaire

Survey questionnaires is a tool that presents a set of questions to the participants. The participant's responses provide valuable data to the researcher (William, 2009).

It is used widely as one of the data collection techniques within the survey strategy which helps to answer research questions and achieve the set research objectives" (Saunders, Lewis and Thornhill, 2009, p. 361). For questionnaire questions to be valid and reliable, four stages must occur, according to Saunders, Lewis and Thornhill (2009, p. 372). The four stages are summarised in Figure 5.2. Sarah (2012) identifies two groups of survey research: according to Instrumentation, and according to the Span of Time involved.

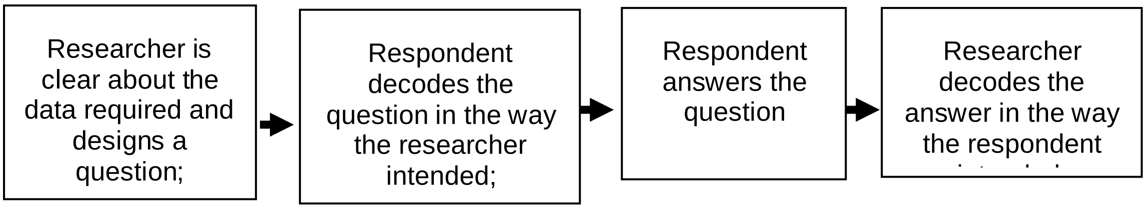


Figure 5.2: Questionnaire stages
Credit: Saunders, Lewis and Thornhill (2009, p. 372).

Sarah (2012) identifies the merits and demerits of administering a questionnaire as follows:

- Advantages: Ideal for asking closed-ended questions; useful for market or consumer research.

- Disadvantages: Limits the researcher's understanding of the respondents' response; requires a budget for the reproduction of the survey questionnaires.

Regarding the order of questions in the module, Oppenheim (2000) suggested that the best choice of approach and sequence must be determined by the specific survey problems and by the results of the pilot work. As Worthington and Whittaker (2006, cited in Martin and Sass, 2010, p. 5) and Hopper, (2010), had suggested, an instrument such as the questionnaire should take no more than 15 to 20 minutes to administer, beyond this point, the participants would most likely lose interest.

5.5.3 Structured interactions

The interactions mimicked the structured interview and were composed of closed-ended questions, with some pre-coded answers, and the participants could express their views. One-on-one interaction is a qualitative tool adopting the theory of interpretivism. Here, there is limited knowledge of the subject matter, therefore, to obtain a better understanding of the topic and issues, open-ended questions have been recommended (Oppenheim, 2000) to allow respondents to say what they think and what they do, with greater richness and spontaneity. A structured interaction was found suitable for a particular stage of this research, because of the nature of respondents, time available for the research, the overall resources available and the research location. The method proved to work better with the farmers/participants and was also supported by further interactions with the key person at the grain silo complex in Kogi State (The interaction can be found in Appendix A) and with those along the supply chain. The interaction and the on-site observation combined to helped evaluate the grain silos project and the grain storage programme of the Federal Government of Nigeria, considering the following themes: progress and impact of the grain silos, challenges confronting the grain silos, funding of the grain silos, staff welfare, planned procedure for acquiring grains into the grain silos.

The interaction with players along the supply chains includes those with rural or local grain merchants, medium to significant grain merchants, transporters of bulky goods, including agricultural products, a firm that participated in the grain silo concession, a member of the State Assembly, pesticide merchants, retailers at the local markets and secondary processing firms.

The primary purpose of these interactions was to understand with full richness, the challenges being encountered by the players along the supply chain. It also helps to understand the economic relationship between the farmers in rural communities with the players along the supply chain, up to the secondary processing consumers (manufacturers).

5.6 Data sampling – criteria and representativeness

A multistage sampling procedure was used to select the participants, using the stratified sampling method. At the first stage, the State was divided into 50 strata called communities. These communities comprise of several villages and towns. However, only the rural villages were considered to conform with the focus of the study. At the second stage, random sampling was used to select two villages from each community. At the third stage, 6 participants were purposively selected to conform with the type of participants required for the study. Where a selected participant does not meet the required criteria or where other participants have successfully completed a criterion, the data generated were discarded as saturated. In this selection process, older married males and females and those who have lost their partners were not explicitly identified in the sample, but they were possibilities that they are members of the sample.

In all, a total of 300 participants were selected for the study at a margin of error of 6 and 95 per cent confidence level. The number was representative of the population. For large populations, Cochran (1963, p. 75) as cited by (Glenn, 2003, p. 3) developed the equation to yield a representative sample for proportions:

$$SS = (Z - score)^2 x \frac{P(1-P)}{ME^2}$$

Where, SS = sample Size

P = Population proportion;

M.E. = Margin of error or confidence level

Z^2 is the abscissa of the normal curve that cuts off an area α at the tails, obtained from Z value; M.E. is the desired level of precision, P is the estimated proportion of an attribute that is present in the population. The value for Z is found in statistical tables (Z-score table) which contain the area under the normal curve.

A comfortable margin of error should be chosen with a degree of precision-made of three components: variability, confidence level and margin of error (Capital Health, 2009, p. 11).

5.7 Limitation of the sampling method used

The selection of the villages in each community was random; however, in terms of age, marital status and gender of the participants, the selection was purposive. In addition, older unmarried males and females, and females who have lost partners were not mainly represented in this selection. However, the chances that these set of farmers fell into the sampled farmers were possible, as it is common for those who have lost their partners to assume a "married" status still. This is common in the research station.

5.8 Research design

Basically, the research design refers to the plan or strategy of the research, and the logic behind it, which made it possible and valid to draw more general conclusions from it. It was concerned with making the current problem researchable by setting up the study in a way that would produce specific answers to specific problems (Oppenheim, 2000). Figure 5.3 shows the design of empirical research. It began with a pilot study and ends with conclusions and recommendations.

This research adopts an exploratory design or strategy. Data gathering was cross-sectional. According to Sarah (2012), if the information is collected from the respondents at a single period, then it is the cross-sectional type, and the questionnaire is usually utilised for this type of survey.

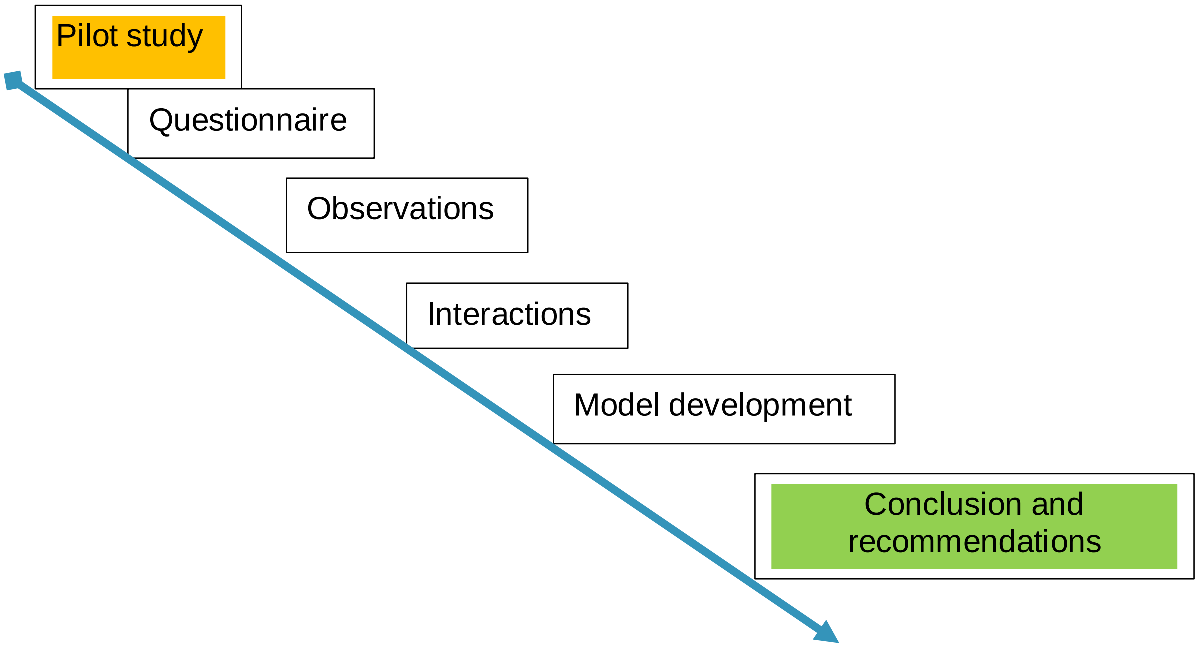


Figure 5.3: The design of the empirical study.
Credit: Author

5.9 Data analysis tools

The data collected was analysed using an Analysis of Variance (ANOVA), tables, figures and sketches. An ANOVA is used to test differences between two or more means. Where applicable, the qualitative data obtained were also analysed using Nvivo. The questionnaire produced both quantitative and qualitative data. The interaction with key stakeholders was qualitative, was audio-recorded (where agreement had been reached with the participants or correspondents), written down in field notes and then transcribed. The coding was based on themes. Coding involves the labelling attached to a phrase(s) of the text being analysed. These codes were placed in categories – which is the grouping imposed on the coded segments to reduce the number of different pieces of data in the analysis. The on-site observation adopts a critical analysis of the pattern observed among the storage structures. These patterns were grouped and analysed accordingly.

5.10 Study Location

Kogi is a State located in the North Central part of Nigeria. The State lies on latitude 7^0 N and longitude 6^0 E (a State in Nigeria is like a County in England). It is popularly called the Confluence State because the confluence of the Rivers Niger and Benue is at its capital, Lokoja. Before the independence of Nigeria from the British, Lokoja was the capital of Nigeria. The economy of the Kogi State is profoundly agricultural, with less than 0.5 per cent in coal mining and other activities (KSMRD, 2015). Figure 5.4, below, is the ecological and climatic map of Nigeria showing the location of the study (Kogi State), while Figure 5.5, below, shows the expanded version of the map of Kogi State.

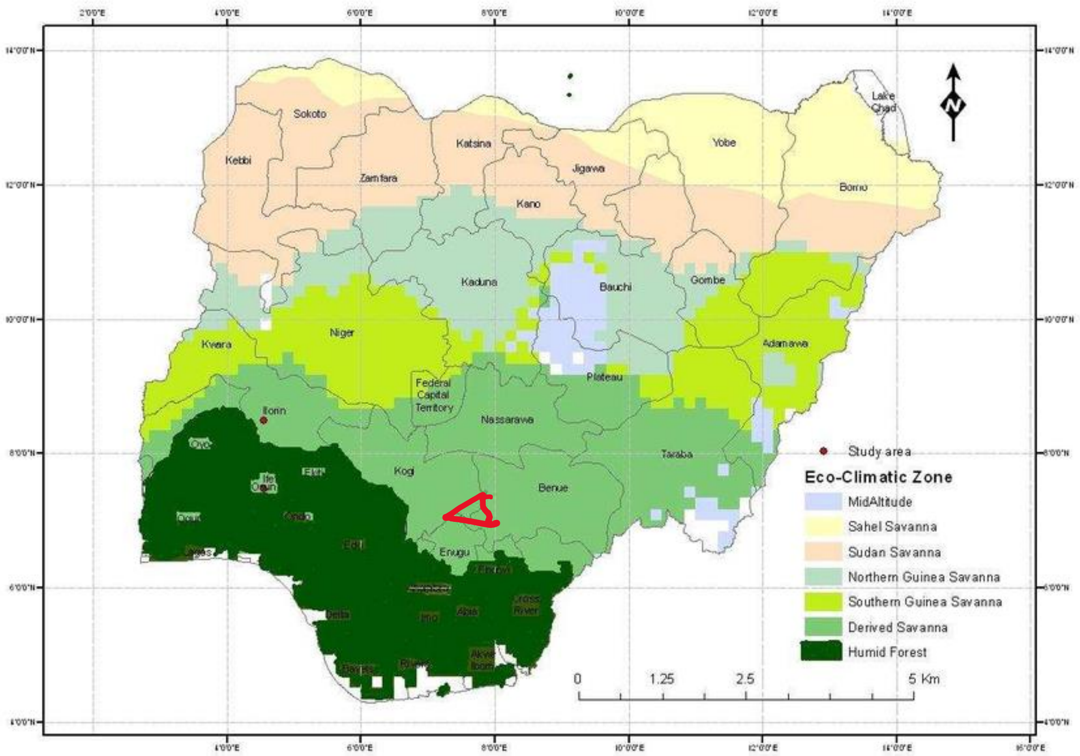


Figure 5.4: Eco-Climatic map of Nigeria showing the Site Location
Credit: KSMRD (2015).

Figure 5.5: Map of Kogi State showing the Districts and the Local Councils
Source: Ameji, Sa`idu and Abdu (2016, p. 2).

5.10.1 Why this Location?

- The Kogi State lies at the confluence of the two major rivers in Nigeria (River Benue and River Niger) – prompting agricultural activities, especially in grains and tubers. For this reason, the State is often referred to as “The Confluence State”. The presence of these rivers encourages massive agricultural cultivation and fishing. It attracts numerous visitors too.

- Historically, Lokoja, the current capital of Kogi State was the former British Northern Nigeria Protectorate after the amalgamation of the Northern and Southern Nigeria in 1914, hence could attract investment opportunities. It is a tourist destination too, attracting visitors to the merging of the two rivers and other historical sites in the State, like the Mungo Park building.

- The State is a transition between the tropical vegetation of the south and the Sudan/Sahel savannah of the north of Nigeria, making cultivation possible for a variety of crops.

The primary cultivations are food and cash crops. Food crops are yam, rice, maize, guinea corn & beniseed while the cash crops include palm oil, cashew and mango. As would be expected, fishing is also a very significant occupation in the State.

The adult literacy rate is 62.1% among males and 37.9% among females (NPC, 2006). According to the National Population Commission of Nigeria, the State had a population of 2,147,756 million in the 1991 census. This population grew to 3,314,043 in the 2006 census and a projected population of 3,478,029 in 2016. However, this research worked with the 2019 projected population of 4.15 million people. Males make up 50.5 % of the population and females 49.5 % (Ibid.). Eighty per cent of the population resides in rural areas (KSMRD, 2015). The number of those above 65 years is low; overall, the State has a young population.

The Igala tribes reside on the east of Rivers Niger and Benue confluence and across the Niger in Lokoja (the Capital of Kogi State). Other information about the location of the Igala tribes is Latitude 6º30 and 8º40 north & Longitude 6º30 and 7º40 east. The land area is about 13,665 square kilometres (Paul and Edino, 2015).

The Ebira and Ogori-Magongo people are the second and third largest ethnolinguistic tribes of Kogi State respectively, with their administrative headquarters at Okene and Akpafa respectively. The Okun people are the minority; they occupy the central part of the State.

5.11 Ethical Considerations

This research followed the University of Gloucestershire’s Handbook of Research Ethics. Additionally, because the fieldwork took place in Nigeria, the National Health Research Ethics Committee (NHREC) was also consulted. NHREC concluded that no ethical approval was needed, as risks to rural farmers before, during and after the interactions were not envisaged.

5.12 Chapter Summary

This chapter has carefully analysed the philosophical background of the research and has expounded on the research methodology, approach and the methods employed. Evidence to support the decision to structure the research this way was presented from literature. In the next chapter, the thesis presents the results obtained from empirical research.

CHAPTER SIX

RESULTS AND ANALYSIS

6.0 Introduction

The information presented in chapters One, Two and Three of this thesis has provided the needed evidence to support objective One. The chapters have also provided valuable insights into the research problem statement on food safety, food security, and how key lessons learnt from case study countries can be modified to solve the identified problems in literature. In this chapter, the empirical results from the field, are presented. The farmers have various postharvest strategies to ensure that the stored grain does not deteriorate while in-store. Though these strategies were adopted purposively, they, however, come with unanticipated consequences. The results presented here provide the needed pieces of evidence to support objectives two, three and four of this research. It helps to answer all the research questions too. But first, the list of communities identified in Kogi State, Nigeria, plus the two villages randomly selected from each community from where the purposive selection produced the participating farmers. The also shows the main crops in cultivation. The demographic information of the farmers is provided in subsequent tables to show the profile of the farmers in terms of age, sex and marital status.

Note that the distance between the two selected villages in each community ranges from 4.5 KM to 15 KM. Table 6.1 shows the list of communities and villages visited with the main crops in cultivation; Table 6.2 shows the educational level of the participants; Table 6.3 shows the mean age of the farmers, farm size and an annual grain output; Table 6.4 shows the main crops cultivated by the participating farmers; Table 6.5 shows the farmers' main challenges in rural farming as identified; Table 6.6 shows the percentage of grain waste as reported by the participating farmers;

and Table 6.7 shows the number of farmers who read pesticides' labels/instructions before use.

Table 6.1: Communities visited, and grain of interest

S/N	Communities	Location 1	Location 2	Major Grain of interest
1	West Yagba	Ogbe	Oni I	Maize + Rice
2	Yagba II	Omi2	Iyemerin	Rice
3	Yagba North -East	Amuro	Ijowa	Maize
4	Yagba South-East	Imela	Jege	Maize
5	Okpo	Gala	Ofogo	Maize
6	Imani	Agaliga	Abo	Maize
7	Ogodu	Ofante	Ogugu	Maize + Rice
8	Okene	Okene	Adegu	Maize
9	Okengwen	Ere	Odenku	Maize + Rice
10	Eika	Aku	Apipa	Maize + Rice
11	Ihima	Akene	Odosi	Maize + Rice
12	Ogori/Magongo	Ogori	Arere	Maize
13	Ugwolawo	Ojodu	Oforachi	Maize + Rice
14	Wwalawo	Gwalawo	Igala	Maize + Rice
15	Ogwa	Okura	Ejule	Maize + Rice
16	Lokoja Rural	Lokon-Goma	Sarkin-Noma	Rice
17	Oworo	Felele	Emu	Rice
18	Kakanda	Nambata	Apata	Maize + Rice
19	Kupa	Egba	Kupa	Maize + Rice
20	Koton-Karfi	Agaga	Osuku	Maize + Rice
21	Kabba	Kabba	Otun	Maize
22	Bunu	Are	Oke	Maize
23	Ijumu	Iyara	Ogidi	Maize
24	Idahn	Ede	Ochijenu	Rice
25	Ofulko	Obaloko	Ujagba	Rice
26	Oforrachi	Alade	Apata	Maize + Rice
27	Adoru	Agboni	Obochi	Maize + Rice
28	Onyedega	Abocho	Ojogba	Rice
29	Dekina	Ulaja	Agojeju	Maize
30	Okura-Egume	Agbeji	Ofakaga	Maize + Rice
31	Birdu	Acharu	Ojapata	Maize
32	Akabasisi	Landu	Oguma	Maize + Rice
33	Akishamishi	Butu	Iyede	Rice
34	Odeyyi/Mozum	Kara	Ogba	Maize + Rice
35	Ahutara/Ikende	Amara	Jato	Maize + Rice
36	Ozonugulo	Daji	Kpanche	Maize + Rice
37	Gboloko	Gboloko	Olowa	Maize + Rice
38	Apala	Gbobe	Akobo	Maize + Rice
39	Ankpa	Emere	Ojuwo1	Maize + Rice
40	Ajaokuta	Ganaja	Egayin	Maize + Rice
41	Adavi	Idato	Karaworo	Maize
42	Ogodu	Ojeh	Okaba	Maize + Rice
43	Abejukolo	Ikpoba	Abejukolo	Rice
44	Ejuku	Ejuku1	Ejuku	Maize + Rice
45	Mopa	Mopa	Muro	Maize + Rice
46	Olukotun	Olukotun	-	Maize + Rice
47	Douala/Malabo	Ajaka	Malabo	Maize + Rice
48	Ojigagala/Ogogba	Ojigagala	Ogogba	Maize + Rice
49	Odolu/Okpo	Odolu	Okpo	Maize + Rice
50	Abejukolo/Ife	Ife 1	Ife2	Rice

6.1 Demographic and other essential information of the participants

The demographic information of the participants was obtained with a researcher-administered questionnaire to provide a "picture" of the farmers. A sample of the questionnaire can be found in Appendix B. Fifty per cent of the participating farmers were males, and fifty per cent were females. However, in terms of marital status, 200 of the participants were married (representing 66.7% of the participants), and 100 were not, representing 33.33%.

Table 6.2: Educational level of the participants

Educational level attained	**Frequency**	**Percentage (%)**
Primary School	204	68.00
Secondary School	66	22.00
Tertiary Institution	7	2.33
No Formal Education	23	7.67
TOTAL	300	100.00

Table 6.3: Mean age of the farmers, farm size and an annual grain output

Variables	Mean	Remarks
Age (years)	41	
Farm Size (Hectares)	4.2	
Grain outputs (kg)/hectare	1, 288.00	Maize
	325.30	Rice

Table 6.4: Main crops in cultivation by the participating farmers

Grain	No. of Farmers (N = 300)	No. of communities	Percentage
Maize	111	12	24
Rice	59	9	18
Maize + Rice	130	29	58
Total	300	50	100

Table 6.5: Farmers' main challenges in rural farming identified

Challenges	Lack of agricultural Credits	Weak market system (inadequate income from sales of harvest)	Poor Processing and Storage Facilities	Total
No. of Farmers	79	91	130	300
Percentage (%)	26.3	30.3	43.4	100

Table 6.6: Percentage of grain waste as reported by the participating farmers

Waste recorded based on grain quantity before and after storage (in 100 kg bags)	Number of responses	Percentage (%)
Zero waste	0	0.0
5 – 20 %	19	6.4
21 – 40 %	193	64.3
41 – 60 %	88	29.3
61 - 100	0	0.0
Total	300	100.0

Table 6.7: Number of farmers that reads pesticides labels or instructions before use

Read pesticide labels before use?	Yes	No
Number of Farmers	4	296
Percentage response	1.3 %	98.7 %

6.2 Discussion of results on the farmers' demographics

Though the number of villages in each community is uneven, there were about 1,215 villages in the entire communities (strata). For the population of 4.15 million in Kogi State, three hundred (300) participants across 50 communities in Kogi State, represented a margin of error of 6 at 95% confidence level. Two villages in each of the communities were chosen for the study making the total number of villages visited to be 100. The main crops in cultivation were maize and rice, plus some tubers such as cassava and yam. Eighty to eighty-five per cent of grain or seed crops in cultivation in Kogi State were maize and rice. Tubers constitute the others.

From Table 6.1, fifty-eight (58) per cent of the communities cultivate maize and rice as their primary crops each year, compared to 18 per cent who are into rice farming as their core produce each year. The small number of rice farmers could be because only a few communities reside near water bodies and water is heavily required for rice cultivation. Other communities rely solely on rainfall to be able to cultivate, as irrigation systems are not conventional. The alluvial soils found in some communities, as well as adequate annual rainfall in the States are suitable for maize cultivation too. Similarly, many of the farmers engage in these two grains because of the ease with which the grains could be processed into several other products for consumption. For example, maize can be eaten raw, roasted, cooked, fried, and even fermented into pap. There are up to ten other ways maize grain can be utilised (value addition) in many communities in Nigeria (Alabi, Akintola and Famakinwa, 2018, p. 146).

6.2.1 Why grains (in this case, maize and rice) are suitable for food security in Kogi State and Nigeria

1. Ease of utilisation;
2. Quick maturity (maize matures within about 70 days after planting);
3. Diverse utilization – can be transformed into different food types;
4. Ease of transportation – 50 to 80% easier to transport than tubers;
5. Higher demands compare to tubers.

The mean age of 41 years suggests that the farmers are still within their productive age. The mean age came close to the mean age value of 43 years for farmers in

Kogi State obtained by Ataboh *et al.* (2014, p. 44) and 45 years obtained by Ibitoye and Odiba (2015, p. 20). In comparison with the average farmers age of 59 years for the UK (DEFRA, 2014, p. 8) and 60 years for Africa as a whole (FAO, 2014a p. 2, World Bank, 2018d), one would have assumed a much more active farmers' age for Kogi State, Nigeria. However, the fact that 60 per cent of Africans is under 24 years of age, the 41 years recorded for Kogi State could mean that most farmers are above 24 years. Again, Nigeria's low life expectancy, which was, as at 2016 report on average, 53 years (World Bank, 2016a), indicate that the average 41 years is closer to the death age than the active years. To provide further information about the quality of life in Nigeria, Premium Times (2018), opined that Nigeria, though a low-income country, but with lower life expectancy than those from the same class of countries - the average life expectancy of people from the low-income country (62 years), was way above the life expectancy of Nigerians, even though Nigeria is from a low-income country. Therefore, with a global perspective, the average farmers' age of 41 represents an active age but not so with the African and Nigeria's perspective.

The level of education obtained by the participating farmers (Table 6.2) were considered because, according to OECD (2015, p. 16), there is a fundamental link between education (be it primary or higher education) and development, such that access to education can boost GDP in both developed and developing economies. However, Kruss *et al.* (2015) had argued that the relationship between development and education, such as the belief that more educated people earn more income than uneducated people, is complex. In fact, in some cases, it is not valid. They recommended that more study was required. However, while education itself may not necessarily increase income, it supports innovation and creativity needed to match today's world. Therefore, the need to find out the level of education of the participating farmers is justified. From table 6.4, more than two-thirds of the participants had just primary education (68 per cent). More so, the percentage of those who have no formal education is more than twice those who received higher education (just 2.33 per cent of the participants received higher education in the entire population). The reason for this could be related to the rural-urban migration among those who have acquired a certain level of higher education, in search of greener pastures and opportunities in the cities. There could be a relationship between acquired education and grain safety consciousness.

The 4.2-hectare average size of farmland available to farmers is relatively small, especially for mechanization. The reason could be because of how land ownership works in Nigeria generally. Though the land is under the control of the government, the Land Use Act of 1978 made rural lands owned before 1978 to be under the control of communities, and the communities are made of families. Over the years, the size of the land available for each farmer kept decreasing as the family lineage in communities increases. For example, a man with 400 hectares of land three generations ago, with say, seven children, would have shared the land among his seven children before his death. The result would be that each of his children would be entitled to about 57 hectares. Imagine that each of the children had an average of five children, it means that each of the grandchildren would have a little above eleven (11) hectares.

Again, if the grandchildren had four children each on average? It means each great-grandchild would be left with less than 3 hectares of farmlands. This scenario could be better for families with fewer children. It would be worse for families with average children ranging between 25 and 60. On the other hand, some people have so many lands passed on to them from previous generations, so much that they do not use them for agricultural purposes, yet, it is difficult for any entrepreneurial farmer to have access to such farmlands. The situation in Kogi State is such that the agricultural land tenure system, remains a significant challenge. As population increases, the amount of land available to each farmer in some households keeps decreasing.

The Land Use Act of 1978, as enshrined into Nigerian constitution, gives power to the Governors to approve occupancy to any individual, except those who have developed their communal lands before the year of the Act (Mabogunje, 2009). There were more problems with the Act, which led to a committee set up by the Federal Government of Nigeria, to address all the issues surrounding land ownership by the communities and the sole power granted onto the governor, to issue Certificate of Occupancy and revoke of the same. The Land Use Act as it affects Lagos State, for instance, has been reported too (Udo, 1990). State by state report on land use for the entire States in Nigeria was not found.

Therefore, the mean farm size of 4.2 ha per farmer indicates a low chance for each farmer to own and manage modern storage systems like a grain silo or to utilise farm machines and machinery. In other words, commercial farming may be unprofitable for each of the farmers because of the small land size. In China and Indonesia, land sizes are even smaller for some rural farmers, but the output per hectare is better than the average output obtained in Kogi State and Nigeria for rice and maize. Table 6.8 shows the yield per hectare for maize and rice in Nigeria compare to other countries.

However, grain yield per hectare of land is particularly very poor in Kogi State, such that maize yield per hectare for Nigeria, was a measly 31 per cent of the yields obtained in China, and 17 per cent of that of the yields in the United States of

America (USA) per hectare of farmland. Similarly, for rice, it was 32 per cent of the yield per hectare of China and 26 per cent for the USA. For Kogi State, however, the maize output of the participants was below the quoted output for Nigeria, including that of rice (see figure 6.8, below). For example, maize output for Nigeria per hectare has an official value of 1.8 ton/ha, but the participating farmers in Kogi State recorded 1.2 ton/ha. Similarly, rice has a national output per hectare of 2.1 ton (a value which appears to have been obtained from experimental farmlands), but that of Kogi State was a mere 0.3 ton/ha. Poor farm management, lack of extension services, non-compliance to Good Agricultural Practice (GAP), maybe the leading cause of the low outputs among the farmers.

Table 6.8: Comparing maize and rice production per hectare in case study countries in 2017 and 2018.

Crops	**Country**	**Yield/ (Metric ton/ha)**	
		2017	2018
Maize	USA	11.08	11.34
	Europe	5.25	5.11
	China	6.09	6.16
	Nigeria	1.69	1.69
	Indonesia	1.40	1.63
	Indonesia	3.21	3.30
Rice	USA	8.41	8.45
	Europe	6.81	6.89
	China	6.91	6.82
	Nigeria	1.88	1.88
	Indonesia	4.76	4.80

Credit: USDA - Foreign Agricultural Service (2018, pp., 17 & 22).

A recent study by Laughton (2017) in the UK found out that small farms obtain better profit than big farms and attract young farmers more than large farms. This is not proven in other climes yet; however, Kogi State can benefit from the commercial and subsistence farming when adequate management is in place. The farmers could still maintain their subsistence farms, but the management would be in the group, giving it a commercial outlook.

Therefore, it is possible to commercialise the subsistence farmers by bringing the farmers together under a single platform and managed digitally. A model to incorporate the farmers under such platform should typically be able to address the situation of individual farmers through a group and also linking the group to global stakeholders.

Furthermore, with 43.4 % of the farmers indicating storage problems as their primary challenge (Table 6.5), it appears to be a significant problem in Nigeria considering the typology of storage systems seen in literature from other parts of Nigeria and Kogi State.

In terms of waste being recorded by the farmers, most farmers (64.3%) wastes 21 to 40 per cent of their farm produce to the storage, 29.3 per cent recorded wastes between 41 to 60 per cent. Only a handful of the farmers (6.3%) claimed a waste of 5 to 20 per cent following any storage cycle. A waste situation of more than 5% is too much for any farmer. When the wastes being encountered during harvest and processing is incorporated into that of storage, the farmers in Kogi State could be wasting as much as 50 to 70 per cent of their farm produce. This has a significant effect on food security and the income of the farmers.

Also, only 1.3 per cent of the farmers claimed that they do read pesticides labels or instructions before they apply any pesticide, while 98.7 per cent claimed they do not read at all (Table 6.7). This situation is alarming with the potential effect on food safety. Excessive pesticide use affects the rules and regulations of export in the following ways:

1. Certain pesticides are prohibited in some countries. For example, the use of DDVP - 2,2- *dichlorovinyl dimethyl phosphate* as found to be the active agents in the pesticides in use in Kogi State, is banned in the UK and in entire Europe.

2. Cost of food poisoning is enormous: the consequences of unsafe food can be severe, and the cost of the recall is vast, the increasing liabilities and legal requirements for retailers, wholesalers and food companies, are intensive. As globalisation of product supply persists, global standards must be adhered to (Julien, 2010).

6.3 Dynamics of agriculture in Kogi State – the pattern of result presentation and result discussion

To understand the dynamics of agriculture in Kogi State and Nigeria, and how post-harvest processing and storage affect food safety and security, the results obtained are presented in the pattern of Figure 6.1. Other empirical results are presented from the farm through the post-harvesting processing up to the storage and marketing of the grains. The results presented below provided the needed evidence to objectives two and three, which are to evaluate the situation in agriculture and food security in Nigeria and Kogi State with a focus on post-harvest processing and storage; and the objective three bothers on appraising the contribution of grains to food security and how the typology of grain storage systems in Kogi State, North Central Nigeria affects the concept of food security. In this section, the empirical results obtained to support objectives two, three and four of the research are discussed beginning from the farm level to the storage.

The Farm – as shown in figure 6.2 below

Harvest – see figures 6.3 and 6.4

Cleaning/Winnowing – see figure 6.5

Drying – see figures 6.6, 6.7. 6.8. 6.9. 610, and 6.11

Transportation -see figure 6.12 and 6.13

Storage – see figures 6.14 to 6.18

In-store Pesticide in use – 6.19 – 6.21

Grain sales/market and the middlemen – see figures 6.22 and 6.23

Figure 6.1: The pattern of result presentation

6.3.1 Farmland development

All stages of land development are done with simple tools – cutlasses for land clearing, larger hoes and sometimes shovels, for making ridges or tillage operations. Smaller holes are for weeding. This is usually backbreaking, tedious and with lots of drudgeries (Figure 6.2). Where the soil is waterlogged, or soils with stones, tillage gets even harder. In all, it is a challenging operation for the local farmers. The implication is that more time and effort spent on the farm does not necessary result in higher production.

Figure 6.2: A farmer in labourious and time-consuming farm work
Credit: The Business Day (2017).

6.3.2 Harvesting procedures

Harvesting (usually done manually as in Figures 6.3 and 6.4) is the beginning of the operations that take place along the supply chain, but it is still laborious, time-consuming and manual, in all the communities in Kogi State. No agricultural machine was sighted on any farm in any of the communities at all.

Harvest begins when about eighty per cent of the grains have turned straw colour; to avoid shattering. For maize plant, the dry maize cob is plugged by hand, dehusked and shelled manually with fingers one cob after another. Alternatively, the dehusked shells are heaped together to be beaten with wooden sticks of between 2 to 5 centimetres in diameter. In the case of rice, threshing is done carefully to avoid dehusking the grains, which may affect the physical appearance of the grains when milled, following parboiling. Agricultural workers (often the members of the farmers' family) carry out other series of labourious operations one after another along the supply chain, at the pre-storage processing stage.

A combine harvester would carry out the entire harvesting process automatically, at a go: they are simply driven through a field of crops, and they cut, thresh or dehusk and clean the grains all by themselves using rotating blades, wheels, sieves, and elevators. The grain collects in a tank inside the combine harvester (which is periodically emptied into carts pulled by tractors that drive alongside), while the chaff spurts from a big exit pipe at the back and falls back down onto the field (Woodford, 2014) to be retrieved later for use as animal feeds.

Figure 6.3: Manual maize dehusking

Note: The husks are usually set on fire by the farmers at the end of the farming season. However, they have great use as animal feeds.

Credit: Author, from the field.

Figure 6.4: Manual method of rice threshing.
Credit: Author, from the field.

6.3.3 Winnowing and post-harvest waste

Winnowing is a process of separating good grains of maize or rice from the chaffs. In each community in Kogi State, it is usually done with trays or baskets made of a weaved palm fronds or metals or plastic. The operation, which is usually carried out by women is done by throwing a small quantity of the grains (about 1 or 2 kilogrammes) in a tray into the air and allow the wind to blow the chaffs away while the grains fall back into the tray or basket. The winnowing operation is dependent on the wind movement (speed), to blow away the chaff in the direction of the wind. Some good grains are often carried along with the chaff. Those are usually irretrievable; they are wasted. When wind speed is low, winnowing operation would have to be suspended. All these take much time and many people, reducing farmers' productivity and encouraging wastes.

Figure 6.5: Winnowing operation by two women in Kano, Nigeria.
Credit: University of Wisconsin Milwaukee Library (1991).

6.3.4 Grain drying platforms and contamination with foreign objects

Figures 6.6 to 6.11 shows the various platforms the rural farmers have adopted for drying grains and some other farm produce that requires drying. The platforms are usually hard road shoulders, car parks, on bare grounds and any such hard surfaces such as flat rocks. These platforms are themselves contaminated. When the grains are spread on them, the grains get contaminated too, usually from domestic animals coming to eat the grains, people using the platform might spat on the grains, and the farmers may introduce contaminations themselves as thy walk and work on the grains.

The implication for export is that contaminations are easily detected with sophisticated equipment. For these reasons, between 2014 and 2016 alone, the European Commission rejected 109 processed and semi-processed food products that originated from Nigeria to the European Union. Some of the food items were rejected because they contained foreign agents, such as glass fragments, rodents' excrement, and dead insects. Elevated levels of chemical contaminants, used in fumigation, such as aluminium phosphide, dichlorvos, dimethoate, trichlorphon, cyhalothrin, were also discovered in the products. Moreover, microbes, such as salmonella, aflatoxins, and mould growth, were also found in some of the products (RASFF, 2016, p. 44).

Figure 6.6: A platform for drying, usually on sacks or trampoline.
Credit: Author, from the field.

Figure 6.7: Drying platforms - the drying process in progress for maize grain
Credit: Author, from the field.

Figure 6.8: Drying platforms.
Credit: Author, from the field.

The hard shoulder of the road, as shown (above) and bare floor (below) for a recently processed cassava. Similar platforms are utilised for maize and other cereals.

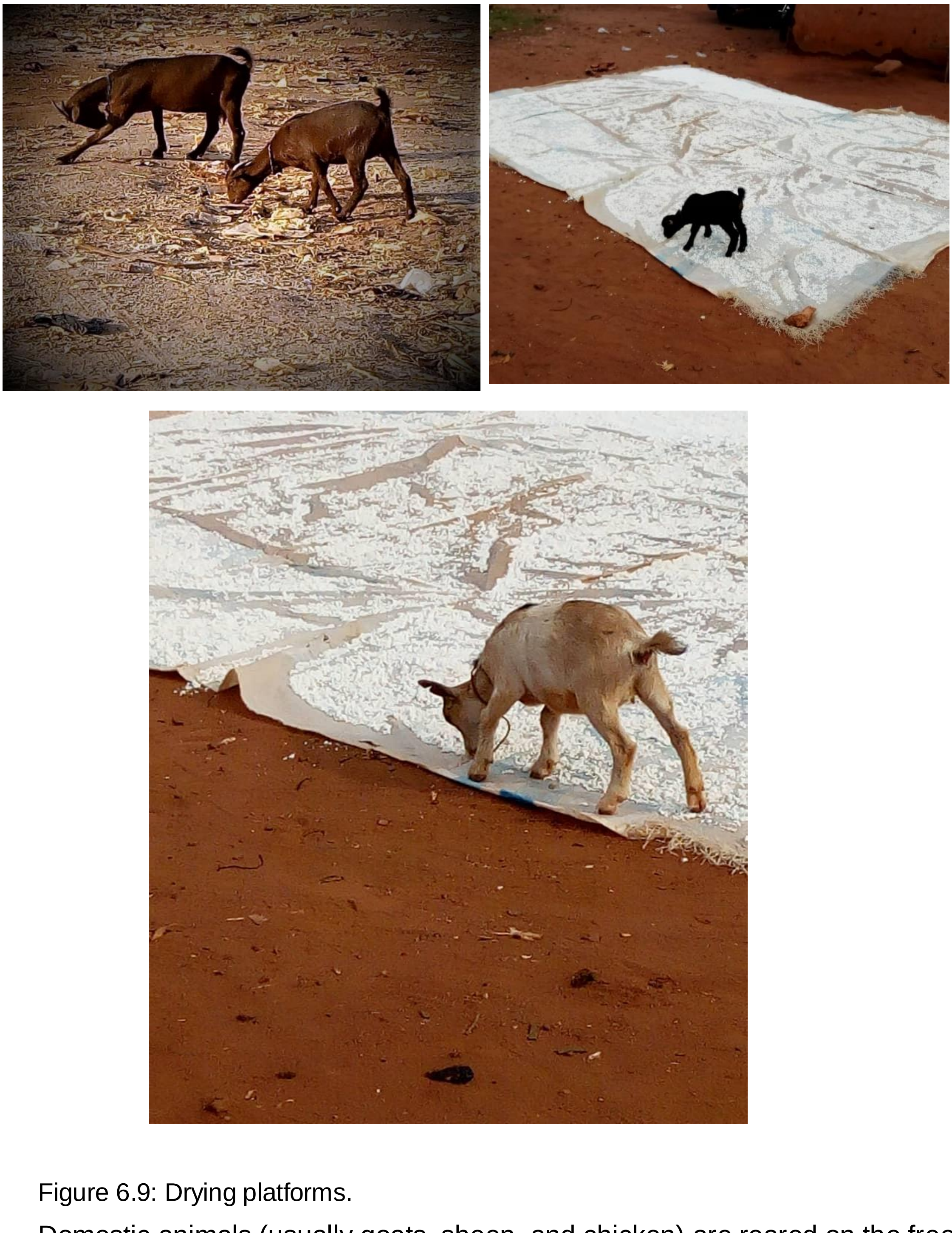


Figure 6.9: Drying platforms.

Domestic animals (usually goats, sheep, and chicken) are reared on the free-range system, and they can be a source of contamination for grains during drying.

Credit: Author, from the field.

Figure 6.10: Drying platform: A car park or similar surfaces.
Maize and rice are also dried on the same platform as this processed cassava.
Credit: Author, from the field.

Figure 6.11: Drying platform: peanuts undergoing drying on bare ground.
Other grains undergo similar drying condition as the peanut showed.
Credit: Author, from the field.

6.3.5 Grain Transportation and implication on food safety and rural economics

The grains are transported by the rural farmers from the farms to the house on the heads, either in their raw forms or following post-harvest processing like threshing. When the grains get home, farmers that do not want to store will head to the available markets in trucks, as shown in Figure 6.12. The challenge of intermediaries not patronising them when they get to the market can be agonising and leads to sales at low prices in order not to bear the burden of transporting them back to their communities.

When the grains are sold to the middlemen, figure 6.13 shows how grains are transported from the local markets to the cities. The implication of this mode of transportation on food safety are as follows:

1. One-for-all trucks mean that the same trucks that carried a corpse yesterday could be carrying food items today, leading to severe contamination from body fluids;
2. Rural farmers are often seated on tons of grains in the trucks as the rickety trucks are driven through unpaved roads. Many farmers have been killed while transporting their grains to the markets when an accident occurs.

Figure 6.12: Grain and people transportation to the local markets in smaller trucks.

Credit: Author, from the field.

Figure 6.13: Grain transportation.

Large trucks are used by major merchants to move grains from local towns to cities and neighbouring countries

Credit: Author, from the field.

6.3.6 Storage system types and implication on food safety, food security and rural income

Considering the grain quality demand from consumers from around the world, especially the developed economies, the storage systems found in all the communities in Kogi State, are primitive (Figures 6.14 to 6.18). The storage system is a critical system that can help grow the essential point of every farming business. The quality of the grain storage systems can determine the success of all the inputs from land clearing and development to the point of harvest. No economic value can be obtained from these structures, especially in a tropical and humid environment where stored agricultural products deteriorate too quickly owing to high humidity and temperature - an ideal environment for moths and insects.

Storing grains in storage systems that would not guarantee safety, quality, and benefits to the farmers are least expected. The farmers with the Thatch-Wall-with-Thatch Roofs system lamented their plight with rodents, fire and even insect invasion and theft. Such systems are also prone to moisture-induced deterioration through the walls and the roofs — the same with the rat infestation. Lassa fever outbreak had caused several deaths in Kogi State as reported by the World Health Organization. The viral infection is transmitted through the urine of wild rats (NAN, 2019; WHO, 2018b, par. 1; Akinfehinwa, 2018; Mohammed, 2017).

Those with zinc roofs but with thatches as walls were also prone to moisture penetration through the walls. The roofing system might not help much, except that direct water penetration from the top is brought to the bearable point if good roofing sheets were used. However, that was not the case with the local farmers in the communities visited. Some of the farmers still complained of leaking roofs, rodent infestation, insect invasion, mould growth within the structure because of high humidity and temperature, as is common in the tropics.

The mud walls mean rodents could effortlessly bore through, into the store and eat the stored grains. In general, there exists no particular benefit in this mode of storage systems, as the farmers who stored in these structures complained of moisture, mould growth, fire and such factors that cause deterioration.

The plastered mud or concrete walls may have been closer to the standard grain silos, but most of the farmers live with the grains. Such structures are not airtight, just like all the others and contamination of the grains was at its peak, first from the humans who live with the grains and from rodents. As some of the farmers placed the grains on the floor and walk on the grains to enter and exit their homes, other foreign materials, such as stones, sands and even animal excrement are introduced.

When compared with the results obtained from Adejumo and Raji (2007), it was realised that storage systems obtainable in rural communities across the savannahs of the middle belt region of Nigeria are similar in materials used both for the walls and roofs. Similarly, the results obtained by Alabadan (2006), Udoh, Ikotun and Cardwell (1994) for the five agro-ecological zones in Nigeria, there were similarities in materials used. This points to the fact that storage systems in rural communities in Nigeria are inadequate. It, therefore, means that a model that works for one community can reasonably work for the other communities with little or no modifications.

Figure 6.14: Storage type: Thatch wall with thatch roofs
Credit: Author, from the field.

Figure 6.15: Storage type: Thatch walls with zinc roofing sheets.

Credit: Author, from the field.

Figure 6.16: Storage type: Mud walls with thatch roofs

Credit: Author, from the field.

Figure 6.17: Storage type: Plastered mud/concrete walls with zinc roofing sheets
Farmers do not live with the grains in this type (non-live-in).
Credit: Author, from the field.

Figure 6.18: Plastered mud/concrete walls with zinc roofing sheets
Farmers do live with grains in this type(live-in).
Credit: Author from the field.

6.3.7 In-store pesticides and implication on grain export

The most common pesticides that those with active agents being 2,2- *dichlorovinyl dimethyl phosphate* – DDVP (familiar brand is *Sniper* and *Crush*) (80%) and others in plain packages with pictures of the human skull on them (20%) – Figures 6.19 to 6.21. Most of the villages have at least, a vendor, that sells these pesticides for grain storage. Others are entrepreneurial farmers, who bought for their use and to sell to other farmers within the villages.

On those with labels, it read three months (12 weeks) within which the grains must not be consumed after the application of the pesticides. Others have no labels at all. These were not subjected to laboratory test, as it was outside the aim of this research. This created a safety problem when a farmer decided to abort the storage process and take the grains to the market. The farmers would not usually tell the buyers of the applied pesticides and the duration they have to wait before consumption. If the prospective buyers take the grains home and consume, it could be fatal. This is the critical point of the storage, as there is no room to remove or minimise the hazards in the grains prior to consumption.

Figure 6.19: Common Pesticides in use.

DDVP - Dichlorvos (2,2-dichlorovinyl dimethyl phosphate (Sniper Brand)

Credit: Author, from the field.

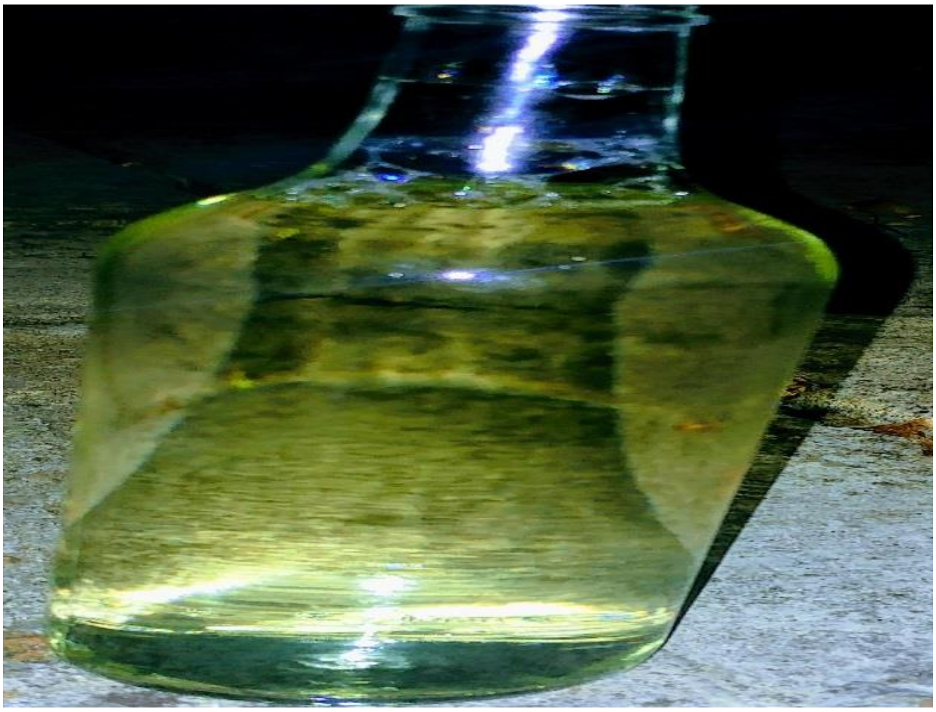


Figure 6.20: Common pesticides in use: Plane bottled “home-mixed”.

Sometimes a mixture of other pesticides for a more potent insect killer.

Credit: Author, from the field.

Figure 6.21: Common pesticides in use: those in tablet form.

Credit: Author, from the field.

6.3.8 Grain sales – Retail and wholesale (middlemen) effects or implication on farmers' income

Grains and other harvested farm produce are usually displayed openly in the market places (Figures 6.22 and 6.23). The sellers, who are either farmers themselves, former farmers or only businessmen and women, would sit near their goods while they wait for buyers. In some cases, the buyers meet the farmers in their homes.

There are implications for food safety and food security with these platforms.

1. The food items are open to all prospective buyers. The buyers would run their hands each time they come to buy or just window-shopping. Wherever the buyers came from is unknown to the sellers; therefore, they are potential contaminators.
2. Wastage is common. When the grains fall to the unpaved market floors, they are in many cases, unrecovered. Where the sellers decided to recover the grains, sands, stones, broken pieces of glasses or bottles and animal excreta are retrieved along with it into the bow of grains, hence contaminating the grains.

Figure 6.22: A typical grain retail market

Credit: Author, from the field.

Figure 6.23: A typical grain wholesale market – farmers, awaits buyers on weekly market days.

Credit: Author, from the field.

6.4 Interactions with key players along the grain supply chain

In this section, the need to interact with more stakeholders, especially those along the grain supply chain was necessary. The stakeholders were selected based on the vital roles they play in grain processing, handling, storage, marketing and utilisation. The objective of the interactions was to examine how the roles of the stakeholders along the grain supply chain affect the earning of the rural farmers. This was considered necessary because a large percentage of the grain supply to Nigerian cities and firms that utilise grains as raw materials are from rural areas.

6.4.1 Key person at the silo complex in Kogi State

The interaction with the key federal personnel at the site was recorded, transcribed and coded along with the following themes: the state of the grain silos, the concession arrangement, planned model for acquiring grains into the silos and the situation with the other similar grain silo complexes across the Nigerian States. Before the interaction began, however, there was an on-site observation of the site, basically looking at the site from the external perception of the activities going on there, the facilities available and the layout of the site.

6.4.1.1 The current state of the Federal Grain Storage Complex in Kogi State

The silos were empty, deserted with no substantial activity going on around the premises. The on-site observation verified and validated the data obtained via interactions with the key person at the complex as at the time of this research. The fact that the construction of the silos has been since 1993/1994 shows that the government may have run into challenges. Figure 6.25 shows the Word Cloud and ten most used word frequency as generated from the Nvivo analytical software. Critical issues identified with the project relates to funding, occasioned by administrative bottlenecks in handling government bureaucracy. As of 2017, the silo project has only reached about 45 per cent completion. Figure 6.24 shows the state of the silos in Kogi State as of 2017. The grain silo complex is sited in Zango, near Lokoja, Kogi State- Nigeria. See Appendix A for the full details of the interactions with the key personnel at the silo complex.

Figure 6.24: The grain silos complex

Above is the full view of the complex and the silos (below).

Credit: Author from the field.

Word	Length	Count	Weighted Percentage (%)
money	5	7	1.67
site	4	7	1.67
materials	9	6	1.43
project	7	6	1.43
fund	4	5	1.19
contract	8	4	0.95
contractor	10	4	0.95
country	7	4	0.95
president	9	4	0.95
problem	7	4	0.95

Figure 6.26: Word Cloud and most commonly used word frequency as generated with Nvivo

6.4.1.2 The government's grain purchase model

The government model plans to purchase the grains from the open market. This model is not different from that of the middlemen (major grain merchants). The problem with this model is that grain contamination could have occurred before the purchase at the open market. Secondly, traceability of the grains would be near impossible. Such grains do not meet the requirement of the GlobalG.A.P. standard and would not be accepted in the European markets because the pesticides being used on the grains are banned products in the UK and Europe, including the USA. This would make it extremely difficult to penetrate the market, even if the demand is available. If however, a model can adopt these standards effectively, the possibility of accessing any market in the world is extremely high.

6.4.1.3 The government concession plans with the private sector

Planned concession of the silos (World Bank & FMARD, 2014) to the private managers has been on since 2011, but the same concession notice resurfaced in 2014 following the failure of the government to secure a deal with any viable private sector. The reason why the government is unable to find private organizations to manage the silos could be because of the existing grain supply chain. It is erratic, and reports of grain contamination are frequent. In Kogi State, there could be a way to connect the rural institution to these silos.

6.4.1.4 How government source for materials for the construction of the grain silos

The materials for the construction of the silos are all imported from Italy and Spain, making it challenging to engage the local communities in the project. However, most of the materials have been paid for, some delivered and remain unused (the reason for the security men always on-site), or some have not been delivered because the funding is not available from the government to pay for the materials. In essence, a well-structured plan for the silo utilisation could encourage private firms to show interest in liaising with the government to get the Complex running. The silo complex has a capacity of 25,000 MT and good access road.

6.4.1.5 External conditions – as observed by the researcher

a) The grain silos complex has no signpost;

b) It has a low fence around the complex;

c) It was overgrown with weeds;

d) A handful of staff was seen on site, but no construction was taking place;

e) The complex does not appear functional from the external view.

6.4.1.6 Internal conditions – observed by the researcher

a) The grain silo complex was overgrown with weeds, bushes;

b) It was constructed with metal sheets;

c) Number of silos on-site as counted was ten;

d) The design of the Silos was such that the loading and unloading would be done mechanically.

6.4.1.7 Available facilities on site – as observed by the researcher

The few facilities found on-site, like storage silos itself, the weighing bridge was still under installation; Some restrooms (8 of them) for truck drivers that would be bringing grains to the complex has been built but not furnished. The laboratory building for grain testing has been constructed but not equipped. The site was under the security of two law enforcement officers, to protect the materials that were already on site.

6.5 Interaction with rural grain merchants (middlemen)

The interaction with the rural grain merchants revealed that they are just the first contact with the farmers, the actual intermediaries between the farmers and the firms (mostly consumers in neighbouring countries) were up to five. The farmers claimed they buy grains for someone else. The rural merchants claimed that they make a little profit by offering the farmers an amount lower than the amount handed to them by their 'boss' (the merchants who provided the fund for the purchase).

Once a certain quantity threshold has been obtained by the rural merchant (usually a full truckload of about 10 tons), the medium to major grain merchants comes to move the grains from the villages.

6.6 Interaction medium to major grain merchants (middlemen)

The interaction with some middle to major merchants revealed that the grains they acquired from the villages using the rural merchants, has a long way to go. The chain could be as much as five middlemen operating between the farmers and the primary consumers of raw agricultural produce, especially the manufacturing firms that use agricultural products as raw materials.

6.7 Interaction with the federal grain silo concession firms

The government's concession plan (World Bank and FMARD, 2014) of the silo complex to private managers failed to initialize. It was because, as confirmed, from two of the bidders who had shown interest in the concession, the scheme had no effective strategy for acquiring grains into the silos, except the plan to purchase from the open market, which hitherto has not been successful. Since the silo complex in Kogi State has been under construction for over two decades against the original completion target of two years, the private organisations (contractors) that bided for its management (two of them) failed to reach an agreement with the government.

6.8 Interaction with pesticide merchants

Pesticides are sold without control in all the communities. The merchants, as revealed from the interactions with two main dealers, the merchants receive the consignment from other top dealers in another long chain that links as far as China. The most common pesticide that serves as the 'all-purpose' pesticide was the brand called *Sniper*. The active ingredient of *Sniper* DDVP (Dichlorvos or 2,2-dichlorovinyl dimethyl phosphate).

DDVP, commonly effective against household and agricultural pests (Das, 2013). It was reported as nerve gas (agent) or chemical warfare agents (CWA) or both (Musilek and Kuca, 2015). Why is it attractive to farmers? According to Pohanish (2015), dichlorvos is effective against mushroom flies, aphids, spider mites, caterpillars, thrips, and whiteflies in greenhouse. It is also effective against outdoor fruits and vegetable crops. It can be used to treat a variety of parasitic worm infections in dogs, livestock, and humans. Dichlorvos can be fed to livestock to control botfly larvae in the manure, and it acts against insects as both a contact and a stomach poison. These are common grain insects in the communities, hence useful for the farmers, as much as it is dangerous on their health.

The effect of DDVP on pests go beyond the pests, and as far back as 1998, the EU had banned it from use (Food and Fairness Briefing, 2008). Its symptoms on exposure include irritation of the eyes, skin; miosis, ache eyes; rhinorrhoea (discharge of thin nasal mucus); headache; chest tightness, wheezing, laryngeal spasm, salivation; cyanosis; anorexia, nausea, vomiting, diarrhoea; sweating; muscle fasciculation, paralysis, dizziness, ataxia; convulsions; low blood pressure, cardiac irreg., targeting Eyes, skin, respiratory system, cardiovascular system, central nervous system, blood cholinesterase (NIOSH, 2018).

It is also known to affect cellular DNA (Rosenkranz, 1973) and interfere with the human nervous system (NRDC, 2011). The lethal dose of 15 mg/m3 and 13 mg/m3 for rat and mouse, respectively, over a 4-hour duration has been reported (NIOSH, 2018).

When the website of the National Food and Drugs Administration and Control (NAFDAC - the body that controls drugs and foods in Nigeria), records of approved pesticides were checked, *Sniper* brand of DDVP was not found. The reality was that no pesticide was found on the approved database of products, even though there are many branded and unbranded pesticides in the communities.

6.9 Interaction with retailers at the local markets

At the local markets, the grain retailers agreed to the use of Sniper brand of DDVP for in-store protection of the grains. When asked if they read the labels, none agreed to have read the labels. They claimed ‘everyone’ uses it by spraying all over the stores or drops in sacks before the grains are introduced into them. Others claimed to mix theirs with water to reduce the concentration before spraying them directly on the grains to avoid or prevent insect infestation.

6.10 Interaction with secondary grain processing firm

The reality was that the grains required by the flour mill contacted were sourced from approved producers in other countries, including the USA. Alternatively, the firm claimed to grow their maize where necessarily, an attempt that was not wholly successful. The demand for crucial grains in Nigeria is more than the supply. It is an excellent opportunity for farmers to thrive; however, the reverse is the case. Firms in Nigeria are sourcing for raw materials that could be cultivated in Nigeria.

Maize (corn) commands the similar versatility in processing as wheat (which has found its use in biscuits, bread and semolina) however, against the demand of 4.7

metric tons, Nigeria produces 0.06 metric tons (FMARD, 2016a). The report also has it that the demand for maize is more than supply, more so that the neighbouring countries demand as much as the demand in Nigeria. Against 7.5 million metric tons demand in Nigeria, current supply is 7.0 million metric tons, many of which are sold outside the country where profit as much as nine times the amount the farmers are offered at their homes. Whooping 6.3 million metric tons of rice is the demand for rice in Nigeria, but total production is 2.3 million metric tons (Ibid.), leaving a massive deficit of 4 million metric tons.

6.11 Analysis of results

Here, the results are further analysed to find the impacts of the empirical results on food safety, food security and rural economic development.

6.11.1 Impacts post-harvest processing and storage on food safety/security

Recall that some of the reasons European Union Rapid Alert System rejected some processed and semi-processed agricultural products that originated from Nigeria were related to foreign materials in the grains, as well as the use of dangerous pesticides that contaminates the grains(RASFF, 2016, p. 44). There is a clear link between the reasons for rejection and the way the grains are processed in Kogi State, Nigeria. Spreading by the hard shoulder definitely introduce stones and sand debris. Spreading at the car parks that are usually patronised by free grazing goats, sheep and even herds of cattle, potentially introducing animal excrement. The fact that the farmers have access to all kinds of pesticides means that chemical pollution of the grains is possible.

The type of storages identified in all the communities has the tendency to cause physical waste of the grains and losses due to mycotoxins, value loss as a result of insect infestations. All these affect food security, food safety and economic performance of the farmers.

6.11.2 Impacts on farmers economic performance

There are many constraints to the economic performance of the rural farmers in Kogi State Nigeria. First is the fact that the markets in most of the communities are opened on a weekly basis. It means that farmers are grossly limited as to when they can access the market. This affects the farmers' wellbeing, restrict economic performance and limit how much they can gain or contribute to the economy.

For farmers that do not store their grains, the next thing they do after drying would be to sell to the retailers at the local markets or to the wholesalers (middlemen) who meet with them in their homes or at the local market. The farmers bore transportation cost if they pull the grains a bit from the most rural locations to the nearest towns. Some farmers do this when the middlemen fail to show up, and the grains are beginning to deteriorate – or at least, there is a tendency to. They also do this because they try to catch a better price.

However, in all cases, the farmers do not dictate the price because of the imperfect nature of the market. Some of the farmers who were unable to find a middleman willing to negotiate with them at the market place in the nearby towns, would be subjected to further price reduction by the local middlemen, otherwise the farmers would have to transport the grains back to their rural communities again, same day, until another market day, which is usually on a particular day in the week.

For farmers who have storage structures, the grains are moved to the storage either after harvest (for maize, the dry cobs are stored, for rice, the threshed grain is stored) or after initial processing (in which case, both grains are stored without dehusking or threshing). How do the farmers faired compare to the world’s poverty benchmark, whether they choose to store the grains in their storage systems or sells them off immediately? That is the focus of the next section.

6.12 Analysis of the storage systems, income and poverty benchmark

The data in this section were generated with the questionnaire administered to the farmers. The annual income of the participating farmers, which represents the probable annual income of the farmer population in the State, is compared with the poverty benchmark of 2017. The relationship between farmers' annual earnings and poverty benchmark could be visualised easily using line graphs. An Analysis of Variance (ANOVA) was also performed on each storage system type identified, comparing the annual income of the farmers with similar storage systems. A comparison was made between the farmers' annual income in 2017 and the 2017 poverty benchmark. An ANOVA was also carried out on the mean annual income of farmers from each group (the different storage types) and the mean storage length from each of the groups. Note that for concise comparison, farmers that do not store their grains (that is, farmers that sell off their grain immediately after harvest), has been added to the list of "storage types" as the "No-Storage" farmers. Table 6.9 shows the list of the storage types identified, the average income of the farmers with similar storage systems, length of storage, and how their earning compares with the 2017 poverty benchmark. The line graphs comparing the economic performance (annual earnings) of each storage group/type with the poverty benchmark can be found in appendix C.

The performance of all the farmers in terms of annual income as compared to the 2017 global poverty benchmark with the middlemen in place and without adherence to global standards shows that only four (4) farmers out of the 300 (representing 1.33%) earned above the global benchmark. These four farmers belong to the group of farmers that first park their grains in woven bags before storing them in any available spaces at their homes or in private storage (the storage type adopted are highlighted in Table 6.8). For a full table showing the earnings of each farmer, see Appendix D.

The duration of storage is limited by the storage type adopted. That is, the typology of grain storage systems has some implications on the length of the storage period. Farmers who stored up their grains up to between 18 to 24 weeks before sales, made the most profit at the end of the year. Storage up to 24 weeks could have yielded an even better benefit, but only a very few farmers could wait for that long without the high possibility of grain deterioration while in-store because of high temperature and humidity – an ideal environment for mould and insect attack.

Table 6.9: Summary of storage types and the farmers' annual income compared to the poverty benchmark in us dollars

Storage Groups/type	Storage type descriptions	Mean Annual Earning (Naira - ₦)	Mean Annual Earning ($)*	The 2017 Poverty Benchmark ($)	Number of Farmers in the category	Mean Length of Storage (Weeks)
1	Concrete blocks with zinc roofs (pics or woven bags)	166667	476.2	693.5	6	18.0
2	Open spreading of grains at home without bagging	67143	191.8	693.5	14	5.3
3	Woven bags then stored in any available space at home	112374	321.1	693.5	97	12.0
4	Mud walls and thatch roofs	56975	162.8	693.5	80	7.2
5	Thatch walls and thatch roofs	57274	163.6	693.5	55	8.1
6	No-storage farmers - grain sold shortly after harvest	31115	88.9	693.5	48	0.0

*A dollar is N 350

Figure 6.27 shows the performance of the farmers when compared to the 2017 poverty benchmark with the middlemen in place and without adherence to the global grain standard. Base on the analysis of the results, when the middlemen are removed, and the grains are produced to the global standard. Figure 6.28 shows the comparison between the 2017 poverty benchmark and a probable performance of the farmers in terms of income at the local, national, African and international markets.

Up to four middlemen were identified between the farmers and the end consumers/firms in this study. The implication of bypassing the middlemen is that more than 90 per cent of the farmers in Kogi State will earn above poverty benchmark, even with their current production volume.

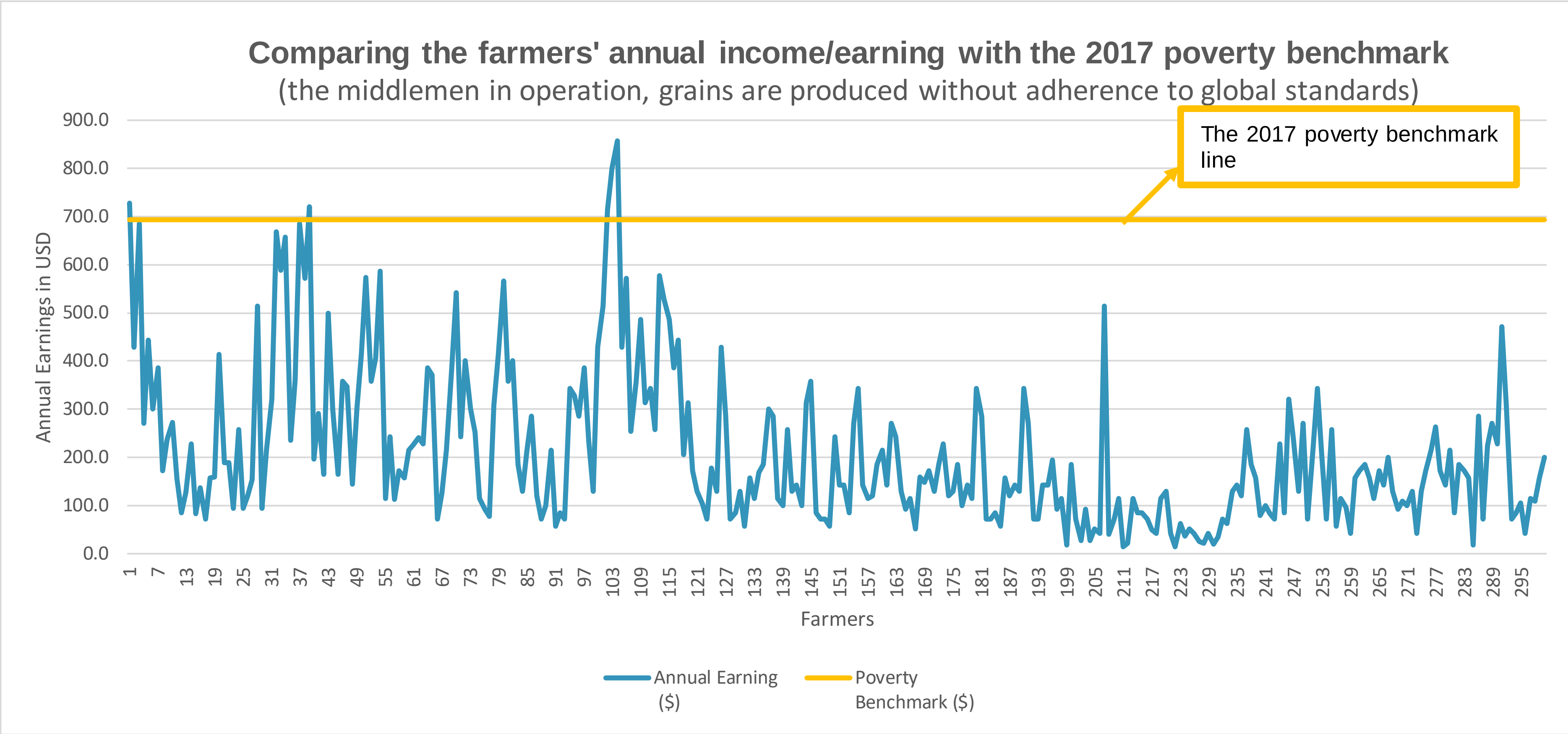


Figure 6.27: Farmers earning in 2017 compared to the 2017 poverty benchmark with the middlemen in place and with no global standards.

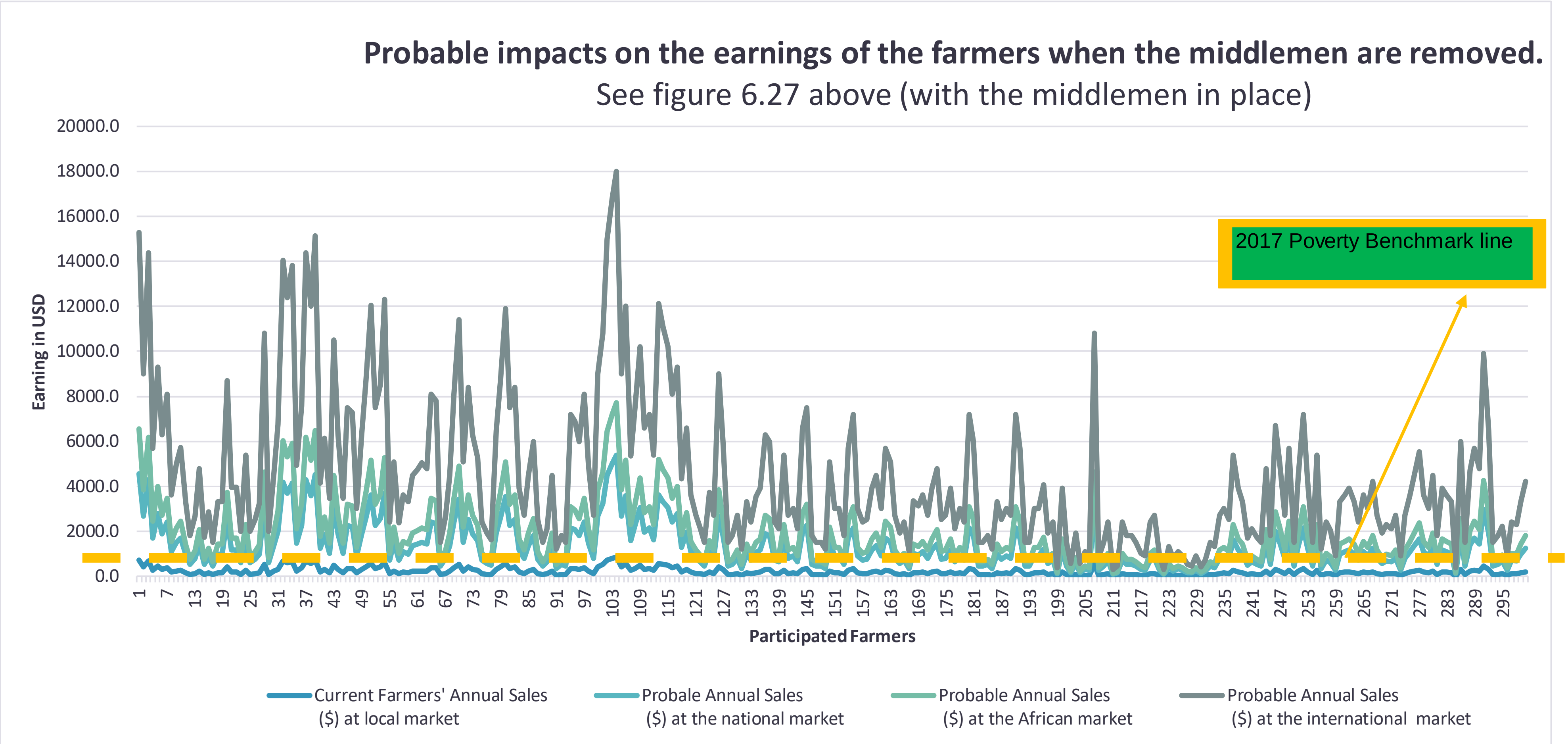


Figure 6.28: Impacts on the annual earnings of the rural farmers at local, national, African and other international markets with the middlemen removed and grain products standardized to the global checklists. See Figure 6.27 above (with the middlemen in place).

6.12.1 Economic implication of the middlemen on the farmers' income

It was clear that the farmers are earning a little from their farm work. The equation below estimates the amount the farmers are paid by the local grain merchant (the first middleman to patronise the rural farmers).

$$k = \frac{\boldsymbol{p}}{\epsilon}$$

k = the amount paid to farmers for x kg of grains;

p = amount paid by the manufacturing firms to the last middleman (on average, the 4^{th} middleman) that delivers the grains to the firms for the same kilograms of grains;

ϵ = is a number between 6.28 and 21. This denotes how much more the farmers could earn if the middlemen were removed. These values were obtained based on market values of the same quantity of grains at the local, national, African and international markets. It means farmers would earn up to 21 times their current earning if they can access the market without the middlemen and with high-quality grains.

Figure 6.29 describes a typical impact of the middlemen along the supply chain on the income of the rural farmers and the manufacturing firms or significant consumers in the cities in Nigeria and outside Nigeria.

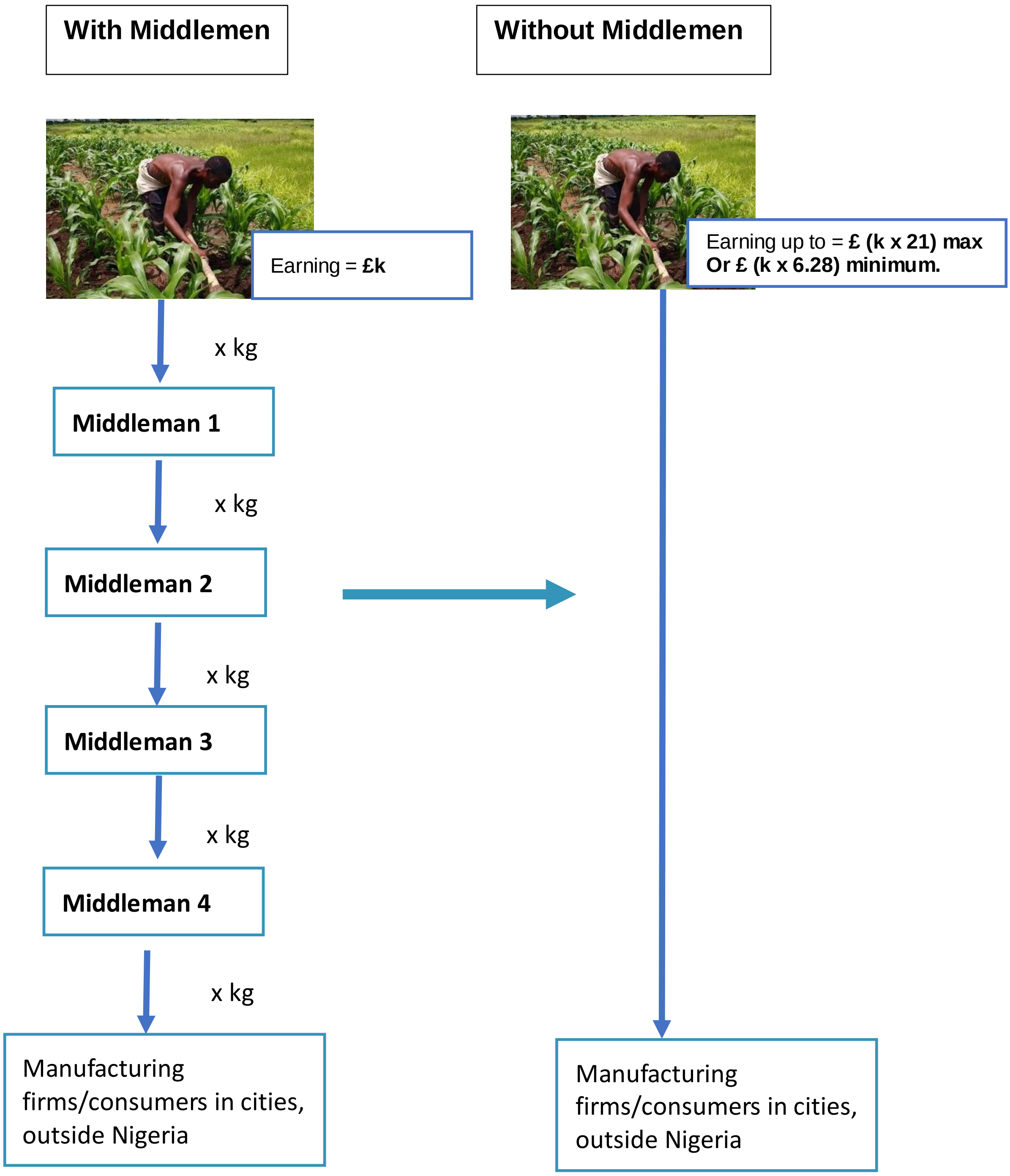


Figure 6.29: The impacts of the middlemen along the food supply chain on the farmers' income.

6.12.2 Analysis of variance (ANOVA) – proofing or disproving the hypothesis

Table 6.10 is the analysis of variance (ANOVA) indicating the variations that exist between farmer's mean annual income and the length of storage for the types of storage systems identified in Kogi State.

Table 6.10: Showing the analysis of variance (ANOVA), indicating the variation between farmers' mean annual income and the Length of Storage for the storage methods.

ANOVA: Single Factor						
SUMMARY						
Groups	*Count*	*Sum*	*Average*	*Variance*		
Annual Earnings ($)	6	1404.4	234.0666667	19821.53467		
Length of storage (Weeks)	6	50.6	8.433333333	37.36266667		
ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	152731.2033	1	152731.2033	15.38163985	0.002857333	4.964603
Within Groups	99294.48667	10	9929.448667			
Total	252025.69	11				

6.12.2.1: Approving or disproving the research hypothesis.

Recall the research hypothesis as set out in chapter one:

(Null): Processing and storage systems adopted by the rural farmers in Kogi State do not influence the farmers' income.

(Alternative): Processing and storage systems adopted by the rural farmers in Kogi State influence the farmers' income.

For an alternative hypothesis to be accepted or the null hypothesis to be rejected, the f-value must be higher than the f-critical. Also, the p-value must be less than the level of significance chosen. In this case (Table 6.9), the f-value is higher than the f-critical value in each of the storage groups. Similarly, the p-value is less than the level of significance (the alpha value) of 0.05 selected for this study. This is also true for the differences that exist in the earnings of the farmers with the same storage types (group). Since the f-value, f-critical value and the p-values in *within the same storage* group and *between* storage types (groups) identified, it fulfils the conditions required to reject the null hypothesis. Therefore, the null hypothesis is at this moment rejected with 95 per cent confidence. In other words, farmers' income in Kogi State, Nigeria, is greatly influenced by the storage systems the farmers adopted. Since the length of the storage process is determined by the storage type, the alternate hypothesis (H1) is, therefore, correct.

6.13 Chapter summary

This chapter has presented and discussed the results of the empirical study. It has shown that the typology of storage structures among rural farmers in Kogi State – Nigeria, encourages dangerous grain waste and losses. The study has identified the various challenges confronting the rural farmers, the purposive actions to protect their grains from deterioration, though with severe consequences on food safety and limitation to market. Figures 6.27 and 6.28 showed the enormous economic impact that accesses to the right market could have on the farmers, especially when the middlemen are bypassed.

The next chapter, the research needs to understand the requirements of the global farm assurance and food safety standard and compare the results already presented to the standard checklist. The reason for doing this is to understand where the current practices in Kogi State and Nigeria stand in the checklist of the assurance and food safety standard. As has been presented, had it been that the challenges in the communities in Kogi State are that of weak storage structures alone, it could have been easier to suggest an alternative storage system that is affordable to the farmers. However, the problems in the communities is a direct consequence of weak rural institution.

CHAPTER SEVEN

FARM ASSURANCE (GLOBALGAP) AND BRC GLOBAL FOOD SAFETY STANDARD REQUIREMENTS

7.0 Introduction

In this chapter, the research presents two vital information: one is the requirements for certification of the farm assurance institution (in this case, GLOBALGAP) and the requirements for food safety certification (in this case, the British Retail Consortium - BRC); the second information is to compare the results obtained and presented from Kogi State to these requirements and find out if an alternative model would be required and how this alternative model can improve the welfare of farmers and consumers.

While the GlobalG.A.P. focuses on farm assurance, ensuring Good Agricultural Practices from the farm up to just before the point of storage; the BRC global standard focus on the point of storage and thereafter. As this research focuses on post-harvest processing and storage of grains (maize and rice), it is essential to consider these in the checklists of the standards. The post-harvest process, drying and storage are considered within the context of hazards to food safety. Both standards rely on the principle that is based on the hazard analysis and critical control points or HACCP.

7.1 Hazard Analysis and Critical Control Points (HACCP)

The general definition of hazard is anything biological, chemical or physical, that has the potential to cause harm to the health of the consumer. The HACCP system was developed for harmonising international food standards by the Codex Alimentarius Commission, (established in 1963) of the Food and Agriculture Organization (FAO) and World Health Organization, to eliminate or minimise food hazards (FAO, 1997).

It helps to identify hazards, the critical control points, to ensure food safety and create wider consumer acceptability. It can be adapted to all types of food business throughout the food chain – from the farm to the table, eliminating or minimising food hazards and their associated risks.

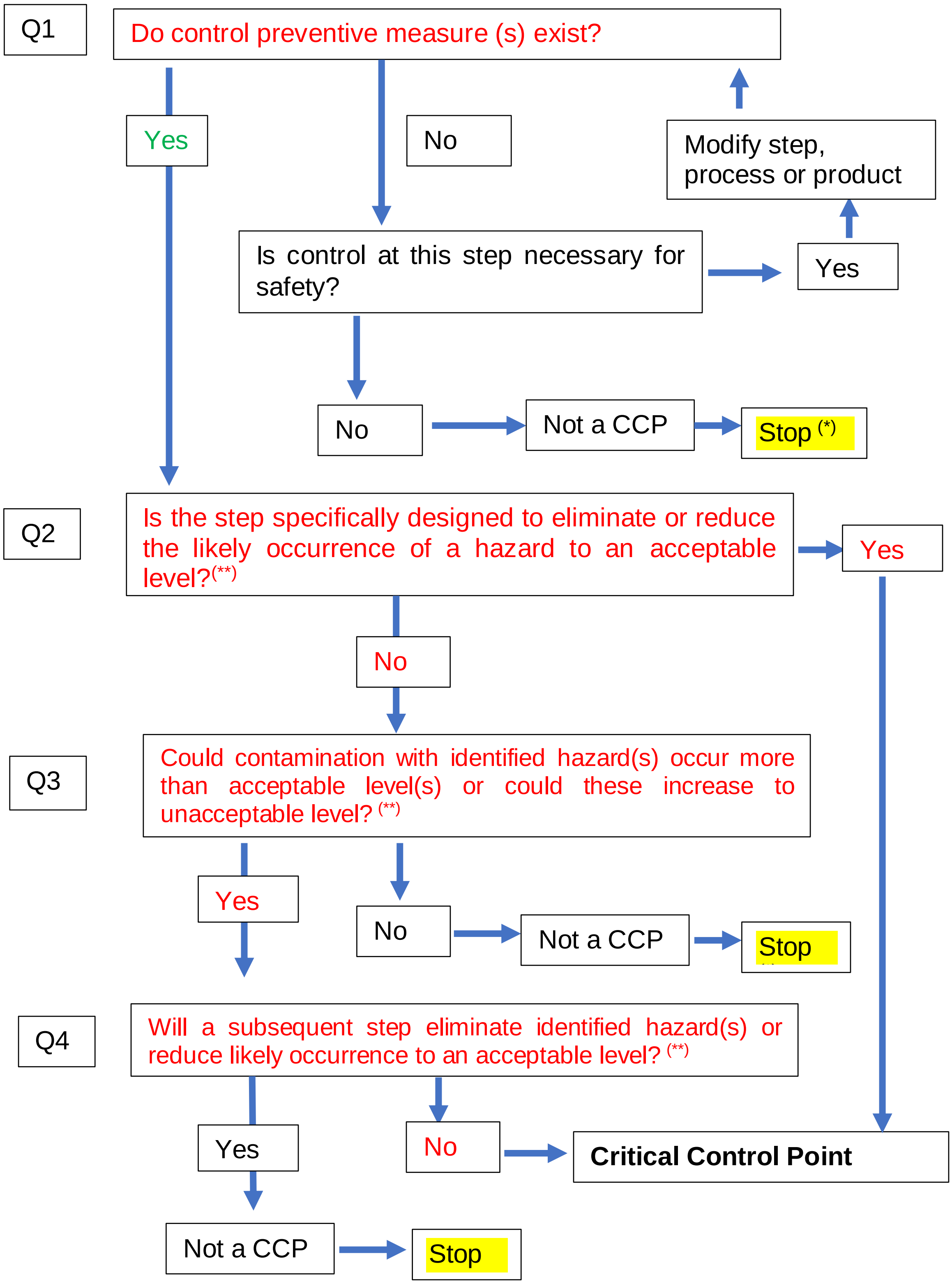
For this study, The Farm, Cropped, and Pest Management based standard requirements of the GlobalGAP was chosen to apply from the farm to just before storage point. Then the BRC Global Standard Food Safety would apply at the storage point.

The purpose of administering two world-recognized standards is to increase the market share of the grain produced in the rural communities in Kogi State, Nigeria. No single certification covers all the requirements from farm to when it would be ready for consumption, although some standard bodies have various versions for critical stages along the supply chain.

7.1.1 The HACCP plan - determining the Critical Control Point (CCP)

The process of identifying a critical point follows the concept in Figure 7.1, as provided by FAO (1997). Therefore, for this case, each step from the farm to the storage or the point of consumption are compared to the decision tree to determine if a CCP exists.

The research analysed the CCPs to work out how the requirements of the farm assurance and food safety standards can be adopted into the production, pre-storage processing, storage and marketing systems for grains produced in Kogi State, Nigeria. The analysis involves evaluation of the adoption of the standards' checklists based on how things are, as the researcher has understood it from the empirical results and other published work.



Notes: * Proceed to the next identified hazard in the described process
(**) Acceptable and unacceptable level needs to be defined within the overall objectives in identifying the CCPs of HACCP; Q1-Q4 are questions to ask at each step in determining the CCPs

Figure 7.1: Identifying Critical Control Points (CCPs) to food safety by asking relevant safety questions

Credit: FAO (1997)

Based on the empirical evidence, the CCP was identified to be at the point of storage. This is because the hazards introduced before the point of storage can no longer be eliminated before the grains are sold to the public for consumption. For the local consumption, any further processing of the contaminated grains is unlikely to reduce or eliminate the hazards. As identified from the fieldwork, and support from literature such as (RASFF, 2016, p. 44) the grains are often contaminated with glass fragments, rodents' excrement, dead insects, elevated levels of chemical contaminants used in fumigation, such as aluminium phosphide, dichlorvos, dimethoate, trichlorphon, cyhalothrin, microbes, such as salmonella, aflatoxins, and mould growth.

However, preventive measures can reduce or eliminate contaminations. A curative measure after the contamination may be expensive, but a preventive measure could be a new processing model involving both the training of the rural farmers on good agricultural practices and the institutional framework that prevents the contamination from taking place. In this instance, and as always, prevention is better than cure. In the next section, the study evaluates the requirements of the farm assurance scheme and food safety standards.

7.2 The GlobalGAP Farm Assurance

According to the GlobalGAP mission statement (GlobalG.A.P Report., 2018), there is no easy answer to the natural and human-made challenges facing the planet earth, however, through the food supply, the welfare of food producers, agricultural standards could be improved, thereby opening markets for farmers, which they could never have reached on their own". The mission statement summarises the core objective of the food assurance scheme, and farmers and consumers are at the forefront. The scheme blends consumer requirements with the Good Agricultural

Practices expected of the producers (farmers) for a mutual benefit. The farmers benefit in economic terms because they have a safe product to sell to a broader market while the consumers obtain the value for money for the assurance of Good Agricultural Practices in the course of the production of the grains.

7.2.1 Conditions for certification and how Kogi State compares

To obtain GlobalGAP certification, producers must undergo an audit by a certification body recognised by the GlobalG.A.P. scheme. The essential documents for obtaining certification are the list of control points and compliance criteria, and the check-list for the auditors. Table 7.1 shows how the post-harvest processing and storage in Kogi State – Nigeria compares with the checklist of this scheme.

The audit is the procedure which determines whether the producer is granted the GlobalGAP certificate. The control points are divided into three categories: the Major Musts, the Minor Musts, and Recommendations. Producers must satisfy all the major musts and 95% of the minor musts; the recommendations do not constitute formal criteria for elimination but essential for good practice and improved compliance. The content of the requirements in the "Control Points and Compliance Criteria" document fluctuates between different rationales. Specific points require producers to use reflexive feedback on how they work in order to implement good practices. Others are based on risk assessment, introduction of risk control procedures, to identify and make an inventory of the components used in the production process to keep records of activities and traceability. Finally, yet others deal with compliance with the local laws. In this study, the feedback on how the current practice complies with the existing and current checklist was used.

Table 7.1: GLOBALGAP All Farm Base Module – Control Points and Compliance requirements

NO.	Control Point	Level	Compliance of the farms and farmers in Kogi State
AF. 1	SITE HISTORY AND SITE MANAGEMENT		Nil
	Site History	MAJOR MUST	Nil
	Site Management	MAJOR MUST	Nil
AF. 2	RECORD KEEPING AND INTERNAL SELF-ASSESSMENT/ INTERNAL INSPECTION	MAJOR MUST except for farm workers receiving annual hygiene training	Nil
AF. 3	HYGIENE	MINOR MUST except for the farm's hygiene procedures which is a MAJOR MUST	Farmers' individual hygiene
AF. 4	WORKERS' HEALTH, SAFETY AND WELFARE		Nil
	Health and Safety	MINOR MUST	Nil
	Training	MINOR MUST except for workers handling or administering medicines and chemicals having the competence and qualification which is a MAJOR MUST	Nil
	Hazards and First Aid	MINOR MUST	Nil
	Protective Clothing/Equipment	MAJOR MUST	Nil
	Worker Welfare	MAJOR MUST except in the area of two-way communication between management and workers on issues related to workers' health, safety and welfare which is a MINOR MUST	Nil
AF. 5	SUBCONTRACTORS	MAJOR MUST	Nil
AF. 6	WASTE AND POLLUTION MANAGEMENT, RECYCLING AND RE-USE		Open-air disposal and burning
	Identification of Waste and Pollutants	MINOR MUST	Nil
	Waste and Pollution Action Plan	MINOR MUST except in the areas of keeping the site tidy and orderly, which is a MAJOR MUST. Providing information about the use of organic waste composted on the farm and disposal of wastewater generated from multiple cleaning, the disposal of which not having health, safety and environment issues, which are on RECOMMENDED LEVEL.	Nil
AF. 7	CONSERVATION		Nil
	Impact of Farming on the Environment and Biodiversity (Cross-reference with AB. 9 Aquaculture Module)	MINOR MUST but the enhancement of the environment for the benefit of the local community, and flora and fauna is RECOMMENDED, including the minimisation of the impact of the agricultural activity on the environment.	Nil
	Ecological Upgrading of Unproductive Sites	RECOMMENDED	Nil
	Energy Efficiency	MINOR MUST and the plan to improve on energy efficiency from renewable energy sources and minimising the use of non-renewable energy which is on RECOMMENDED LEVEL.	Nil
	Water Collection/Recycling	RECOMMENDED	Nil
AF. 8	COMPLAINTS	MAJOR MUST	Nil
AF. 9.	RECALL/WITHDRAWAL PROCEDURE	MAJOR MUST	Nil
AF. 10	FOOD DEFENSE (Not Applicable for Flowers and Ornamentals and Plant Propagation Material)	MAJOR MUST	Nil
AF. 11	GLOBALG.A.P. STATUS	MAJOR MUST	Nil
AF. 12	LOGO USE	MAJOR MUST	Nil
AF. 13	TRACEABILITY AND SEGREGATION	MAJOR MUST	Nil
AF. 14	MASS BALANCE	MAJOR MUST	Nil
AF. 15	FOOD SAFETY POLICY DECLARATION (Not Applicable for Flowers and Ornamentals)	MAJOR MUST	Nil
AF. 16	FOOD FRAUD MITIGATION (Not Applicable for Flowers and Ornamentals)	MINOR MUST	Nil

Casey (2009) posited that GlobalGAP's existence is because of three converging shifts: 1) public authorities transferring responsibility for food safety and food quality over to the [private] food industry 2) the international diversification of sourcing which has led to the retailers wanting additional guarantees, and 3) the change in consumer attitudes towards food.

Since the first producer was certified in 2001, there has been a steady increase in the number of certified producers up to the current level of 190, 255 (GLOBALGAP News, 2018, p. 5).

7.3 The BRC Global food safety requirements and how current practices in Kogi State compares with the requirements

The British Retail Consortium (BRC) was designed to specify the safety, quality and operational criteria to be in place by food manufacturing firms, to ensure legal compliance to safety and to protect the consumers. The emphasis of the BRC Global Standard for Food Safety has been on management commitment, a Hazard Analysis and Critical Point (HACCP) -based food safety programme and supporting management system. Monitoring has been keenly directed towards the implementation of good manufacturing practices within the production areas with the increased emphasis on areas which have traditionally resulted in recalls and withdrawals – like the label and packing management (BRC, 2015, p. 4).

The certification will only apply to products that have been manufactured or prepared at the site where the audit has taken place and will include storage facilities that are under the direct control of the production-site management (BRC, 2015, p. 5). The Standard requires the development and compliance with the following fundamental requirements (BRC, 2016, p. 6):

7.3.1 Fundamental BRC requirements

Some of the standard requirements have been designed as "fundamental" requirements for undertaking audits and certifications. Audits may be undertaken in a single visit - as either an announced or unannounced audit (BRC, 2015, p. 9), with the first part bothering on good manufacturing practices and the second part deals on records, systems, documentation and procedures (usually an announced audit). These requirements relate to systems that are crucial to the establishment and operation of adequate food quality and safety firms. The fundamental requirements are:

- Senior management commitment and continual improvement -the site's senior management are required to demonstrate that they are fully committed to the implementations of the requirements of the Global Standard for Food Safety. This can be made evident by the investment in resources required for demonstration of the commitment to achieving the requirements and to processes which facilitates continual improvement of the food safety and quality management.
- The food safety plan – the company, shall have a fully implemented and effective food safety plan based on Codex Alimentarius HACCP principles. It shall provide a focus on the significant product and process food safety hazards that require specific control to assure the safety of individual food products or product lines.
  - Internal audit – the company shall be able to demonstrate it verifies the practical application of the food safety plan and the implementation of the requirements of the Global Standard for Food Safety. The organisation shall provide details of its structure, management policies and procedures that provide a framework by which it would achieve the requirements in the

Standard. That is, a robust institutional framework to help achieve the purpose is required.

- Management of suppliers of raw materials and packaging – a sufficient supplier approval and monitoring system to ensure that any potential risks from raw materials (including packaging) to the safety, authenticity, legality and quality of the final product are understood and managed. The underlying environmental and operational conditions in a food business that is necessary to produce safe food, covering ethical manufacturing and good hygienic practice. The core facilities needed to achieve these must be available.
- Corrective and preventive actions – the site shall be able to demonstrate that it uses the information from identified failure in the food safety and quality management system to make necessary corrections and prevent a recurrence.
- Traceability – the site shall be able to trace all raw material product lots (including packaging) from its suppliers through all the stages of processing and dispatch to its customers and vice versa.
- Layout, product flow and segregation require that the factory layout, flow of processes and movement of personnel shall be enough to prevent the risk of product contamination and to comply with relevant legislation.
- Housekeeping and hygiene – housekeeping and cleaning systems shall be in place which ensures appropriate standards of hygiene are always maintained, and the risk of product contamination is minimised.
- Management of allergens – the site shall have a system for the management of allergenic materials which minimises the risk of allergen contamination of products and meets legal requirements for labelling in the country of sale.
- Control of operations – the site shall operate to documented procedures and work instructions that ensure the production of a consistently safe and legal

product with the desired quality characteristics, in full compliance with the HACCP food safety plan.

- Labelling and pack control – the management controls of product labelling activities shall ensure that products will be correctly labelled and coded.
- Training: raw material handling, preparation, processing, packing and storage areas – the company shall ensure that all personnel performing work that affects product safety, legality and quality are demonstrably competent to carry out their activity, through training, work experience or qualification.

Other requirements include a clear organizational structure and lines of communication to enable effective management of product safety, legality and quality, is required, including the food safety and quality manual, documentation control, record completion and maintenance, raw material and packaging acceptance and monitoring procedures, management of suppliers of services and management of outsourced processing and packaging.

Some of the requirements related to specifications, control of the non-conforming product, complaint handling, management of incidents, product withdrawals and product recall, customer focus and communication. Some bothers on the locations and the actual structure for storage such as, site standards (size, location and construction), security systems, building fabric, raw material handling, preparation, processing, packing and storage areas, utilities – water, ice, air and other gases, suitable equipment, maintenance programme and staff facilities.

The fundamental requirements also include chemical and physical product contamination control, raw material handling, preparation, processing, packing and storage areas, foreign-body detection and removal equipment, waste and waste disposal, management of surplus food and products for animal feed, pest control, storage facilities, dispatch and transport – people involved, and vehicles/equipment used. Information about the actual product design/development, product labelling, product authenticity, claims and chain of custody is required. Others are product packaging, product inspection and laboratory testing. The product release is allowed when all agreed procedures have been followed. The quantity – weight, volume and number control, calibration and control of measuring and monitoring services must be in place. The personal hygiene, raw material handling, preparation, processing, packing and storage areas, medical screening and protective clothing and such measures to ensure safety must be followed to the end.

Table 7.2 shows the level of compliance to the BRC standard of the post-harvest processing and storage as obtained in Kogi State. Table 7.3 shows the auditor checklist and site self-assessment components.

Table 7.2: BRC Fundamental requirements.

S/N	BRC Self-Assessment	Compliance level based on empirical results from Kogi State
1	Foreign body control	Not available
2	Transport control measures	A one-for-all public transport
3	Traceability records	Not available
4	HACCP documentation	Not available
5	Final product procedures	Not available
6	Raw material supplier approval	Not available
7	Raw material specifications	Not available
8	Factory facilities	Not available
9	Hygiene procedure and records	Not available
10	Quality systems	Not available
11	Specific handling requirements	Not available
12	Accreditation	No accreditation in place currently
13	Product recall procedures	Not available
14	Pest control	Yes – however, with dangerous pesticides used indiscriminately
15	Hygiene monitoring systems	Not available
16	CCP monitoring and control	Not available
17	Staff training	Not available
18	Personal hygiene procedures	Farmers’ personal hygiene

Table 7.3: BRC Global Standard for Food Safety – Issue 8 – Auditor checklist and Site Self-Assessment Tool.

S/N	BRC Checklist (requirements)	Compliance level based on empirical results from Kogi State
1	Senior Management Commitment	Not Available
2	The Food Safety Plan – HACCP	Not Available
3	Food Safety and Quality Management System	Not Available
4	Site Standards – size, location, construction and maintenance.	Not Available
5	Product Control – product design and development procedures shall be in place for new products or processes and any changes to product packaging or manufacturing processes to ensure that safe and legal products are produced	Not Available
6	Process Control – the site shall operate to procedures and work instructions that ensure the production of a consistently safe and legal product with the desired quality characteristics, in full compliance with HACCP food safety plan	Not Available
7	Personnel – competent to carry out an activity, through training, work experience or qualification.	Not Available
8	High-Risk, High-Care and Ambient High-care Production risk zones for sites where handling constitute a high risk	Not Available
9	Requirements for traded products	Not Available

Credit: Compiled from BRC, 2016.

Without the full compliance with the checklists and auditor checklists, no certification is issued. Even when certification has been issued, it can also be withdrawn if at any time there is a breach in compliance with any of the fundamental requirements. As seen from the empirical results presented, these fundamental requirements are lacking in the study location.

7.4 Benefits of obtaining the global certifications with GLOBALGAP and BRC standards

There are primary benefits of acquiring a global certification on food and its associated products. In today's world, retailers and consumers require specific standards. In some cases, they are entitled by law, to know all there is to know about any product, to boost consumers' confidence in the quality and safety of the food products. Therefore, having the GLOBALG.A. P and BRC Global food safety certification connotes a new world of doing business with several firms along the food supply chains. There are manufacturing firms in Nigeria that do not patronise locally produce grains because of safety issues among grain producers in Nigeria. These firms have large markets beyond Nigeria. It is, therefore, not surprising that the USA is set to supply 128,000 metric tons of wheat to Nigeria in 2019 (USDA-FAS, 2019). It could have been that Nigeria's grains are heading elsewhere around the world. However, an institutional framework is required, strong enough to allow the adoption of HACCP principles which are fundamental in both standards. Once this is achieved, it would yield benefits in short and medium-long terms for the communities as shown in Figure 7.2.

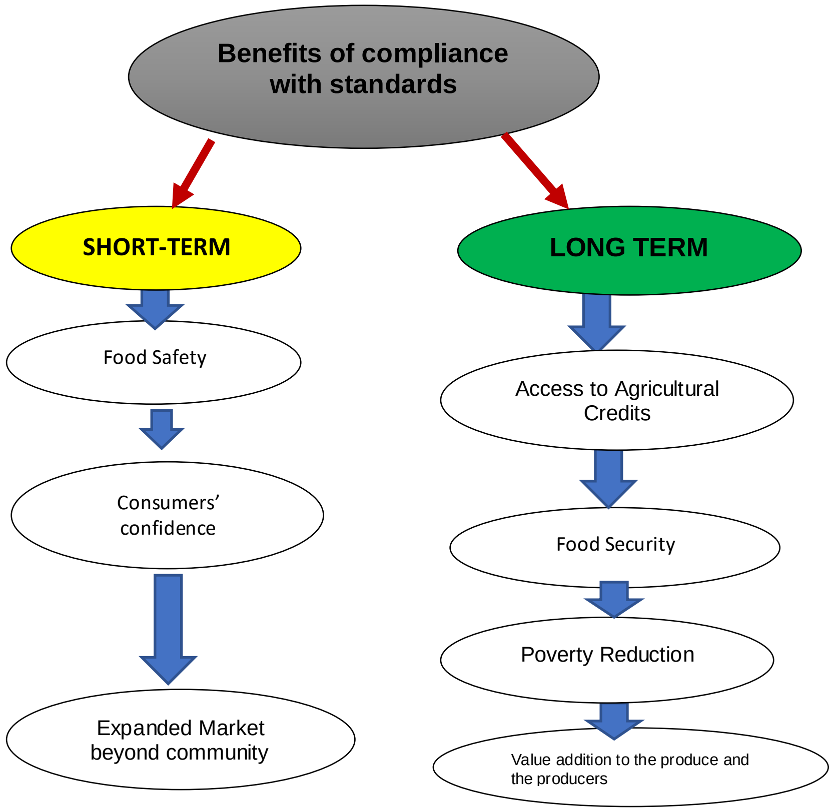


Figure 7.2: Potential short and long-term benefits of compliance with the standard in the model

Generally, certification adds value to the products, in the case of this research, the grains and allows producers to gain access to both local and global markets, suppliers, retailers and consumers. Also, the rigorousness of the requirement for the certification helps to reduce exposure to food and product risks, improves the efficiency of farm processes, management and general movement of farm produce. The need for recalls may arise. Therefore, identification and traceability, which are critical requirements for these certification stamps, helps better coordination between suppliers and producers or between firms and consumers.

7.5 Chapter Summary

In this chapter, the research has outlined the requirements of the farm assurance and food safety standards that can stand the food quality demand anywhere in the world. The post-harvest processing and storage activities in Kogi State fell grossly short of these requirements. Therefore, an alternative model is required. For the development of the alternative model to meet the requirements of the farm assurance scheme (GLOBALGAP) and the BRC Global food safety standards as recognized, there is a need to consider the lessons from the case study countries where these standards are in operation successfully, and other case study countries that have challenges in food safety, food security and economic development of rural farmers, similar to that of Nigeria but have improved or ultimately come out of these challenges. In the next chapter, the research combines the recommendations from the literature on the issues of food safety, food security with the empirical results, to develop an alternative model that would benefit the rural farmers economically and improve the food safety and food security in Kogi State, Nigeria.

CHAPTER EIGHT

ALTERNATIVE MODEL DEVELOPMENT

8.0 Introduction

In this chapter, the research combines the lessons learnt from the case study countries and those from the empirical study to develop an alternative model, to solve the identified challenges in Kogi State, Nigeria. The goal is to develop a robust rural institution that ensures food safety, food security and rural economic development of the rural farmers. This chapter will address the objective four of the research, which is to develop models to support rural economic development whilst ensuring food safety, food security and encourage waste minimization. The concept of the alternative model is as summarized in Figure 8.1.

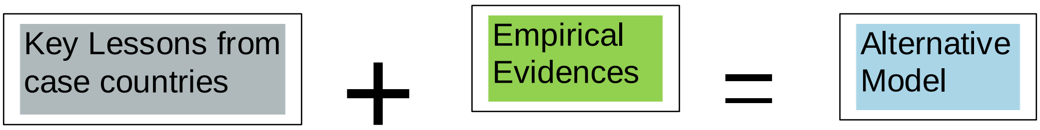


Figure 8.1: Combining the recommendations in literature with the empirical results to develop an alternative model.

For rural farmers in Nigeria to thrive in the current global economic climate where food safety is of paramount importance, a comprehensive solution within a robust rural institution is of immense importance. The solution would ensure that the food quality demands of the consumers are met, not only for economic benefits but also for the wellbeing of the people in Nigeria. In achieving this, goods and services must be presented in their best form possible, for the right market at the right time and extensively utilising technology for ease of access. This would be possible where there is a strong institution in place, first to train the rural farmers continuously on Good Agricultural Practices (GAP) from the farm to the point of utilisation. The model should be able to connect the farmers to the needed stakeholders for economic purposes. Such an institution should also be able to keep the records of the farmers' activities year-in and year-out, for the purpose of building agricultural credits scores.

8.1 How models are developed – Theoretical background

All developmental projects begin with developing a model based on empirical data. Theoretical modelling is a solid foundation for community development projects. According to Gladun & Cybern (1997, p. 7), hypothetical models are often used as the basis for decision making, diagnosis, or prediction which involves constructing a model of the object of study in cases where there is no reliable knowledge of some of its essential characteristics and the acquisition of such knowledge by direct observation is difficult or outright impossible.

Technically, a model is an illustration or representation of an object, an idea, or a process, system or structure that describes/explain some phenomena that ordinarily cannot be explained directly. David, Gail and Thapelo (2002) described a scientific model as a learning tool, a representation of abstract concepts …for prediction and correlation. It involves finding the data that are most important in predicting behaviour, a phenomenon or concept or a situation. In developing any model, there are iterative steps to follow. First, the objectives are first outlined, as have been done in Chapter One. Secondly, the problems to be solved are identified as has been done with the presentation of the empirical results. Thirdly, parameters are obtained from the field, upon which the model would be designed. The parameters from the field have been obtained and presented. In this case, the farmers produce grains mainly, but the post-harvest and subsequent storage conditions fall short considerably of the expected global standard, hence militating against market share and profit. The grains were not safe following the use of dangerous pesticides. The safety of the grains from the communities in Kogi State could improve consumers' confidence, resulting in the wide-ranging market, and enhanced economic prosperity of the rural farmers.

Model development must have plans to protect the environment, admitting "the future trend" recommended by Baines (2010, pp. 320-321). The need for a recognised certification and compliance with standards in today's world cannot be over-emphasised. Therefore, the future trend secures a place for the environment and the welfare of the employees [in this case, farmers] working in food manufacturing [or production] firms. The Global Food Security Index report, GFSI, in 2017, introduced similar parameters among the indicators that determine the food security of countries. It specifically seeks to understand the impact that these risks [the growing threats to food security posed by climate change and natural resource depletion such as natural assets—land, water and oceans] …will have on global food security (The Economist Intelligence Unit, 2017, p. 4). Haruna and Umar (2011, p. 63) also posited the need to include the preservation of the environment while increasing agricultural production through the adoption of new technologies. Therefore, Yield, Planet (environment), Profit and People (the welfare of the people) - (Y3Ps) connotes the most sustainable way of ensuring good agricultural practice from the perspective of this research. Yield must increase, or waste must be reduced to meet the demand of the teeming population, the environment must be protected, farmers and food manufacturers must make profit. The welfare of farmers and consumers is paramount.

8.2 Lessons from case study countries

Table 8.1 summarises the key findings from the case countries (UK, USA, China and Indonesia) in terms of food security, hunger indices, farmers performance and other vital statistics.

Table 8.1: Performance of case countries in food security, hunger and farmers' performance

<table>
<tr><th>FACTORS</th><th colspan="4">UK</th><th colspan="4">USA</th><th colspan="4">CHINA</th><th colspan="4">INDONESIA</th></tr>
<tr><td rowspan="2">Food security indices – specific ranking on key indicators-ranks out of 113 countries</td><td>Affordability</td><td>Availability</td><td>Quality/Safety</td><td>Nat. Res. & Resilience</td><td>Affordability</td><td>Availability</td><td>Quality/Safety</td><td>Nat. Res. & Resilience</td><td>Affordability</td><td>Availability</td><td>Quality/Safety</td><td>Nat. Res. & Resilience</td><td>Affordability</td><td>Availability</td><td>Quality/Safety</td><td>Nat. Res. & Resilience</td></tr>
<tr><td>11th</td><td>1st</td><td>18th</td><td>45th</td><td>5th</td><td>10th</td><td>4th</td><td>44th</td><td>49th</td><td>44th</td><td>37th</td><td>65th</td><td>63rd</td><td>58th</td><td>84th</td><td>111th</td></tr>
<tr><td>Overall 2018 Food Security Ranking</td><td colspan="4">3rd</td><td colspan="4">3rd</td><td colspan="4">46th</td><td colspan="4">65th</td></tr>
<tr><td>The level of food safety</td><td colspan="4">High</td><td colspan="4">Very High</td><td colspan="4">Medium (in recent times) - Low</td><td colspan="4">Very Low</td></tr>
<tr><td>Food safety institutions</td><td colspan="4">Mostly controlled by private institution standards, less government involvement except for regulatory roles, trust in private standards</td><td colspan="4">The government takes the driving seat. Less private involvement</td><td colspan="4">Fully controlled by government institutions with interwoven functions.</td><td colspan="4">A few governments Acts on food safety</td></tr>
<tr><td>Hunger indices: Key indicators are: Inadequate food supply (undernourishment), child mortality (of under-fives) and child undernutrition (wasting and stunting)</td><td colspan="4">Not Applicable</td><td colspan="4">Not Applicable</td><td colspan="4">25th out of 119 countries</td><td colspan="4">73rd out of 119 countries</td></tr>
<tr><td>Storage systems/methods among farmers and instances of post-harvest wastes</td><td colspan="4">Three ways – flexible storage hire, own store, or cooperative options, all driven by the private institution. Waste and losses are minimal. Less than 5% waste</td><td colspan="4">Similar to the UK but more individual farmer ownership; Waste and losses are minimal. Less than 5% waste</td><td colspan="4">Secretive about government food reserve but well managed local storages; Waste and losses are minimal.</td><td colspan="4">Separate policies for reserves and storage-for-better profit or market; storage mediums are still prone to waste.</td></tr>
<tr><td>The efficiency of the farmers: Farmer-to-population ratios</td><td colspan="4">1:317</td><td colspan="4">1:101</td><td colspan="4">1:3.1</td><td colspan="4">1:3</td></tr>
<tr><td>Overall lesson learnt</td><td colspan="4">Private-driven institutions create innovations and healthy competition. It provides options and increases participation. Farmers are not considered weak. The farmers have access to a robust credit system to support their enterprises.</td><td colspan="4">The government-driven food supply chain can be profitable if the needed structures are in place; access to the market is crucial. Farmers are not considered weak. The farmers have access to a robust credit system to support their enterprises.</td><td colspan="4">Overlapping food safety institutions; Poverty among the farmers exist in substantial numbers; poverty level is mild.</td><td colspan="4">The country exhibits challenges among the farmers; government intervenes significantly. There is a clear separation of farmers agricultural policies from that of government policies in food security. Severe poverty cases exist among rural farmers.</td></tr>
</table>

8.3 Key challenges identified from the empirical study in Kogi State, Nigeria

In this section, the research outlines the key challenges that were discovered from the empirical study. These challenges can be grouped into two: structural and economic. The structural challenges arise from lack of infrastructure, unutilized or underutilized infrastructure and misaligned infrastructural placements. The economic challenges emanate from lack of functional business models that can help the farmers achieve more or make a decent living from farming. It also includes those challenges identified in the literature that affects the communities in Kogi State. The reason for outlining these challenges is to enable the research to combine the lessons learnt from the case countries with those from the study location in order to develop an alternative but useful model. The alternative model would improve food security, food safety, reduce post-harvest wastes and improve the economic situation of the rural farmers in Kogi State, Nigeria. Table 8.2 and 8.3 lists the structural and economic challenges, respectively and the appropriate solutions.

Table 8.2: Structural challenges identified

Challenges	Solution
Empirical findings: Poor processing and storage facilities	Community-based processing & storage institution
Empirical findings: Excessive use of in-store pesticides such as those that contain DDVP as active agent, regarded as Nerve Agents or Chemical Warfare Agents around the world; banned in the UK and entire Europe ;	Community-based infrastructure
Empirical findings and confirmed from literature: Waste of agricultural products up to 60% of stored harvest;	Community-based infrastructure
Empirical findings: A very long chain between the farmers and final consumers;	Community-based and technology-driven infrastructure
From the literature: previous schemes lacked “local feel”, they were non-inclusive, and they adopt a “top-down” approach or solutions to the farmers' challenges;	Community-based solutions

Table 8.3: Economic challenges identified

Challenges	Solution
Complete lack of access to agricultural credit; No medium to measure farmers' creditworthiness;	Economic-based business strategy powered by technology
Low income from the sales of harvest, resulting in poverty.	Standard-based solutions, following the requirements of the target market
Poor food safety issues hence limit access to broader markets;	Economic-based business strategy; taking out the Critical Points where contamination is most likely.
No access to stakeholders for economic opportunities.	Business based model driven by technology for easy access

8.4 Connecting the dots – The choice of the Communal Model

Based on the lessons learnt from the case study countries and the identified challenges from the communities in Kogi State, a communal model is considered suitable. Two concepts are employed in the development of this model: the first is the concept of "community" which focuses on building the solutions to the identified problems around the benefitting community and maximizing the collective strengths that exist among the people who want to work together to achieve common goals. The second is the concept of access: accessibility to opportunities and stakeholders with an economic-based business strategy aimed at a win-win scenario for the farmer and the stakeholders . It is an innovative way of increasing access to people, firms, businesses that can associate with the rural farmers through a strong rural institution for mutual benefits, powered by technology.

The Communal Model combines community infrastructures and economic business model to build a rural institution aimed at creating market opportunities for rural farmers. Figure 8.2 below shows the conceptual components of the Communal Model.

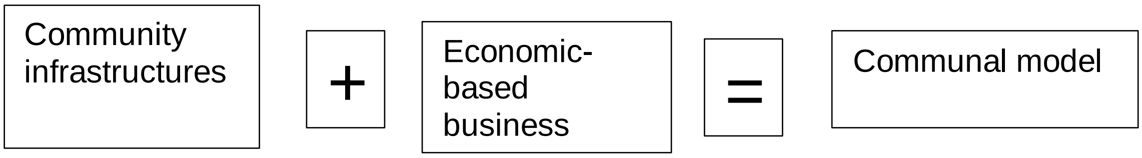


Figure 8.2: The components of the Communal Model

For the economy of Nigeria to progress, the rural communities must transform economically, through agricultural innovations that encompass services, equipment and collaborations. Such innovations must be able to create an all-inclusive platform for the farmers to soar, transforming the agricultural sector into a sector for creating wealth. It must encompass the comprehensive economic strategy, as recommended by FAO, IFAD, and WFP (2015, p. 1), that focus on access to the market by the rural farmers as the only way they can pull out of extreme poverty in developing countries.

The conceptual framework of the model is, as shown in Figure 8.3 below. In each community, a Processing and temporal Storage Centre is established. All the farmers in the villages located within each community (with their subsistence farms) would receive training and inputs from the Centre within their community.

The communal model is appropriate for the communities based on the pieces of evidence from the field so far presented. The idea is to have the harvested crops captured before there is any chance of being exposed to the various hazards associated with local processing and storage systems. Note, however, that the communal model did not come out of the blues, it was appropriate based on evidence. Farmers surveyed strongly supports community storage point rather than individual storage (76.3% supports community-based model) against State, Council or Zonal schemes. It should be noted that many of the communities' span across local councils or across zones; which means, people from the same community, who typically would want to do things together, were found separated by the way the council land areas are divided.

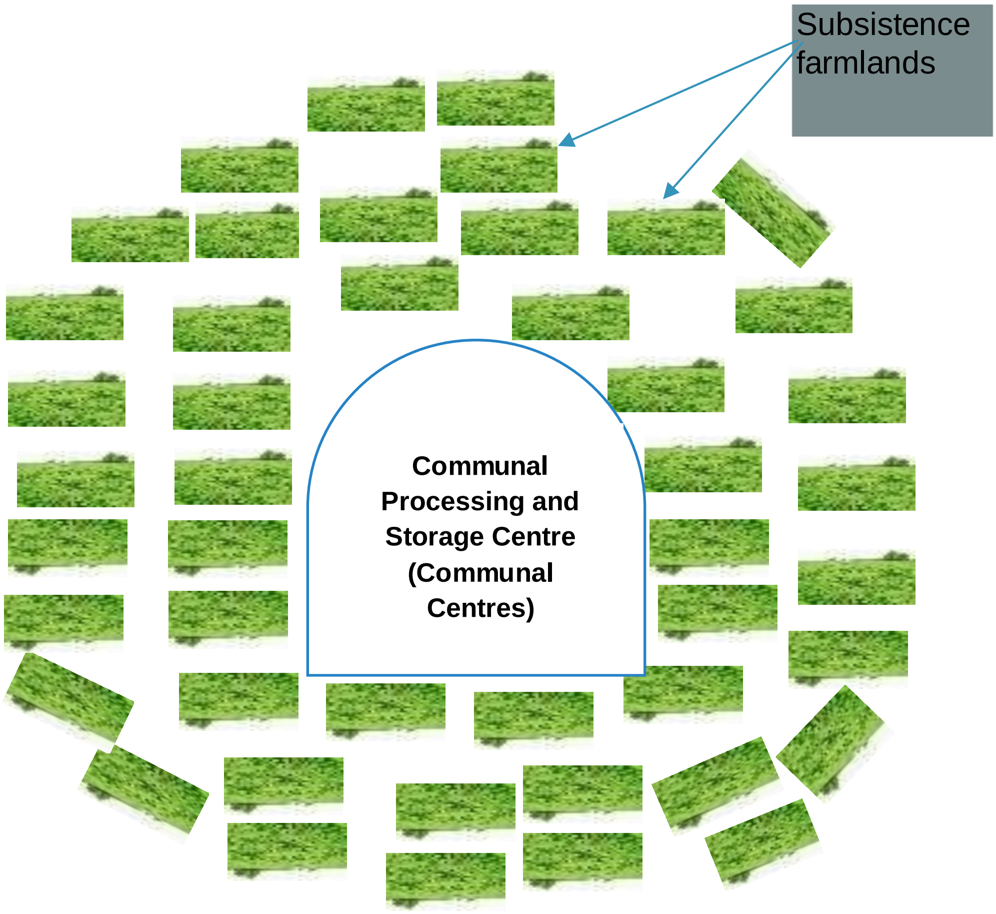


Figure 8.3: Framework of the Communal Model

8.4.1 Lessons from previous schemes/projects/programmes/models in support of the Communal Model.

Other researchers had repeatedly talked about agricultural programmes or schemes in Nigeria lacking the "localised feel" (Essiet, 2014) or having a top-down approach (Daneji, 2011) in tackling local problems affecting the farmers as some of the reasons why the schemes either failed or were ineffective.

More importantly, storage systems near the production zones have been reported to be more profitable than anywhere else (Lynton-Evans, 1997). Therefore, crops produced within a community are better processed and stored within the community. When storage facilities are located within the community, the costs of transport and handling are kept to a minimum, only being incurred as and when the grain would be required in another location. It helps to keep the environment clean (Baines, 2018) and reduce unnecessary grain movement and contamination. It would also help the economy and the soil.

Previously, the federal government of Nigeria had established zones called the Staple Crops Processing Zones of the federal government of Nigeria to boost crop production, minimise postharvest waste and encourage agro-industrialisation (Odunlami, 2016; FMARD, 2016a). However, the strategy, just like the Strategic Programmes that established silos in each State of the federation, has failed to deliver the objectives because the strategy had no localised feel or [community engagement], such that would encourage participation (Essiet, 2014). Each zone covers approximately six (6) States in Nigeria, which would have made it impossible for the rural farmers to engage and maximise the infrastructure. However, the policy failed to take off. It means that even if the policy had succeeded, it could have succeeded only within the local standard.

Again, the federal government of Nigeria produce another strategic plan in 2015. It was targeted at ensuring food safety plan, financing agriculture for rural farmers, and to demonize food traceability issues (FMARD, 2016a). This initiative was not within reach of the farmers at all.

The concept of communal storage is not entirely new; what is new is the approach to it. In China, a “food bank” for central or commercial storage has been mentioned, such that only the local storage systems were recommended for the farmers' immediate or household use (Lorini *et al.* 2006, p. 48). In Indonesia, concepts like contract farming have been used to pull farmers together for a "common" goal, helping many farmers out of poverty effectively (Patrick, 2003). The author had explained, that "through contractual arrangements, agro-industry [assisted] the smallholders to shift from subsistence or traditional agriculture to the production of export-orientated, high-value products".

The challenge of Growth Enhancement Scheme of the Federal government of Nigeria has been attributed to the lack of capacity between the real farmers and a host of stakeholders that could help the farmers maximise their potentials and opportunities. Identifying the real farmers was a challenge to subsidy programmes (GrowAfrica, 2015, p. 4). With the communal model, real farmers, identified by the Community Heads and match to farmland within the community, are the farmers that will be captured within a community. Therefore, non-farmers who will want to take advantage of the farmers will find it challenging to do so.

Although the world's impoverished people are unevenly distributed across regions and countries. As at 2011, nearly 60 per cent of the world's 1 billion poor people lived in just five countries: India, Nigeria, China, Bangladesh and the Democratic Republic of the Congo - ranked from the highest to the lowest (United Nations, 2017, p. 15). Poverty among the farmers in Nigeria is a national emergency.

8.5 Developing the Communal Model: Communal mapping

To build the Communal Model, there was a need to map the communities, to create a unique structure for easy record keeping, traceability and product recall. This will help to achieve the model's objectives. Several factors were considered in the mapping for appropriate location for the Communal Processing and Storage Centres:

- Accessible road network – necessary for the quick movement of raw materials and finished goods;
- Access to telephone and internet networks – to connect the communities to the world;
- Access to electricity lines – to power dryers and pre-storage processing machines, although the use of solar power for drying is also considered;
- Production volume - location having the primary production volume than the surrounding villages;
- The centrality of the location and population density were also considered.

Figure 8.4 shows the identified locations where the Centres should be located for optimum performance. The blue-filled spherical shapes represent the rice-producing communities, and the white-filled spherical shapes represent the maize producing communities.

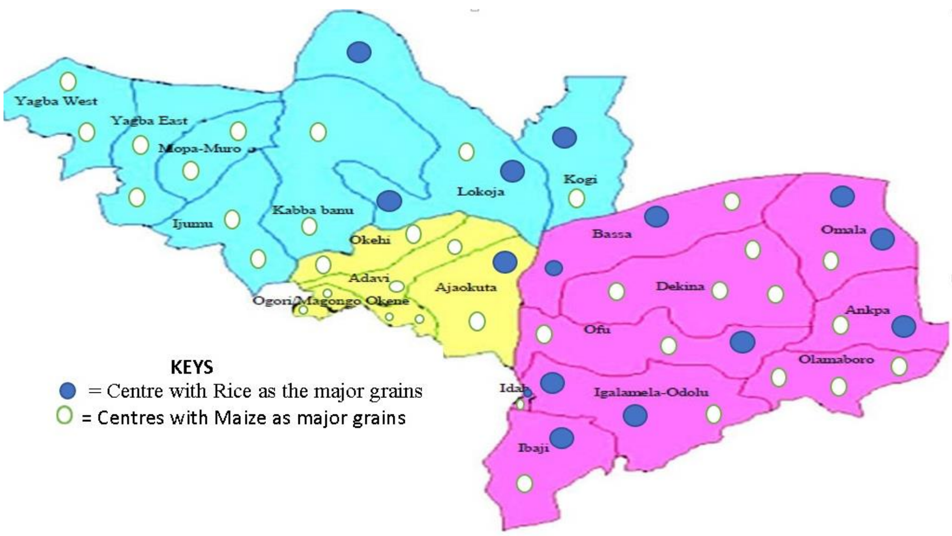


Figure 8.4: A model map of the Communal Processing and Storage Centre Locations for Kogi Communities, Kogi State.

8.6 Operational Models - How the Communal Model works

First, a Communal Centre is established in each of the fifty (50) communities identified in Kogi State. Each centre surrounded by villages and subsistence farmlands owned by families. Secondly, farmers from each community would be registered with the Communal Centre in their respective communities. Information such as the farmers' names, villages, passport photographs, next of kin and exact location of the farmlands would be captured on the Communal Database. An identify card unique to the farmers' community is then issued.

An extension officer would be assigned the World Bank recommended number of farmers for a single officer (usually ratio 1:500-800 farmers). The extension officer is expected to build the right relationship with the farmers assigned and know them in detail. Soil samples are then taken to ensure the most suitable crops and the kind of inputs that would be required. The farmers are then to return to the Communal Centres where training are provided.

For effective management, two models are possible with the same objective. The framework of the models would be, as shown in Figure 8.5. It places the infrastructure in such a way as to ensure optimal performance and taking into consideration the peculiar needs of the people of the communities. The villages work with the Centres, and the Centre supplies the Value Addition Centres as part of the storage scheme to utilize older grains in stock.

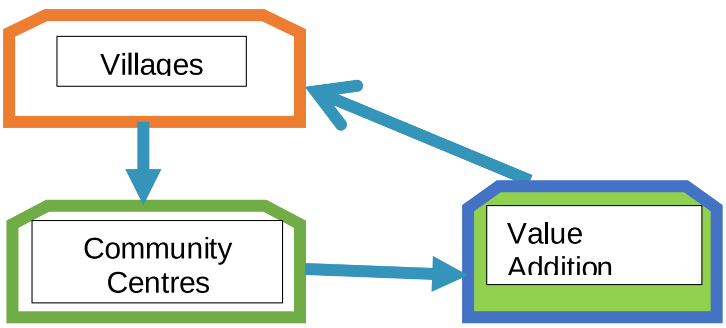


Figure 8.5: The framework of the models

8.6.1 Model One: Connecting the Communal Centres to the existing Silo Complex in Lokoja.

As was presented in the results, the advantage of connecting the Communal Model to the Silo Complex is that the silos would have been utilized for a purpose for which it was built. However, the execution of the model would have to bear the cost of completing the silo project, which sadly began in 1994, and it is only 45 % completed at the time of the research. Report from other investigations has shown that more than six times the initial budget for the silo complex has been spent till date. Another disadvantage is the location of the complex, which is too far from most of the communities, hence increasing the cost of transporting the grains from the communities to the silo complex (see Figure 8.6). It also excludes rural communities from direct labour participation.

Base on the interaction with the key person at the silo complex, and the on-site observation, there are significant fixes required at the complex before it can be put to use:

1. Installation of weighing bridge, to weigh incoming and outgoing grains;

2. Laboratory building constructed but need to be equipped with quality control equipment. The exact equipment required will need to be ascertained by the managers of the Communal Model in terms of cost and availability.

3. Installation of mechanical conveyors for loading and unloading.

4. Alternative power system like a generator would need to be installed in the generating room built but not equipped.

5. Since some of the installation equipment was purchased from Italy or Spain, local fabrication may have to be considered.

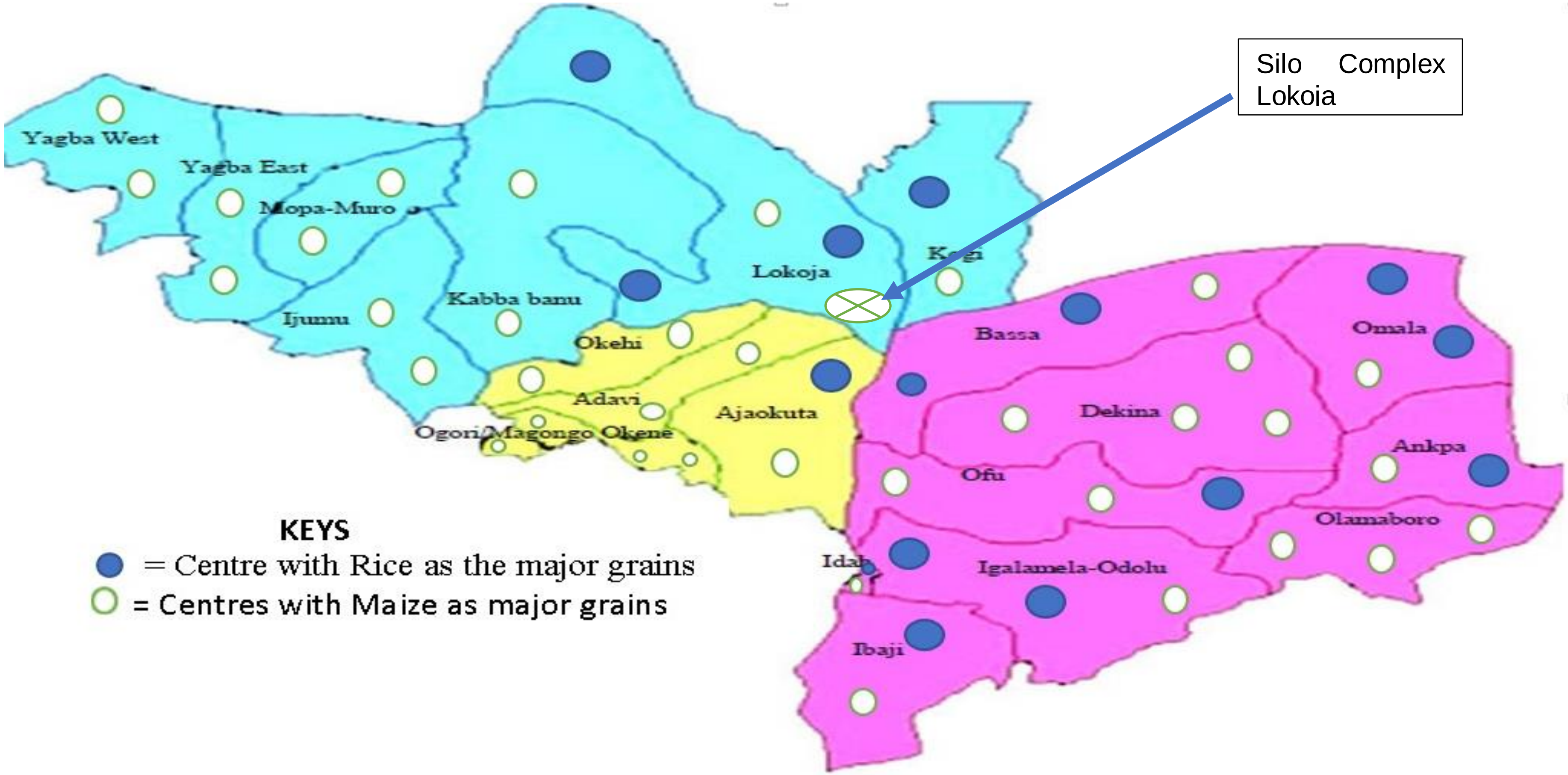


Figure 8.6: Model One – connecting the communal centres to the silo complex in Lokoja

8.6.2 Model Two: Connecting the Communal Centres to new Zonal Storage Centres.

Here, a Zonal Storage Centre would be established in each of the senatorial zones in Kogi State, and all the Communal Centres in each zone would have their long-term storage services at the Zonal Centres. The advantage of this model is that the communities would be closer to the Storage Centres, it will also create options for grain buyers to pick up the products they have paid for online, in a nearest Zonal Centre. The disadvantage is that the existing silos would not still have any use (see Figure 8.7). Therefore, a new medium to sizeable long-term storage facilities may have to be installed.

Recall that the government plans to use the silo complex for emergency food reserve, directly contradicting the storage-for-profit objective of the Communal Model, which may result in a conflict of interest. Therefore, for Model One to work, there has to be policy change with the act that established the silo project so that the objectives of the Communal Model could become the objectives of the silo complex. In Indonesia, there is a clear demarcation between government reserves and farmers storage for the purpose of making a profit.

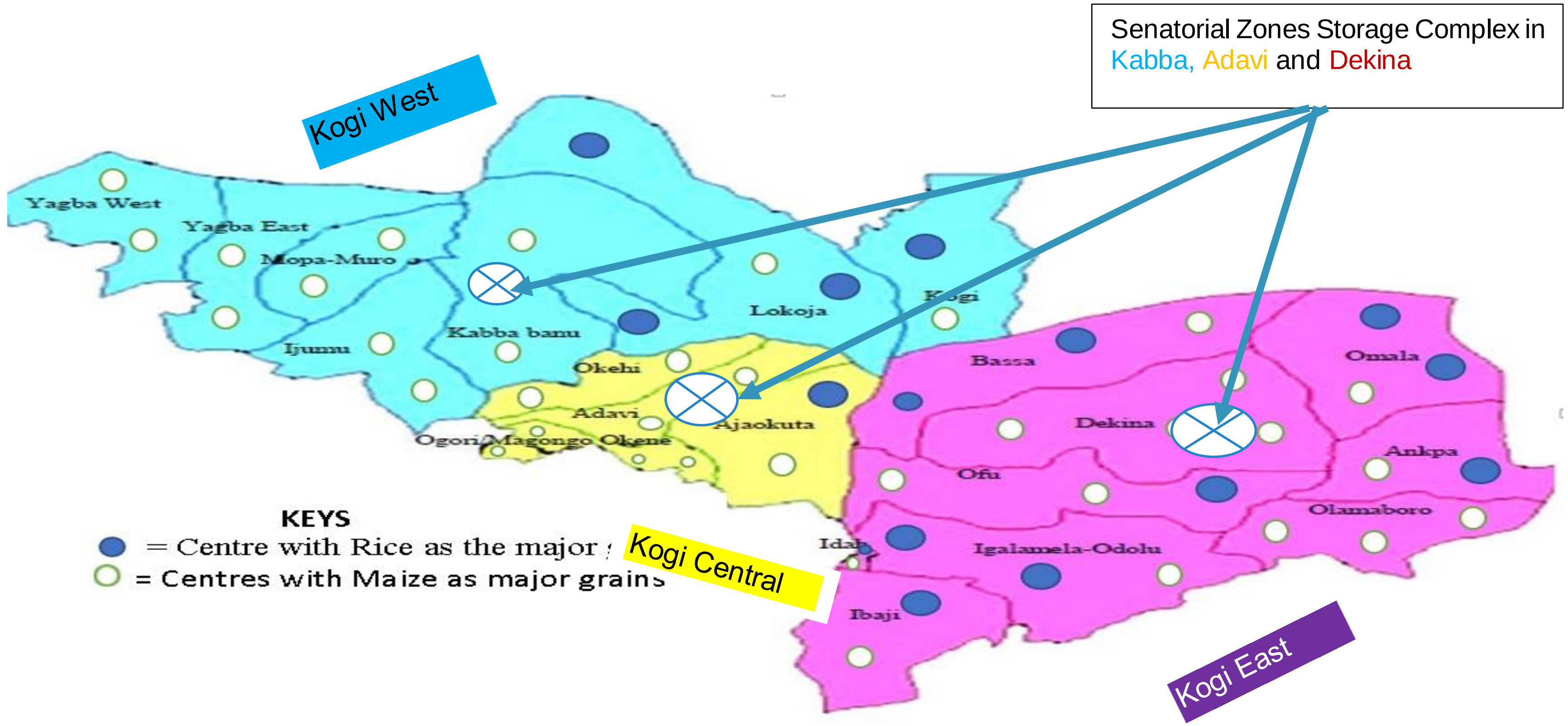


Figure 8.7: Model Two – connecting the communal centres to storage centres in each senatorial zone

8.7 Incorporating the Communal Models with Agricultural business models that provide opportunities for rural farmers –

The formation of the business models into the community infrastructure follows the steps provided in Figure 8.8. It shows the stages where the GLOBALGAP requirements and the BRC Global food safety system requirements must be adhered to and built into a business model. The combined recommendation of the Food and Agriculture Organization (FAO), International Fund for Agricultural Development (IFAD) and World Food Programme (WFP) – all of the United Nations, had firmly suggested that poverty and undernourishment in developing countries can only be effectively tackled through an all-inclusive economic growth that provides opportunities and well-functioning markets for the poor and those meagre assets (FAO, IFAD and WFP, 2015, p. 12). However, Sonja and Lorenzo (2010, pp. 3 and 7) opined that more inclusive business models encompass a wide range of arrangements…such that no single model fit for all-purpose, but government policy and action can do a great deal to promote more inclusive models. Sonja and Lorenzo (2010, p. 4) had, from literature provided six broad models that can provide opportunities for smallholder farmers: contract farming, management contracts, tenant farming and sharecropping, joint ventures, farmer-owned business and upstream/downstream business links.

While each of the models has prospects, there is a need to incorporate peculiar situations of the people to know which business model works.

8.8 The identified Stakeholders, their roles and sustainability

There is a significant number of stakeholders that can associate with the farmers, through the Communal Centres (Figure 8.9). However, there has to be a medium through which they can be reached easily. The Communal Centre would have an online channel to bridge the rural farmers and the identified stakeholders. The Communal Centres represent the physical point of call for the farmers.

The Economic Business Model

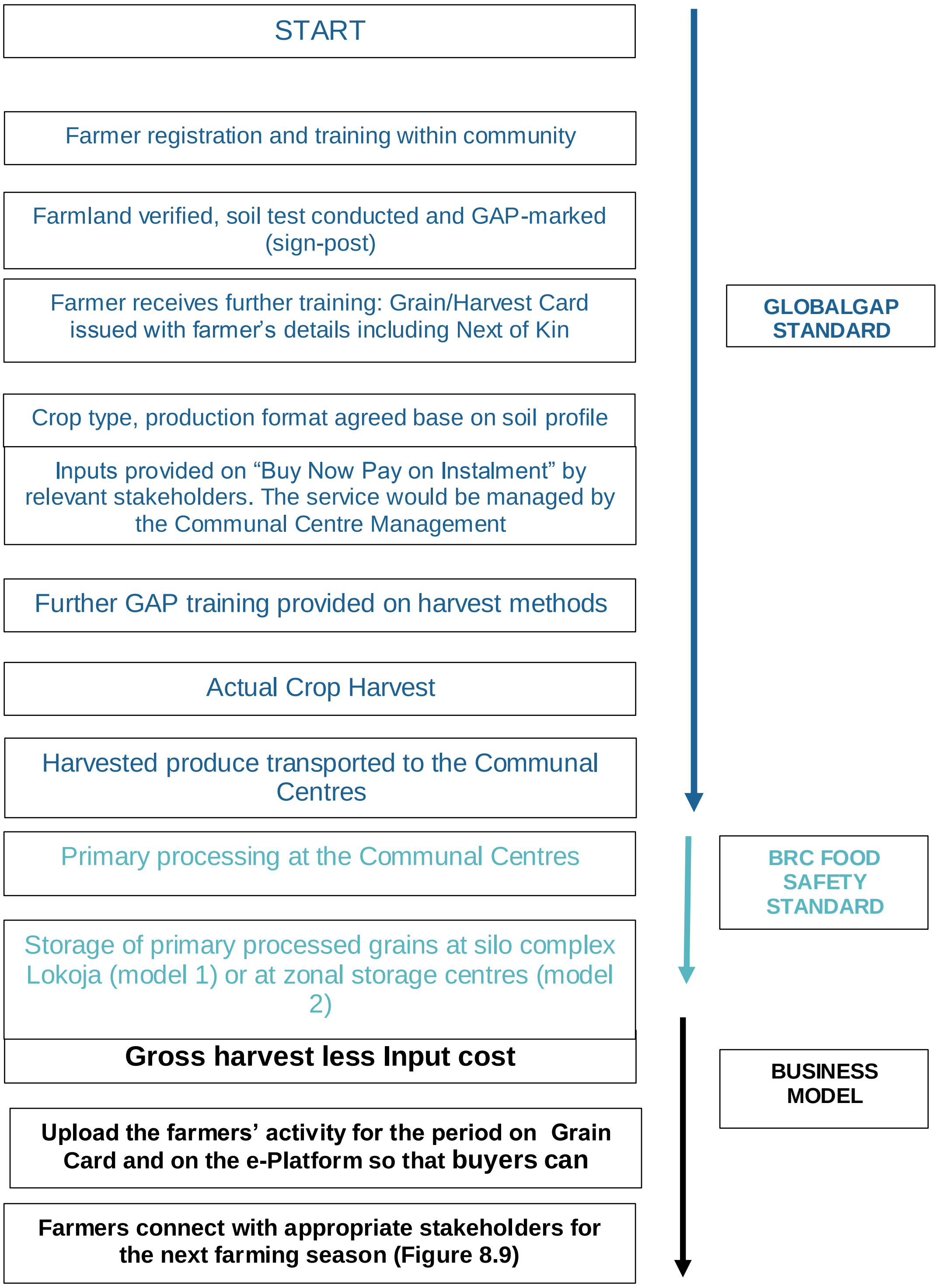


Figure 8.8 Stage of farmer registration and model business

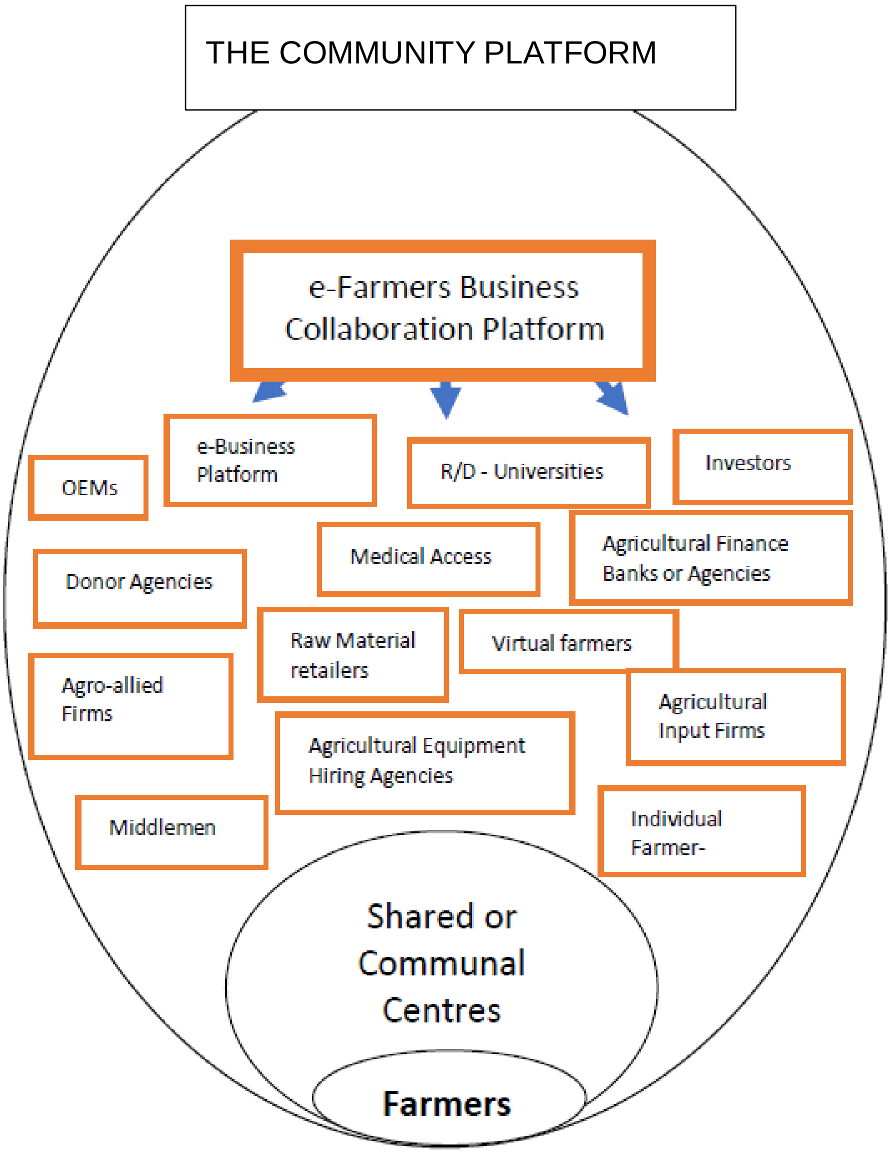


Figure 8.9: The potential stakeholders of the research model and the importance of introducing e-business to the sector in the modern world

From the figure, three sets of stakeholders could be identified;

[1] The input stakeholders such as the original equipment manufacturers (OEMs), pesticide manufacturers, equipment hiring agencies, research & development organisations and donor agencies which could support with agricultural inputs such as fertilisers, improved seeds and technology or advice;

[2] The output stakeholders which includes the middlemen, the food manufacturers that use agricultural products as raw materials;

[3] The third is the investment, financing and support stakeholders who would include the agricultural finance banks or agencies, individual and corporate investors, Virtual farmers (that is, non-farmers who contribute to the inputs required by the farmers, then share profit with the farmers after harvest), to provide credit facilities. While the banks and agricultural finance agencies would serve as the formal source of agricultural credits, a potential alternative lies with raising capital through the virtual farmers.

Even the centre could be used as a gateway to deliver quality healthcare services to the farmers because the farmers capacity to produce is directly proportional to their health condition and wellbeing. Therefore, the centre can attract investment solely for the farmers in their respective communities according to their medical needs. Payment for such services could be spread over a period, using the farmers activity ratings as an assessment tool. Access to medical care in rural areas is a big challenge in Nigeria. Where free medical access is available, the existing farmer records can help in ensuring an efficient medical solution/delivery to the farmers.

The Centres would sustain itself from the premiums paid for storages, service charges for various transactions between the buyers and the farmers, government and donor agencies support, commission or discounts obtained from stakeholders on inputs and equipment supplies, value addition to the grains bought from the farmers and incomes from consultations. The communal model prevents unnecessary movement of the grains and contributes to lowering the chances of contamination.

Table 8.4 shows how the Communal Model bridges the gaps in building capacity among the farmers.

Table 8.4: How the Communal Model bridges the gap

Challenges	Communal Model Solution
Empirical findings: Poor processing and storage facilities	Community-based grain processing and storage; continuous training of farmers on harvest, processing and storage.
Empirical findings: Excessive use of in-store pesticides such as those that contain DDVP as active agent, regarded as Nerve Agents or Chemical Warfare Agents;	GAP practices require the safety of the people and the environment. Only approved products would be used at the storage centres under strict professional personnel, including the assigned extension officers.
Empirical findings and confirmed from literature: Waste of agricultural products up to 60% of stored harvest;	Community-based processing and storage would take the burden of processing and storage off the farmers. Once it is time to harvest, the assigned extension agent would be in touch with the farmers, following a laydown procedure.
Empirical findings: A very long chain between the farmers and final consumers;	Community-based and technology-driven facilities at the Communal Centres would sell farm produce directly to end-users, cutting out the entire middlemen.
From the literature: Previous schemes lacked “local feel”, they were non-inclusive, and they adopt a “top-down” approach or solutions to the farmers' challenges;	Community-based solutions mean that each community’s peculiar challenges would require solutions that are peculiar to that community. Farmers are part of the solution for their own challenges through continuous contact with extension service providers
Empirical findings and confirmed from literature: Lack of access to agricultural credits, no medium to measure farmers’ creditworthiness;	Virtual Farming is a credit facility that allows individuals from far and near to fund agricultural activities with the farmers and thereafter share in the profit and loss. Government credit facilities could be provided to the Communal Centres, which then further distribute the facilities to the farmers according to their capacity.
Empirical findings and confirmed from literature: Poor sales after harvest, resulting in poor earning and poverty;	Direct sales to end users would ensure farmers earn more and be able to break even and pull out of poverty.
Empirical findings and confirmed from literature: Poor food safety issues, hence limit access to broader markets;	All grain production, processing, storage and distribution would follow the strict guidelines of the GlobalGAP farm assurance schemes and the BRC Global food safety scheme for storage and distribution.
Empirical findings: No access to stakeholders for economic opportunities.	Using existing technology, the farmers and the identified stakeholders would have a Common meeting point where both farming and personal household needs of the farmers can be provided on Buy Now Pay Later scheme. This provides the farmers with the flexibility of payment (either with farm produce or with cash) and creates the opportunity for the stakeholders to sell their products.

8.9 Communal Model's solutions to the community problems

8.9.1 A training centre

The Communal Centres are training points. The training must be a continuous process, to be provided at least quarterly. These training are geared towards Good Agricultural Practices (GAPs) – practices that ensure food safety, higher yield and sustainable environment. Table 8.5 shows the GAP contents and how the farmers would be trained in the areas covered in GAP scheme at the Communal Centres.

Table 8.5: GAP training manuals at the Communal and Storage Centres

GAP areas of concern	**Pieces of training at the Communal Processing and Storage Centres**
Soil	HOW TO: Establish a detailed knowledge of the nature, properties, distribution, and potential uses of soils of the farm. Avoid contamination with agrochemicals, organic and inorganic fertilizers and other contaminants by adapting quantities, application methods and timing to the agronomic and environmental requirements.
Water	HOW TO: Avoid the contamination of water resources with production inputs, waste or recycling products of organic, inorganic and synthetic nature caused directly by inadequate handling practices and technologies and indirectly by erosion and leaching.
Crop and fodder production	HOW TO: Apply fertilizers, organic and inorganic, in a balanced fashion, with appropriate methods and equipment and at adequate intervals to replace nutrients extracted by harvest or lost during production.
Crop protection	HOW TO: Store and use agrochemicals according to legal requirements, e.g. registration for individual crops, rates, timings, and pre-harvest intervals.
Animal production	HOW TO: Integrate livestock and agriculture to avoid problems of waste removal and ensure recycling of nutrients in an efficient way
Animal health	HOW TO: Where applicable, proper pasture management, safe feeding, appropriate stocking rates and right housing conditions
Animal welfare	HOW TO: Where applicable, provide adequate and appropriate feed and clean water at all times.
Harvest and on-farm processing and storage	HOW TO: Harvest food products following relevant pre-harvest intervals and with-holding periods, Process produce hygienically, e.g. for washing, use recommended detergents and clean water, store food products under hygienic and appropriate environmental conditions, pack food produce for transport from the farm in clean and appropriate containers and maintain accurate records regarding harvest, storage and processing.
Energy and waste management	Establish input-output plans for farm energy, nutrients, and agrochemicals so as to ensure efficient use and safe disposal, Store fertilizers and agrochemicals securely and in accordance with legislation.
Human welfare, health and safety	HOW TO: Direct all farming practices to achieve an optimum balance between economic, environmental, and social goals, provide adequate household income and food security, establish and adhere to safe work procedures with acceptable working hours and allowance for rest periods, instruct workers in the safe and efficient use of tools and machinery.
Wildlife and landscape	HOW TO: Identify and conserve wildlife habitats and landscape features, such as isolated trees, on the farm.

8.9.2 Adhering to the GlobalGAP and BRC Global assurance/standard

The following tables (Tables 8.6, 8.7 and 8.8) shows the current compliance of the practices in Kogi State and how the Communal Model would address the gaps in the GlobalGAP farm assurance scheme and BRC Global food safety standard.

Table 8.6: How the Communal Model bridges the gaps in the GlobalGAP farm assurance scheme

NO.	**CONTROL POINT**	Current compliance of the farms and farmers	**Compliance when the Communal Model is in operation.**
AF. 1	SITE HISTORY AND SITE MANAGEMENT	Nil	Signposts at the farms plus full history of the farms would be documented
	Site History	Nil	To be captured annually on record by the Communal Centre Management
	Site Management	Nil	Under the control of the Communal Centres
AF. 2	RECORD KEEPING AND INTERNAL SELF-ASSESSMENT/ INTERNAL INSPECTION	Nil	Online and offline record-keeping – database of farmers and their activities shall be captured.
AF. 3	HYGIENE	Farmers' individual hygiene	Individual staff would be encouraged to observe personal hygiene both at work and at home. Facilities would be provided for hand washing, and disinfectants shall be provided.
AF. 4	WORKERS' HEALTH, SAFETY AND WELFARE	Nil	
	Health and Safety	Nil	Quarterly health assessment for those handling grains directly.
	Training	Nil	Training at critical stages of production, especially during fertilizer application and harvesting
	Hazards and First Aid	Nil	Standard procedure
	Protective Clothing/Equipment	Nil	Personal Protective Clothing (PPE) for all workers handling the grains. Loose bodily wears like pieces of jewelry or earrings would be restricted.
	Worker Welfare	Nil	Workers welfare, including the farmers and their individual workforce, shall be taken seriously
AF. 5	SUBCONTRACTORS		
AF. 6	WASTE AND POLLUTION MANAGEMENT, RECYCLING AND RE-USE	Open-air disposal and burning	Plant wastes like the fodder and dried plants would be processed in bales - into animal feeds or worked back into the soil. It is a "No-waste" Communal Centres.
	Identification of Waste and Pollutants	Nil	Management control of the farms
	Waste and Pollution Action Plan	Nil	Waste Reuse reduces and recycling.
AF. 7	CONSERVATION		
	Impact of Farming on the Environment and Biodiversity	Nil	Establish input-output plans for farm energy, nutrients, and agrochemicals so as to ensure efficient use and safe disposal. Store fertilizers and agrochemicals securely and in accordance with legislation. Where applicable, crop wastes shall be baled for animal feeds.
	Ecological Upgrading of Unproductive Sites	Nil	
	Energy Efficiency	Nil	
	Water Collection/Recycling	Nil	
AF. 8	COMPLAINTS		Channel of communication shall be provided at each stage.
AF. 9.	RECALL/WITHDRAWAL PROCEDURE		Tags on all packaged grains for traceability down to the farm and the farmer
AF. 10	FOOD DEFENSE	Nil	The system shall ensure intentional contamination are easily detected and isolated. Only registered farmers who abide by the laydown procedure (end-to-end) shall benefit from the services of the Communal Centres.
AF. 11	GLOBALG.A.P. STATUS	Nil	To be obtained
AF. 12	LOGO USE	Nil	Communal certification rather than individual certification shall be obtained
AF. 13	TRACEABILITY AND SEGREGATION	Nil	Tags are provided on all packaged grains – to be traced down to the farm and the farmer
AF. 14	MASS BALANCE	Nil	To ensure waste reduction as much as possible, materials entering the farms commensurate those leaving the farms.
AF. 15	FOOD SAFETY POLICY DECLARATION	Nil	HACCP shall be followed at all applicable stages
AF. 16	FOOD FRAUD MITIGATION (Not Applicable for Flowers and Ornamentals)	Nil	A supervisory team would ensure the monitoring and control of Critical Points where contamination is most likely to occur.

Table 8.7: How the Communal Model bridges the gaps in BRC Fundamental requirements.

S/N	Self-Assessment	Current situation without the model	With Communal Model
1	Foreign body control	Nil	Post-harvest processing would be carried out at the Communal Centres with facilities that do not allow foreign body contamination.
2	Transport	Only approved	Only approved transport vehicles or other means would be mandated to move grains from the farms.
3	Traceability records	Nil	Every batch of the harvest would be labelled with the farmers' name, the exact location of the farm, community name and store location.
4	HACCP documentation	Nil	All information from the farm to the farmer up to the store would be adequately captured.
5	Final product procedures	Nil	The final product would be graded according to the international grain grading standards and packaged in eco-friendly or reusable materials.
6	Raw material supplier approval	Nil	Every raw material required for the production, processing and storage must be from approved standard organizations.
7	Raw material specifications	Nil	Raw materials must meet the specification accepted globally.
8	Factory facilities	Nil	All storage medium at the Communal Centres (Model 1) or at the Silo Complex (Model 2) would have facilities for record-keeping, grain weighing, sealing and labelling.
9	Hygiene procedure and records	Nil	Personal Hygiene procedures would be followed, following standard procedures.
10	Quality systems	Nil	A robust system that allows online and offline monitoring shall be considered as the standard.
11	Specific handling requirements	Nil	Personal handling equipment would be provided for all workers.
12	Accreditation	Nil	Communal Accreditation by the BRC's approved accreditation agent for Africa or Nigeria would be provided.
13	Product recall procedures	Nil	Tags on all packaged grains for traceability down to the farm and the farmer
14	Pest control	Yes – however, with dangerous pesticides used indiscriminately	Only approved pesticides would be used within the approved limit, and under the strict supervision of the
15	Hygiene monitoring systems	Nil	Personal Protective Clothing (PPE) for all workers handling the grains. Loose bodily wears like pieces of jewelry or earrings would be restricted.
16	CCP monitoring and control	Nil	A supervisory team would ensure the monitoring and control of Critical Points where contamination is most likely to occur.
17	Staff training	Nil	Continuous training at both the Communal Centres and long-term Zonal or at the Silo Complex.
18	Personal hygiene procedures	Yes	Individual staff would be encouraged to observe personal hygiene both at work and at home. Facilities would be provided for hand washing, and disinfectants shall be provided.

Table 8.8: How the Communal Model bridges the gaps in BRC Auditor checklist and Site Self-Assessment Tool.

S/N	Checklist	Current situation without the model	With Communal Model
1	Senior Management Commitment	Not Available	Communal Management would consist of multi-dimensional experts in food-related fields.
2	The Food Safety Plan – HACCP	Not Available	At the Storage Centres, all direct handling must adhere to the HACCP plan.
3	Food Safety and Quality Management System	Not Available	The BRC Global Standard for food handling, storage and distribution must be followed.
4	Site Standards	Not Available	Farm size, location, construction and maintenance information shall be kept
5	Product Control	Not Available	Product design and development procedures shall be in place for new products or processes and any changes to product packaging or manufacturing processes to ensure that safe and legal products are produced
6	Process Control	Not Available	the site shall operate to procedures and work instructions that ensure the production of a consistently safe and legal product with the desired quality characteristics, in full compliance with HACCP food safety plan
7	Personnel	Not Available	Competent to carry out an activity, through training, work experience or qualification.
8	High-Risk, High-Care and Ambient High-care Production	Not Available	Zones with risk would be provided with high care to ensure the GAP components are protected while production takes place; risk zones for sites where handling constitute a high risk.
9	Requirements for traded products	Not Available	Traceability tags on all packed grains

Credit: Compiled from BRC, 2016 and updated by the author.

8.9.3 Maximizing the existing mobile phones project for poor farmers

In 2001, the Federal Government of Nigeria embarked on supplying 10 million mobile phones to poor farmers in Nigeria. Nigeria's Agricultural Ministry has registered 1.2 million local farmers in 2012 and created a database that utilises mobile telephone numbers. With these mobile devices, the Ministry has created a system that sends vouchers to the mobile devices, which local farmers can, then, take these vouchers to registered dealers and get subsidized fertilizer and seed to grow produce with (Hooks, 2013).

However, critics had observed some challenges that such gesture would bring, with questions that bother on the need for it, who would pay for the phones, who pay for the farmers' air time and the selection criteria (Nkemachor and Nnadozie, 2013). Like many agricultural and rural projects in Nigeria, once there is a change of government, many existing schemes are abandoned. This mobile phone project has lost momentum following the end of the government that initiated it.

However, the Communal Model can take a cue from this project and leverage on the phones available to the farmers now, either from the government or those they have purchased individually. In disseminating market information, funding information, input availability and other related information to the farmers, the mobile phone projects would be extensive use at the Communal Centres.

8.9.4 Communal Mobile App (CMA)

In previous research, Nkemachor and Nnadozie (2013) had suggested the development of mobile applications with local contents (local languages, images and local names for crops, tools or equipment) that capture and share the farmers existing experiences. In this research, not only would the farmers own the phones, there would be an application (CMA) that allows farmers to enter data and share experiences with other farmers within their communities. There would be immense collaboration among the various stakeholders identified in this research.

8.9.5 Building a database of farmers at the Communal Centres

The Communal Centre is for registration of the farmers from the community within which it is located. Each farmer receives training at the Community Centre where their farmland is located. Subsequently, the farmlands would then be marked, and a traceable code or number would be assigned using the coordinates of the location to prevent a single land being registered twice. The suitable crops, the system of farming (inorganic or organic) would be agreed on with the farmers based on soil analysis.

8.9.6 A centre for capacity building

The Centre would be a connecting point between the farmers and the market and the stakeholders. Stakeholders are connected to the farmers for mutual benefits through the Centres; for example, equipment manufacturers can connect with the 2.8 million farmers where farm equipment would be sold on a flexible repayment plan. Farmers can walk into the Communal Centres to seek information of any kind, including meeting up individually with their assigned Extension Officers.

8.9.7 A processing and storage solution centre

The Communal Processing and Storage Centres would be a processing and storage centres, allowing farmers to bring their harvested crops to a common point within their community for processing and storage to be done with modern equipment and expertise. The researcher found farmers drying farm produce using odd platforms like the hard shoulder of a road, car park and even on bare surfaces. These platforms create rooms for contamination, even before the product gets to the storage. Once a farmer has gathered some harvests, all that would be required would be to move the harvest to the community centre in the community. The grain movement must be by an approved means of transportation to avoid contamination and to keep to the required standard.

8.9.8 Instant Sales Point at guaranteed minimum price

The markets in rural communities operate on specific days of the week, thereby limiting economic activities. The Communal Centre serves as Instant Sales Point (ISP) at a Guaranteed Minimum Price (GMP). Guarantee Minimum Price is an amount a farmer must earn for cultivating certain crops. The price is arrived at by taking into consideration all the costs incurred from land preparation, planting, harvesting plus a profit margin between 5-25 per cent of the cost of production. With this model, the harvested grains could be exchanged for cash immediately at a Guaranteed Minimum Price (GMP) right within their communities. The GMP is arrived at using equation 1 or 2, below.

$$\mathbf{GMP} = \mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D} + \mathbf{E} + \mathbf{F} + \mathbf{P} \qquad (1)$$

Where A = Cost of input (fertilizer, pesticides, and improved seedlings) /ha; B = Cost of land lease/ha; C = Cost of labour/ha; D = Cost of transportation; E = Cost of other materials; F = Insurance premiums; P = profit for the farmers, which should be at least between 5 – 25 percent per ton.

Or GMP = (k + P) (2)

Where = $\boldsymbol{k} = \mathbf{A} + \mathbf{B} + \mathbf{C} + \mathbf{D} + \mathbf{E} + \mathbf{F}$

For farmers to break even, GMP > (k + P) always. This formula works for the States in the north-central zone of Nigeria because of similarity in vegetation, mode of storage and general agricultural practice. For the southern part of Nigeria, the cost of labour per hectare (C), either with human labour or machines, could be up to six times that of the north-central zone (like Kogi State) for the initial land preparation, owing to the forested vegetation, coupled with swamps and mangroves. For the northern part of Nigeria, the labour cost could be 3/4C because its vegetation is less thick compared to that of the central and southern parts of Nigeria. These must be considered if the formula must be applied in the south and north of Nigeria.

Alternatively, the harvested grains could be stored for later sales following negotiations between the management of the shared or communal centres and the prospective buyers. In such case, the farmers pay premiums or service charges, but not more than 10 per cent of the produce stored per annum, to cater for storage cost and administrative charges involved in connecting with the buyers. This would ensure the sustainability of communal centres. Kumar and Kalita (2017) had suggested that community-level silos, is an economical alternative to having individual silos because the cost per unit grains decreases with an increase in the size of the silo.

It is the responsibility of the management of each Centre to ensure the protection of farmers' investments and ensure that the best practice in terms of training and inputs acquisition is provided from the production to the point of storage. The management of the centres would be regulated by the financial conduct authorities operating in Kogi State and Nigeria.

8.9.9 The Communal Centre is an offline and online marketplace

For the purpose of maximising the opportunities for the farmers through the use of the mobile app (Communal Mobile App), the platform would serve as a marketplace. In addition to the sales of grains, members can also put other items or advertise services for others within their communities.

In order to maximise the use of the internet platform, the following steps would be optimised for transactions on the web page of the Communal Centres, to place an order for grains.

Step 1: Buyer creates account and login to the Community Platform or approaches the Communal Centres if there is no access to internet technology through telephone or one-on-one.

Step 2: Buyer selects the appropriate grain type – graded according to international standard;

Step 3: Buyer selects grain grade (quality)

Step 4: Buyer selects quantity required and the system automatically calculate the total cost;

Step 5: Buyer selects a delivery method

Step 6: If the buyer would be providing their own pickup and delivery, then

– View Summary
– Selected payment method
– Buyer selects the nearest community or centre to pick up the order
- Make Payment
- Email Confirmation on both ends
– End

Step 7: Or Provide delivery service – Select payment method and make Payment, Email Confirmation on both ends;

- Close Sales

– **End.**

8.10 Benefits of using Communal Centres

There are key benefits of using this model, rather than using the conventional local markets. From the empirical data, farmers are earning below the poverty line because the middlemen have taken advantage of the farmers' challenges – which are inadequate storage systems, poor access to the market, poor access to credit (identified from the empirical results) and bought the grains at a ridiculously reduced rate.

Apart from bypassing the middlemen, the benefits of using the centres are;

1. Access to credit - Agricultural credit is necessary to support the farmers to produce effectively. This credit does not come easy, as various commitments are required on the part of the farmers, most of which they are unable to meet. Such commitments bother on collateral. The inability of the farmers to access agricultural credit is a direct result of a lack of quantifiable collateral

to support the application for such credit. However, in the current reality in Kogi State, Nigeria, farmers are unable to maximise available agricultural credit because credit agencies are unable to verify the creditworthiness of the farmers.

2. Preventing fraud within the agricultural finance schemes - non-farmers have often pretended to be actual farmers, have accessed this credit for other businesses to the detriment of the farmers. On rural agricultural financing, repayment with harvested crops has been reported to have effectively worked for farmers in some communities in Kogi State. Therefore, similar and other flexible repayment platforms could be worked out for flexibility. The flexibility is necessary since this model is still at its emerging stage.
3. Access to investors, like the virtual farmers (non-formers who contributes financially to secure inputs for the farmers and share in the profit at the end of the farming season); this could be the most effective alternative financing method in Nigeria's agriculture;
4. Competitive prices;
5. Access to original equipment manufacturers;
6. Direct access to firms that process grains into consumer goods;
7. Equal access to agricultural inputs either at a subsidised rate by the government or on the flexible cost-recovery arrangement.
8. Access to donor agencies and international organisations and governments – such as the DFID, USAID and World Bank.
9. Less movement of agricultural produce in the store, hence lower chance of contamination and deterioration.

8.11 Suggested Storage mediums at the Communal Centres

Note that storage at the Communal Centres is for a short period – up to a maximum of four (4) weeks. One of the critical factors to consider in bulk grain storage is the storage medium. While the use of silos requires high construction cost, its cost of maintenance is low, with slim chances of waste. Managing the stored grains is more effective with silos. However, the use of jute bags, the cocoon or such hermetic bags or materials are cheaper at the initial stage but could be prone to rodent attack, waste and losses.

The Cocoon is a trademark, of a commercially available hermetic bags or sacks made of two plastic halves, that are joined together with an air-tight zipper. Once the cocoon is loaded with sacks of the commodity to be stored, it is zipped up and secured. Compared to traditional storage systems, the Cocoons extends the germination life of seeds, control insect grain pests without chemicals), and improve the head rice recovery of stored grain (IRRI, 2019). It can, however, be problematic if the grains are not dried to the right moisture content or the Cocoon itself is left open for oxygen to penetrate the bags. Rodents can damage the Cocoon, and poor management can ruin the storage.

The plastic water container with lid and the Purdue Improved Cowpea Storage (PICS) bags has been reported to keep insects away (Daluba and Okoye, 2013) with positive results. Wooden silos have been experimented as well (Alabadan, 2006) but were vulnerable to environmental factors like rainfall and strong winds. The temperature within the wooden silos is unstable, reducing the quality of the stored grains. Figure 8.10 are some of the suggested medium of storage at the Communal Centres.

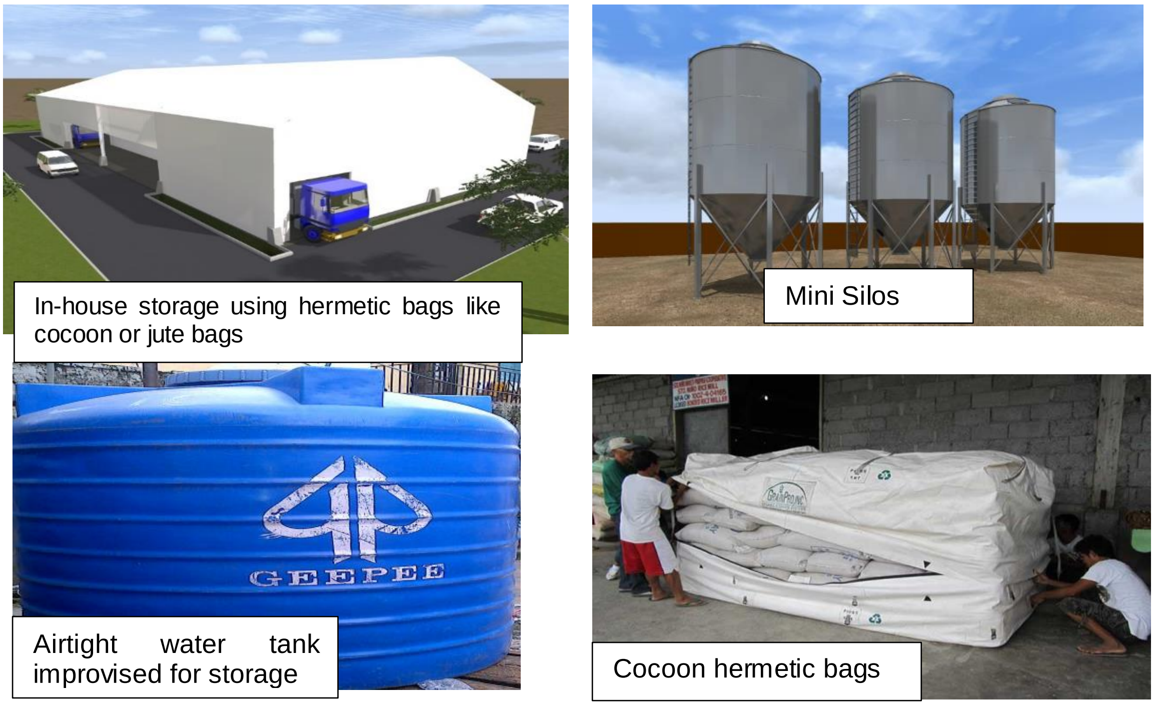


Figure 8.10: The storage medium that could be utilised for the Communal Storage; the Cocoon is courtesy of IRRI, 2019.

8.12 Measuring research impacts

Research impact, according to the University of York (2016) is achieved, 'when the knowledge generated by [the] research contributes to, benefitting the health, prosperity and well-being of the people and influences society, culture, our environment and the economy'. In this regard, this model is a step towards rural farmers' economic development. However, continuous effort is required to ensure that the benefiting communities have access to economic opportunities.

8.13 Impact goal

The goal of the research is to encourage production, processing and storage of grains, which directly lead to the economic well-being of the people and their communities. The model can increase trade agreements between Kogi State and the other States in Nigeria; it could also foster a bilateral relationship in grain trade between Nigeria and the rest of the world, especially the strong economies like the

UK and the USA. Prosperity is the direct consequence of the rural farmers producing safe foods in a standard and acceptable environment. The model may also lead to policy change or policy initiation around food safety and management in Nigeria.

8.14 Beneficiaries: who they are

The first and obvious beneficiaries of this research are the rural farmers in Kogi State, Nigeria, and the various communities they represent. Similarly, agro-allied companies, grain consumers from within the communities, Nigeria and those countries with which agricultural products from Nigeria are sold, are also potential beneficiaries. The rural economy stands a chance of gaining improvement, and the public would also benefit from the research directly and indirectly with the assurance of quality raw food materials. The other States in Nigeria are potential beneficiaries too, especially states within the north-central zones as these research results can be adopted for these States.

8.15 What is in it for them: Impacts

Though the model is hypothetical, evidence from the research results suggested the following benefits and impacts on the rural economy.

- Safe grains – Once the communities could produce grains in a standard and acceptable manner, using only approved resources, including proper labelling to help traceability as detailed in the model, it is possible for the following benefits to be achieved:
- Economic improvement – a direct outcome of market accessibility;
- Improve social activities because of improved economic activities;
- Employment generation – direct and indirect employment within the Communal Centres is highly possible.

8.16 Impact engagement: How to reach them – activity

Impact engagement denotes the various routes, channels and activities through which the beneficiaries of the research results could be reached. The use of mobile phones in one of the previous schemes would be utilised as a means to reach the farmers. Quality engagement encompasses purpose, people and process; therefore, in addition to the mobile phones, the Communal Centres is a walk-in centre for the farmers when they need any information. Other viable alternatives would be considered.

8.17 Capturing pieces of evidence supporting impact purpose

For impact measurement, the evidence is vital. As Chubb (2018) suggested, impacts should be captured during and throughout the research process, keep a file of evidence after activities and make a note of the developments. This can equally continue after the study is completed.

One of the evidence captured so far is that the farmers are now better informed, especially on the silos project that has been around the Kogi State for such a long time but was unaware. The Grain Storage Project was already ongoing before some of the participants were born. Even the farmers within proximity of the silos project were not aware that the structures were for grain storage. More so, as the researcher continues to collaborate with relevant government, organisations, to seek the actualisation of the model, the impact would continue to draw closer to the beneficiaries.

8.18 Risks in making the impacts happen

Referring to the analysis of in-depth discussion with the key personnel at the silo site in Kogi State (See Appendix A), corruption was identified as a factor militating against the project. Therefore, a model that tends to stop leakages, embezzlements, frauds and even stopping illegal pesticides from reaching the farmers, may cause counter-reactions from pesticide merchants, grain buyers and some government agencies. However, with adequate engagement with the people, the actual beneficiaries, via podcasts, radio jingles and town hall meetings, collaborations with the stakeholders, the government regulations and other organisations, the risks are minimised, but may not be eliminated.

8.19 Dissemination of research results

There are various ways research results can be disseminated. Result dissemination brings the actualisation of research results closer to the beneficiaries. For this research, this would be achieved through (but not limited to) the following:

- Publication of research results in journals so that other researchers, farmers, policymakers and other stakeholders may have access to it and be informed of such results.
- Paper presentations at professional conferences, seminars, symposiums and other such places would engage with people of interest, and perhaps, investors.
- Authoring a book based on the research results could also be a means for the public to have access to the research results and recommendations.
- A podcast, such as the 2D animation produced to summarised research model and its potential impacts on the rural farmers in Nigeria, could help the stakeholders to understand and engage. The stakeholders would play the animation on their mobile smartphones or personal computers and can connect with the management of the Communal Centres following the links provided at the end of the podcast. The farmers would also be communicated through radio jingles, as battery-powered radio is widespread among the

farmers. The local radio stations could create the opportunity on various platforms to pass the message to the farmers. A new radio programme to be broadcasted in the local languages would also be of help.

- Collaborations and co-production of the execution of the model with farmers, agricultural investors, communities and local councils, is a vital means to uptake the research results outside the academia, with its potential impacts with stakeholders and beneficiaries.

8.20 Chapter summary

FAO (2016) listed the many challenges facing the agricultural sector in Nigeria. Included among them the land tenure system that allows access to only about 1.8ha per household, with less than 2 per cent of the cultivated lands uses an irrigation system. Also, new technologies and research findings are not readily adopted. The input costs are high, and abysmal access to agricultural credit. There is also inefficient fertiliser procurement and distribution, inadequate storage facilities, poor access to markets. The yield is also weak, with only 1.2 metric tones per hectare (for cereals), indicating low productivity. Postharvest waste is high. As seen from the results presented, the issue of rural poverty is related to these challenges, and this has been shown to be maximum at the point of storage.

However, the burden of grain storage could be taken from the farmers to a Communal Processing and Storage Centres, which can be under the management of the private sector organizations, licensed by the State government, with the government playing regulatory role, as obtainable in the USA and other countries (Leathers and Foster, 2017, p. 352 -353; or the uses of Central stores in the UK (Fengrain, 2016).

Similar agricultural policies exist in other places, like the agricultural revolutions in the 1990s and the targeted subsidies in 2009 in Iran (Moradi *et al.* 2013; Ehlers, 2014) and Indonesia's management of rice (rice being the principal crop) and separating *food policy* from *agricultural policy* (Falcon, 2014, p. 35, 59). McKevith, (2004, p. 118) has described levels of storage systems available as temporarily on the farm before being taken to the collection centre or to more extensive facilities called Country Elevators, which are filled with grain by rolling belts.

Concisely, 'there is no easy fix for persistent hunger, and no single strategy can be deployed in all locations' (Annan, 2014, p. ix – x). The model agrees with the recommendation of the FAO, that rural economic diversification needs to be built on strengthened rural-urban linkages, by providing 'the economic space for rural households to purchase their inputs and household items, as well as to sell their produce at the local markets, thereby linking rural producers to the national and global economy' (FAO, 2014a, p. 4).

The chapter has detailed the Communal Model proposed as a solution to the challenges identified both from literature and from the empirical study.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

9.0 Introduction

The research has produced a number of useful insights into the food safety, food security and the requirements of global standards that must be met before the locally produced grains can lead to an economic improvement among the rural farmers in Kogi State, Nigeria. However, the research has provided a clear picture of the dynamics of challenges confronting rural farmers in Kogi State, with a model that has the capacity to address the challenges.

In this concluding chapter, the research would show critical findings to the research questions and the objectives as set out in Chapter One.

9.1 Key Findings

OBJECTIVE 1: Identify good practices in case study countries in relation to storage systems and access to markets

The first research questions focused on generating data to support the first, third and fourth research objectives; to categorize the storage systems in Kogi with the aim of comparing same with the best standards found in case study countries. It was framed to know if *the current grain post-harvest activities, and grain storage systems among rice and maize farmers in Kogi State sufficient to cut down waste and improve food safety? What are the post-harvest grain processing platforms available among maize and rice farmers in rural communities? What is the typology of storage systems among rice and maize farmers in rural communities?*

Evidence from literature and empirical research results were used to support this objective. In the UK and USA, food provenance policy is a selling point for retailers and manufacturers. It practically sets the UK and USA apart from China and Indonesia. Access to markets, buyers and retailers alike, now require not just the implementation of food safety controls based on hazard analysis and critical control point (HACCP) on products they have interest in (Buchweitz *et al.*, 2003, pp. 97-144), they also require the origin or source of such products (food provenance).

In the UK, private-driven food safety institutions create innovations and healthy competition. The system provides options for various production and manufacturing firms and increases economic participation. The United States government-driven food supply chain systems can be profitable when the needed structures are in place.

Access to the market is considered by all the case study countries as crucial to the farmers and the government.

The place of storage system in the food supply chain in the UK and USA especially, is such that food items must be subjected to the hazard analysis and critical control points (HACCP) food management system. The farmers have access to a robust credit system to support their enterprises, including those related to various storage technology and facilities on a “Buy Now Pay Later” system. Where a farmer has no intention of erecting a storage system, there are adequate but flexible storage alternatives.

OBJECTIVE 2: Evaluate the situation in agriculture and food security in Kogi State, Nigeria with a focus on post-harvest processing and storage

Food security is a function of food safety, food availability, affordability, constant supply and adequate utilisation. Therefore, the second research question focused on knowing the extent that the post-harvest platforms and storage systems encourage grain waste and losses. It also seeks to know if the platforms improve food safety in Kogi State or not. The post-harvest processing existing in the communities in Kogi State and Nigeria is unwholesome and in primitive conditions. For grain drying, for instance, farmers use the hard shoulder of roads, car parks or even on bare ground are used for drying grains by pushing the loose sands aside. This encourages waste and contaminations. In developed case study countries, dryers are used within safe confinement, to reduce contaminations and waste.

For storage systems, the storage systems found in the communities were those with thatch walls and thatch roofs, thatch walls and zinc roofs, some with mud walls and thatch roofs while others have the mud walls plastered with the roofs made of zinc. In addition to the fundamental local storage structures, many of the farmers keep the grains under their beds or spread them in any available space in their living rooms. Some of the farmers even walked on the grains while they go about their daily activities, hence introducing foreign contaminants.

These were, however, in contrast to those obtained among the farmers in developed case study countries like the UK, USA and China. While the available storage systems may suffice for short term storage for family use, considering today's grain quality demand from consumers and manufacturing firms, the typology of grain storage found in Kogi State, Nigeria, are quite primitive.

The storage systems are prone to waste, losses, and there were safety concerns — farmers losses between 20 to 70 per cent of stored grains to inadequate storage facilities. The safety concern is borne out of excessive use of in-store pesticides as a response to the inadequacy or deficiencies in the storage systems. The research found out that the use of excessive pesticides was purposive; it has detrimental unanticipated consequences on the safety of the grains and the health of the consumers, including the farmers themselves. Also, the breakout of Lassa Fever in the State in recent times, claiming lives, was mainly due to the weak storage structures, which allowed wild rats (the carriers of the viral fever, usually in their urine) to gain access to stored grains or foods.

Owing to the inadequate storage systems, the grains from all the communities in Kogi State, are exposed to various hazards, hence capable of making all associated manufactured foods from the grains unsafe. It confirms the report by the European Commission that food items from Nigeria are contaminated with various hazards (RASFF, 2016), leading to a red alert (warning) on Nigerian food items. The red alert is still active. Access to the global market is only possible by complete compliance to global standards.

Inadequate storage systems also affect food security negatively. Food shortage, especially in emergencies is not uncommon in Kogi State and Nigeria. For this reason, Songwe (2012) posited that governments must address the fundamental issues of storage facilities, market supply and demand to control commodity price volatility, with a long-term plan for food security. Furthermore, short-term emergency responses to food security, such as provisions for heavily subsidised inputs, will not address Africa's food insecurity problem in the long run and may, in fact, further distort prices. Therefore, in the absence of storage facilities, seasonal price fluctuations are even higher than those witnessed at the international level (ibid.). It means that a strong institution, as has been designed through the community storage systems, is required to ensure food security from the family level up to the national level. This is possible through reduced waste and losses and increased production where feasible.

OBJECTIVE 3: Appraise the contribution of grains to food security and how the typology of grain storage systems in Kogi State reflects on farmers' income

Grains, especially maize and rice, are staples in Kogi State and in Nigeria generally. In Kogi State, about 85 per cent of farmers cultivation is on grains while 15 per cent focuses on tubers such as yam and cassava. Therefore, grains make a massive contribution to the households, community and national food security in Nigeria. However, the economic contribution of grains to the welfare of the farmers is weak – a direct consequence of the typology of the storage structures and the length of storage.

Literature showed that farmers in Kogi State, like those from other States in Nigeria, earn very little from their farms. The empirical result confirmed that only 1 per cent of the farmers' population in Kogi State earned above the 2017 poverty benchmark. The low earning is also a direct result of the storage systems, storage duration and market dynamics rather than the quantity of the grain harvested, or the size of the land cultivated by the farmers. Incidence of waste is massive, up to 60 per cent of harvest in many cases. However, there are prospects to earn more, but adjustments must be made to strengthen the rural institutions, which is currently weak.

With the interactions with key players along the grains supply chain, the research found out if the farmers had direct access to the primary end-users (like manufacturing firms, the government of other countries or just large consumers), the capacity to earn between 6.28 to 21 times their current earning is possible. This has not been the case, however, because of the activities of the middlemen. To achieve better income for the farmers, the number of middlemen between the farmers and food manufacturers (those that makes use of raw agricultural produce as their raw materials) must be reduced to zero or at most one. This will only be possible where there is a strong institution to manage and connect the activities of the farmers and the middlemen.

Meanwhile, evidence from the empirical study has also shown that there is a direct link between the storage systems adopted by the farmers and the farmers' earning (which indirectly determine the level of poverty existing among them). In Kogi State and Nigeria, causes of poverty among rural farmers are diverse, and the study has been able to show that storage structures adopted by the farmers determine when they can get their grains to the market and invariably determine how much they can earn. In economic terms, the research has shown that even the most successful rural farmer in Kogi State lives below the world poverty benchmark.

Similarly, on a global scale, Nigeria-produced grains have little presence. The reason being that many of the country's agricultural products do not meet the global standards required to penetrate the markets with very high food safety standards - like the European and North American markets. Hence the stamp of excellence or approval on the products that could boost consumer confidence around the world is mostly unavailable. This is where adherence to private standards become paramount. There is a growing global demand for safe foods and its provenance by consumers from around significant economies of the world, especially in Europe and North America. Food provenance is showing transparently to the consumers' full information about the food on their menus, including the where it was produced, when it was produced and how it was produced, and in some cases, the name of the farmers. These information boost confidence among the supply chain actors and ultimately, the consumers.

Also, the market in the rural communities in Kogi State – Nigeria, is so erratic that the middlemen often short-change farmers. The researcher found out that there are too many middlemen between the farmers and the major firms that make use of agricultural products as raw materials. On the other hand, many of the firms whose manufactured products go beyond Nigeria, prefer to source for raw materials from as far as the United States instead of patronising the local farmers. They do this to protect their investment, to reduce the cost of recall that may arise from using contaminated raw materials from the rural farmers. Therefore, there are institutional bottlenecks, as well as storage problems in the entire communities as evidence from empirical research has shown.

In addition, the patronage for agricultural products for farmers in Kogi State lies only within the local markets – a disadvantage that does not allow the farmers to compete with other farmers from around the world or at least, to attract national and international patronage. In this technological age, access to market should be near-universal.

Taking a cue from case-study countries, the global standards compels the farmers and even countries to adopt the global regulations in order to gain access to the global markets. This has become industry practice.

Therefore, the first step in poverty reduction in the research location of study is by increasing the income of the farmers, but a strong institution to manage the farmers' produces (mainly maize and rice grains) such that can help to access the best market, and obtain the most value for the products, is required. The target should not always be for the farmers to produce more. It should also be that they have access to competitive markets and prices anywhere possible. This would allow them to earn enough to break even, to pull over the poverty benchmark.

The analysis of variance showed that there was a significant relationship between the typology of grain storage system adopted by the farmers (which invariably, determined the length of storage) and the average income of the farmers.

OBJECTIVE 4: Develop models to support rural economic development while ensuring food safety, food security and waste minimization.

The third research question was seeking for an alternative model (*How can an alternative model improve rural economic institutions in Kogi State, Nigeria?).* Based on the research evidence presented, there is a need for an alternative but improved model for rural economic development. The research has provided a clear understanding of the requirements to achieve the level of food standards that can be recognised globally. Right from the farm, documentation of activities related to the crops in question, the growers (farmers), the soil on which the crops were cultivated (be it soilless or hydroponic farming) and best storage condition when purchased by the consumers, are required. This is in addition to a strong commitment by the management of the farm sites, to acquire the facilities needed to actualise the documentation. Hence, the need for a robust rural institution in the research area cannot be overemphasised. This, therefore, was the basis for the alternative model aimed at a robust institutional system that provides solutions to the identified challenges and at the same time allows the documentation of farmers' activities, detect and monitor critical control points targeted at preventing contamination at all levels along the grain supply chain. The model targets economic improvement of the rural farmers through direct engagement with some specific stakeholders.

The food safety aspect is not unconnected with inadequate storage systems. Therefore, the rural farmers, in their attempt to preserve their farm produce, resolved to the use of potent pesticides against the various storage pests. Although the actions of the farmers are purposive, it is not without unanticipated consequences. The outcome, therefore, is the contaminated stored food items, not only unfit for the global market but has also claimed the lives of some of the rural farmers themselves and other consumers.

The relationship between post-harvest waste and food security is apparent. The food security issues emanate from the post-harvest waste and losses that the rural farmers encounter year-in-year-out. Between 25 to 60 per cent of the farmers' annual harvests are lost to waste and losses. This contributes to food insecurity significantly. In many locations of the world where grain storage is through the traditional means, high volume of waste and losses are not uncommon (Kumar and Kalita, 2017).

The weak economic situation of the farmers is a direct consequence of the fact that the farmers have minimal access to competitive markets. With the food safety compromised at the point of storage, coupled with high post-harvest wastes/losses, weak access to competitive markets and prices, economic benefits become extremely difficult. The outcome is the meagre income of the farmers resulting in poverty affecting about 2.8 million farmers in Kogi State and the 112 million farmers across Nigeria. From literature, low income is directly proportional to poverty in developing countries generally. This finding has been corroborated by Leathers and Foster (2017).

In addition to the problems of food safety, food security and poor economic condition of the rural farmers, there are other weighty challenges among the farmers such as follows:

- Poor access to agricultural credits. Agricultural credit is vital so that farmers can gain access to the best inputs possible. However, none of the farmers surveyed has accessed credit facilities in their lifetime of farming, even when such credits are available from the government. The reason is the weak rural institution, where the farmers appear disconnected from various economic opportunities.

- Also, many government schemes aim to increase agricultural production but less attention to access to completive markets that would benefit the farmers economically.
- There is also the problem of adulteration of agricultural inputs like fertilisers (FEPSAN, 2018) so harmful that fertiliser merchants (wholesalers or retailers) would mix sea sands with fertilisers and sell to the farmers as original fertilisers. Seeds that are not high yielding are also being sold to the farmers as high yielding, disease-resistant varieties.
- The corruption existing among fertilizer distribution agents do not allow actual farmers to gain access to the inputs being provided by the government. The mobile phone projects of the federal government of Nigeria allows the farmers to receive alerts on their phones about subsidized fertilisers in their State and where they can get the fertilisers at the subsidised rate. However, non-farmers also registered their numbers, collecting the fertilisers and reselling to farmers at full prices or even take them to the neighbouring countries at higher profits. No Communal Database of farmers exists in Kogi State at the moment that can checkmate intruders who are not farmers.

With the porous institution, the farmers would be unable to solve their individual challenges and improve economically on their own, not even with the assistance being provided by international donors and stable governments such as those of the Department for International Development (DfID – UK), the United States Agency for International Development (USAID – USA) and the World Bank.

The building of a robust rural institution is, therefore, the way forward. Hence, based on substantiated evidence from the communities in Kogi State, a Communal Model was designed. The focus of the model was collaboration. The collaboration among the individual subsistence farmers into a community or giant “commercial farmers”; and most importantly, the collaboration between the rural farmers and several important stakeholders identified to be relevant to the economic development of the farmers, the growing and storage of safe grains, access to competitive markets, food security of Kogi State and Nigeria. The Communal Centre would be an intermediary between the rural farmers and the stakeholders.

The identified stakeholders include the original equipment manufacturers (OEMs), firms that utilise raw agricultural products as raw materials, improved seed firms, and other stakeholders that would provide health services and household items to the farmers to be repaid with harvests or on an instalment payment system. The “Virtual Investors” would have the opportunity to finance available farmlands and share in the profit without actual participation in the farming activities. As it is obtainable now, the weak collaborations between the farmers and these vital stakeholders are one of the leading causes of the weak, and low performance of the rural farmers.

Therefore, the research’s Communal Model creates the opportunity for the rural farmers to link the supply chain between the rural and urban areas, indirectly promoting the concept of Sustainable Cities (Baines, 2018; FAO, 2014a, p. 4) by creating a platform at the point of storage, filling the gap between production and consumption of agricultural produce. In other words, the raw harvest would leave the rural communities in return for finished consumer goods. With an enabling environment, Value Addition Centres can be created at the primary storage centres where old stocks can be converted to other finished goods, thereby creating further opportunities for the rural communities and improving the rural economy.

9.2 Building Capacity among the farmers

The building of capacity among the farmers would improve their main occupation and other day-to-day activities. Based on the empirical results, the farmers identified the challenges of inadequate processing/storage facilities, lack of agricultural credits and reduced sales price of harvested crops. It is therefore envisaged that the communal model would bear the existing burden of processing and storage on the farmers, and with capable management, would also serve as the “collateral” for agricultural credits, whereby farmers would build up “credits” by merely having reliable records of grain production, processing and storage at their registered Communal Centre, to indicate activity or credit scores.

The Virtual Farming concept has some excellent prospects on rural enterprise funding. With this concept, investors are to provide inputs (which could be cash, improved seedlings, fertilisers, sprayers and agricultural machines/machinery) for the farmers to grow an advertised crop in return for an advertised crop. In other words, the virtual farmers would provide the credits, while the rural farmers provide both farmlands & time; they both would share in the profit or share the output based on advertised terms and conditions. The relevant authority in Nigeria would regulate Community Centres.

The grain marketing strategy would include the intensive use of the internet, possibly with real-time update of available grains in each of the 50 Communal Centres in Kogi State. This would enable consumers who require large quantities of grains to pay online and then choose the most preferred community to collect their purchase or even have it delivered. It would help reduce the cost of transportation and other logistics. The pattern of grain sales could happen among the farmers, or between the farmers and the government, or between the farmers and the manufacturing firms.

9.3 Farmers Training at the Communal Centres

Various trainings on Good Agricultural Practices, fertiliser applications, use of improved seeds, ethics of agricultural credit, credit repayment, building up “activity” or credit scores and those related to harvests, handling, personal protective equipment (PPEs) and commerce and the terms and conditions of borrowing or partnership, would be provided.

9.4 Training at the Zonal Storage Centres or at the Silo Complex.

At the main storage centres, long term storages are undertaken. Therefore, training on handling, packaging and environmental conditions of the storage medium to ensure the safety of the stored products are provided. Other pieces of training would be on personal hygiene and the use of personal protective equipment (PPEs).

9.5 General contribution to knowledge

Unsafe food costs low- and middle-income economies US$ 110 billion in lost productivity and medical expenses each year (World Bank, 2018a). Preventative measures suggested include more significant investment, better regulatory frameworks that can help countries avoid food safety problems. The research findings corroborated the World Bank findings. It is clear that unsafe food creates severe economic problems for farmers. There could be health challenges, too, because if the farmers are not healthy enough, their productivity would be affected, resulting in low income and poverty (FAO, 2008). Sudden deaths of farmers and entire family members are common in many rural and urban communities in Nigeria. While some of these deaths are usually attributed to evil forces by the locals, this research has provided strong evidence that shows excessive use of dangerous, unapproved pesticides was responsible. More so, many of the pesticides have no labels or clear procedure for use. In cases where there are labels, the research has provided evidence that farmers do not even look at the labels before using the product. Many of the farmers rely on secondary information from other rural farmers.

Similarly, in terms of economic opportunities, it is estimated that Nigeria is losing USD 10 billion (about £ 7.01 billion) in annual export opportunities from agriculture (FAO, 2008; Keronwa, 2012; FMARD, 2008). In Kogi State, the poor opportunities, weak market structure and lack of capacity building for the farmers have left 99 per cent of the farmers living below the poverty level, based on the results presented. The research has shown that the contaminations from the rural farms made it impossible for the farm produce, as obtainable in their present form, to sell in standard, regulated markets. No country with standard food safety regulations would jeopardize the health of their citizens just to patronize a region or country for whatever reasons. This is where the Communal Model comes in.

The study has also provided evidence that there is no effective platform to engage the farmers in training on Good Agricultural Practices and to connect farmers with stakeholders – for capacity building. In other words, the rural institution is, at best, feeble, or technically non-existent.

There is also no value addition to the grain produced in the communities except as those for local consumption of the immediate family members or local community members. This limits the economic prospects, diminish farmers' income and encouraging undernourishment among the people. Also, all by-products of the farm operations such as maize husks and the fodders, are wasted – usually burnt off.

The by-products or waste produced after the harvest can be baled for animal feeding.

However, the research has shown if products from the rural communities are processed within the community, soil structure could improve, promoting environmental and economic benefits. It is better to process the farm produce nearer the production site than to transport the raw produce elsewhere (Lynton-Evans (1997).

Furthermore, this research has shown that access to agricultural credits is essential, but extremely difficult for rural farmers, even when provisions for the credit is in place. Sadly, there is no means to measure the creditworthiness of the farmers. However, the Communal Model presented as an alternative funding arrangement in addition to the increased possibilities with many other stakeholders – the Virtual Investors. The Virtual Investors is a concept whereby active farmers with lands but lacking access to credits would be matched with Virtual Farmers or Investors (individuals who are willing to invest financially into the providing inputs to the rural farmers and share the profit of the output with the farmers on agreed percentage and terms). These investors can collaborate with farmers from anywhere in the world via the internet. The importance of the internet in this regard cannot be over-emphasized. The internet in agriculture would not only link the farmers with investors like virtual farmers; it would also lead the farmers to global markets.

Other challenges identified from the empirical study bothers on low yield per hectare compared to those of other countries like the UK, US and China. The research found out that it is not the number of farmers in a country that determines the food security of that country or region. Effectiveness of the farmers is the key. This effectiveness is in the form of yield per hectare of the farm and the contribution of the farmers to food security. In Kogi State, and in Nigeria, yield per hectare is too low – about 80 per cent below expectation. The contributing factors to this are deprived access to good agricultural practices, access to fake farm inputs, including fertilisers and seeds. However, with the Communal Model, access to improved seeds would be direct from the seed firms. Likewise, fertilisers. If there is an issue with seeds or fertilisers, it would be easy for the Communal Centres to address the issues. This is in contrast to the present situation where some fertiliser merchants were reported to have sold sea sands mixed with real NPK fertilisers and sold to the farmers.

Also, access to technology in this age is essential, but most of the farmlands are small, thereby limiting the capacity of each farmer to acquire or hire a tractor, for instance. As has been shown in this study that it is possible to combine the farmlands such that the subsistence farming could be managed like a commercial farm, allowing the use of technology through collaboration with Original Equipment Manufacturers (OEMs). The Communal Centres can access the technology on a Buy Now-Pay Later basis or purchase through collective effort of the farmers.

Similarly, the erratic nature of the market structure as currently obtained in the rural area of Kogi State would only make the situation of the rural farmers worse. There is a long chain between the farmers and the primary consumers of grains from the rural areas. This is such that only a fraction of what the farmers should have earned had it been the middlemen were not there, is what they are earing. However, with the Communal Model, farmers' produce can reach consumers directly.

9.6 Specific contribution to knowledge

The research has contributed to the body of knowledge in the following ways:

9.6.1 Research area and location

Understanding the typology of grain storage structures have not been studied in detail by any researcher, as has been done in this research. Besides the fact that the research incorporated all the communities in Kogi State in the study, it has also recognised the economic implication that the storage structures available has on the income of the farmers and the safety of the stored grains.

9.6.2 Methodological contribution

The use of a mixed-method approach in a multistage sampling to study storage structures in Kogi State is a new approach in the location this research covered. The methodology employed in this study was not counting how many silos or storage structures there was in Kogi State; it instead looked at the economic implications of the storage structures for grains (maize and rice). It looked at the implication of the storage structures on food safety, food security and farmers' economic condition. The roles of the market, the roles of the middlemen, the roles of the key players in the grain supply chain, and how the farmers can benefit optimally from an alternative storage model were also covered.

9.6.3 New approach to capacity building for the rural farmers

In support of the solutions to the challenges identified in the communities, the research recognised the need for a robust rural institution. Inadequate processing and storage facilities, poor access to markets, poor access to inputs and agricultural credit were the main problems. In addition, farmers' identity has been a challenge with past schemes. There is no means to know the actual farmers. Therefore, fraud and corruption are not easily spotted. Therefore, the Communal Model designed would not only solve the main problems identified by the farmers; it would ensure adequate collaboration between the farmers and various stakeholders for mutual benefits and preventing fraud.

9.6.4 Communal Model contribution

The research has contributed to the body of knowledge by the introduction of a new concept called the Communal Model. Nigeria has numerous agricultural schemes, programmes and projects over the last five decades, starting from the period of independence from the British in 1960. However, they do not focus on building the farmers economically or building a rural institution and capacity; instead, they were introduced as government interventions. The reality, however, none of these have helped pull the farmers out of poverty. The previous schemes could not be operated by the private sector because there were not optimized with any business model. This makes it difficult for stakeholders to get involved.

The Communal Model put forward in this study would bring the farmers within the same community together, devoid of political structures that exist at the ward, council, State and Zonal levels in Nigeria. The Communal Model was based on the survey carried out with participants from all the communities in the Kogi State, which indicated that farmers prefer to associate with farmers from their community instead of those form their ward, council, State or zones. The Communal Model ensures that a processing and storage centre exists within each community, where harvested grains are processed and stored to the international standard. The Centres would serve as a reliable intermediary between the farmers and stakeholders, which include consumer firms, input firms, credit firms and even donor agencies. The farmers would have the option to save in grains rather than in cash. Records of farmers' activities are kept both offline and real-time, enabling hardworking farmers to build up credit ratings called "activity ratings". The rating would help to ensure that active farmers are those farmers that can be recommended for agricultural credits and other personal household items from the stakeholders.

Similarly, market information would be provided to the farmers, and the farmers are to decide when they want their grains sold. Also, grains can be traded among farmers or between farmers and their respective Centres, or even between farmers and firms that utilise agricultural harvests as raw materials. Therefore, grains can be traded without moving the grains from the store until the final buyer is ready to use it. This, therefore, helps to reduce contaminations. The Communal Model would be regulated by the relevant institutions in Nigeria.

9.7 Research limitations

9.7.1 Methodological limitations

The methodology applied in this study was a mixed method. That is, both qualitative and quantitative research methods were used to address the role of storage systems in food security, food safety and rural economic development in Kogi State, North Central Nigeria.

The need for one-on-one contact and a face-to-face conversation with the participating farmers to obtain information on ease of access to pesticides, how to use the pesticides, grain processing methods, such as drying, and the different storage systems among the farmers, the overt and covert observation methods were adopted where appropriate.

It was also vital to obtain information on the grain silos complex in Kogi State, Nigeria. The silos have been under construction since 1994. The study used in-depth interactions with a key manager at the Silo Complex, to gain information into the current state of the complex. It was also essential to understand the typology of grain storage among the farmers and how it affects grain prices, quality of grains and farmers' perception of the probable solution to the everyday challenges. The research used the Questionnaire method to achieve this. The adoption of the mixed-method approach in this research has strengths as well as limitations as discussed below.

Questionnaires, like most evaluation methods, are subject to some limitations when used. For example, standardised questions could make it possible for participants to misinterpret some of the questions, and without the chance of explaining the points. However, this limitation was reduced significantly by piloting it with similar participants intended, thereby creating the needed avenue to note confusing and easily misunderstood part of the questionnaire. Secondly, the questionnaire was administered by the researcher, which provided room to clarify any grey area in the same manner to all the participants. The participants may also be forced to provide answers superficially due to fatigue. This was, however, minimised by adhering to the suggestion of Worthington and Whittaker (2006, *in* Martin and Sass, 2010), by keeping the time required to complete each questionnaire below 15 minutes.

Observation is a favourable method in behaviourism (Bandura, Ross & Ross, 1961). Covert observation is criticised as being deceptive, owing to lack of informed consent, because the researcher kept his true intentions secret. However, considering the nature of data required, the no observer-effect of this method was favourable to this research, especially when information on the ease of access to some dangerous pesticides are required. Also, no harm whatsoever was intended against the participants. Therefore it was within the research ethics.

The overt observation method means that the researcher is open, honest to the participants, intentions were made clear hence avoiding any ethical and local issues. However, the observer-effect or Hawthorne effect could mean that the participants could alter their behaviours because they were being observed. This disadvantage was minimised by engaging only the participants that are willing to participate without reservations.

Generally, the observation method was weakened by the fact that not enough time was spent with the communities and the people. However, the research was able to balance this weakness through adequate representativeness (positivist view) and validity (interpretivist view) by obtaining reliable data from the actual situation, people and location with mixed methods.

There was no feedback mechanism.

9.8 Recommendations for further research

Based on the evidence from; literature and empirical data of this research, the research provides the following recommendations: For immediate storage for family use, the existing storage systems could suffice for individual farmers' use but with adequate training provided to the farmers at the various Communal Centres designed in this research.

However, for "storage for better profit", the quality of the stored produce is determined by the effectiveness of the storage systems. Therefore, I recommend that the burden of processing and storage system be taken off the rural farmers in a private-public partnership platform called the Communal Model. However, the welfare of the farmers must be the focal theme of the model. The government plays regulatory and support roles, and it can also be one of the clients of the farmers and the Centre if it wants to build up its grain reserve for emergencies. The farmers must be able to earn at least, between 5-25 per cent profit for any production cost incurred. If farmers cannot break-even, then the essence of the manual toiling is defeated. This could increase bad agricultural practices and farming fraud among farmers.

I also recommend the restructuring of the National Agency for Food & Drug Administration and Control (NAFDAC) into two: The National Agency for Food Safety (NAFS) and then The National Agency for Drug Administration and Control (NADAC). The food sector requires as much scrutiny as that of the drugs in many cases. With adequate foods, the need for some medical treatment may drastically reduce. The division will help to increase efficiency, service delivery and help create new food and drug value chains.

Finally, a Communal Mobile Application could be built to manage the relationship between the stakeholders and the farmers while the Communal Centres stand as a secure, walk-in intermediary between them.

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APPENDIX A

INTERACTIONS WITH THE KEY PERSON AT THE GRAIN SILOS COMPLEX, KOGI STATE

Preamble

All responses provided are for research purposes only. The interview may last between 10 to 15 minutes, and you are free to decline any question(s) you may be uncomfortable with, at any time. May I also inform you that I will be recording this interview to enable me to review later. Once again, it is for research purpose only, and your identity is fully protected. Could you please confirm you are okay for us to proceed?

SM – Yes. Let us get started.

To start with, do we have grains in these Grain Bins?

SM – No. The Grain Bins is still under construction. It is unfortunate that a contract awarded in 1993 to be completed within 2 years is still under construction. That's how this country operates, and that is why we are not making progress with this project.

What then is the problem, why is it taking so long?

SM - It is corruption. What else could be the problem? Look, some people in the ministry of Agriculture, and even the Minister of Agriculture may be making money from the fund. Late President Umaru Yaradua [Former President of the country] released the entire fund required for the completion of the project. The process of freeing the money is the problem. Otherwise, the fund has been approved by the previous government.

Even before the contract was given, the money was kept somewhere for the project. For those in charge of the project to release the funds for the project to proceed is the issue. The components, everything from start to the finishing have been bought and brought to the site.

So, the Grain Bins is still under construction. We are just waiting for the needed fund.

When did the construction start?

SM – Technically, the Grain Bins project started in 1989. The other Grain Bins were awarded initially, but they were few of them. Those initial sites began just after the approval of the scheme in 1987. They were like samples of what they were going to do in other locations. The Storage Complex in Kogi State took off around 1993. Soon after, the project came to a halt. Nothing was done again until Late President Yaradua came on board [in 2007]. He revisited the programme in 2009 and approved the needed fund.

So, do the government pay you salary currently, since you are not working?

SM - No money yet.

The government have been looking for managers to manage the 33 Grain Silo Complexes across the country, but it appears they have not been able to reach a consensus with any company?

SM - How can they find managers when the Grain Bins have not been completed? No company would commit to the concession agreement because, first, the Grain Bins are still under construction with no definite completion date. Two, there is no clear strategy in place to maximise the grain silos. Until the logistic issues surrounding the grain production from the rural farmers are sorted with all sincerity, there is no apparent chance of any managers succeeding. There are no commercial farms around here that can provide the needed grain.

What is the capacity of this one?
SM - This one is 25000 MT capacity.

There are many of Storage Complexes in the country as we earlier said, which among them have been completed?

SM - Only a few have been completed. Maybe about three of them: two in the north and one in the south. The rest are still under construction.

In other words, this Grain Bins has no grain in it?
SM - Yes. No grains. In fact, I will take you round to see it yourself.

When this is completed, don’t you think it would be another problem getting grain into it?
SM - There are lots of grain in the villages. Go and see for yourself. For those that have been completed, like the ones in the north, the government awarded the contract for grain purchase to contractors, but the contractors are usually their political allies. They allocate and monitor the deals themselves. Nobody to checkmate anything. It is like the case of one

person being the lawyer and the same judge time. Corruption has eaten deep into the Grain Bins programme.

Okay, what has been done on-site now?

SM - Just metal construction. After that, the electrical wiring will follow. No control unit. The trailer drivers' lodge (about eight rooms) have been built, so that delivery drivers can spend the night when they come to deliver or pick up. The administrative office, warehouse for bagging, mechanical workshop, powerhouse, has been built. Other facilities available include the weighing bridge, dryers, blowers, and cleaning units but they are yet to be installed. There is a laboratory to check the quality of the grains. The conveyor, when completed can deliver up to 50 tons per hour.

How about the security personnel and other staff on-site?

SM - There is security. Even right now, there are 2 policemen on-site permanently. Also though it is not functioning yet, there must be secured to protect all the materials and equipment on-site which have not been installed. The other staff only comes when money is available for the work.

How do you source for materials and facilities for the bin construction?

SM - As of 1993, the government was giving the contractor money to purchase all the needed materials for the construction of the bins. All the materials for this site are supplied by a company called Mulmix, in Italy. However, the government ran into problems each time the contractors failed to deliver, and the means of revoking the contract and recovering the money became complicated and time-consuming. The new method now is that the contractor source for the required materials and facilities, then the government goes to pay for those materials, and they are delivered to the site. If a contractor fails to do the job, the contractor can then be replaced easily without any problems. When President Yaradua was alive, the work was moving as fast as expected.

APPENDIX B

A SAMPLE OF THE QUESTIONNAIRE

Preamble

Questionnaire to determine the mode of storage and significant challenges confronting the farmers in Kogi state. In this section, the questions would be read with their possible answers or options (where necessary) while you choose the option that most applied to you. Notes: All responses provided are for research purposes only. The questionnaire would take about 10 minutes but not more than 20 minutes to complete. Any of the questions can be declined if found uncomfortable. Thank you.

1. Which of the following is your primary system of storing grain after harvest? Please Choose ONE

- ☐ Bags/Sacks and then store in any available space within residential accommodation.
- ☐ Government-owned Grain Bins or structure for grain storage
- ☐ Spreading on the floor at any available space within residential accommodation without bagging.
- ☐ Grain storage in structures with mud walls and thatch roofs
- ☐ Grain storage in structures with thatch walls and thatch roofs
- ☐ Private Grain Bins (A cement block or metallic structure separate from residential building solely for storage)
- ☐ No, I do not store grain.

2. How long do you usually store your grain harvest before selling? Please specify---

3a. How much (gross) do you receive for a 50 Kg bag of (a) Maize -------------------- (b) Rice ---------------- if applicable?

3b. How many of the 50 Kg bags do you harvest in a year? ----------------------

3. How much is your estimated profit from the gross sales in question (3b) above? Please specify:

4. As a farmer in this community, what do you consider to be the primary challenge to your farming business? Please Choose Just ONE

- ☐ Low price on grain

- Unaffordable Fertilizers
- A scarcity of Improved Seedlings
- Lack of Agricultural Credits or Loans
- Poor of Storage/Processing facilities

5. Which of the following grain do you produce each year, usually for SALE (please select all that applies to you)
(a) Maize (b)Wheat (c)Rice (d)Guinea Corn (e) Soybean

6. How strongly do you agree with government empowering rural farmers within this community?

- Strongly Agree.
- Agree
- Neither Agree or Disagree
- Disagree
- Strongly Disagree

7. Which of the following ways should the government adopt as the MAIN rural empowerment strategy (Please tick JUST ONE)

- Buying their farm produce right at their communities at competitive prices
- Create Grain Processing and Storage Centres across the communities to improve grain market value
- Fertilisers availability/accessibility
- Provide Agricultural Credits or Loans for the farmers
- Accessibility of improved seedlings
- All the above
- None of the above

8. Do you agree with the scheme that allows the government to buy off grains by farmers willing to sell?

- Strongly agree
- Mildly agree
- Neither agree nor disagree

- Mildly Disagree
- Strongly Disagree

9. Are you aware of any government Grain Bins (Grain for grains storage) in Kogi state?
   - Yes, I am aware
   - No, I am not aware
   - I do not know

10. Do you experience grain waste during processing? YES NO

11. Do you experience grain waste during storage? YES NO

12. If YES, how much of the harvest do you think you are losing to waste during processing?

13. How much are you losing during storage?

14. Do you consider a Community Storage Centre for storing grains that are up for market something you would love to be part of? YES NO

15. Have accessed agricultural credit/loan at any time? YES NO

16. If Yes (in Question 16), Who provided the credit? --

17. Do you have a bank account? YES NO

18. Do you think central storage for your community a welcome alternative?

    YES NO

19. Note that such community storage will buy your grains, helps you to sell your grains, keep the record of your grains and even help you access credits and

inputs for your farms. Do you still think central community storage is okay in your community?

Yes NO.

20. How old are you? Please state EXACT age. If you don't know, estimate.

____

21. What is your gender?
- ☐ Male
- ☐ Female

22. Which of the following educational institution did you complete?
- ☐ Primary School
- ☐ Secondary School
- ☐ Tertiary Institution
- ☐ No formal education

23. Are you married?
- ☐ Married
- ☐ Single
- ☐ Divorced
- ☐ Prefer not to say

24. Do you have a bank account?
- ☐ Yes
- ☐ No

In the following section, I will be asking you two questions to know how you sell your grain and what drives your attachment to your community (if any).

25. How do you usually sell your grains?

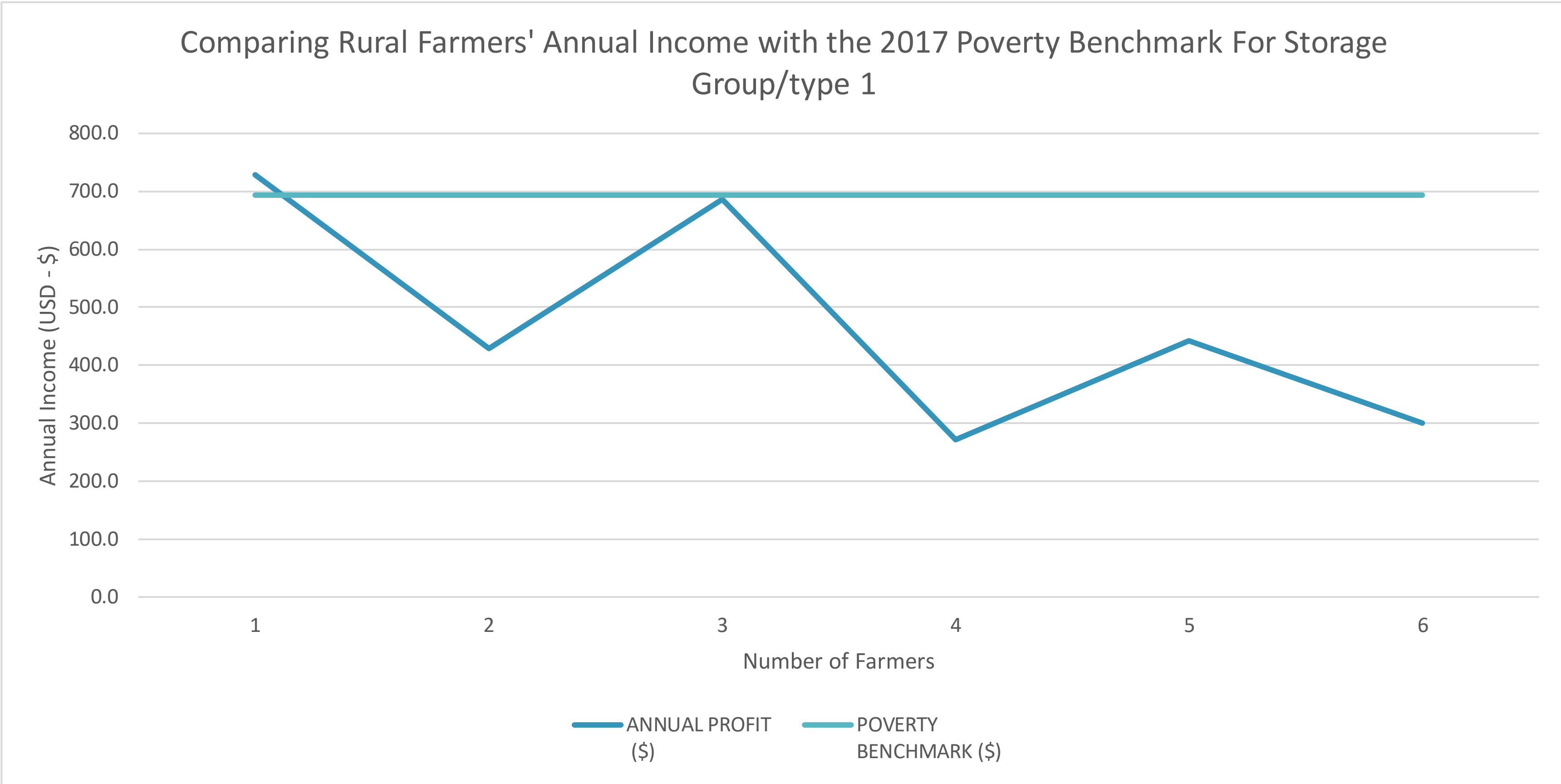
26. In one word or sentence, describe your connection to your community?

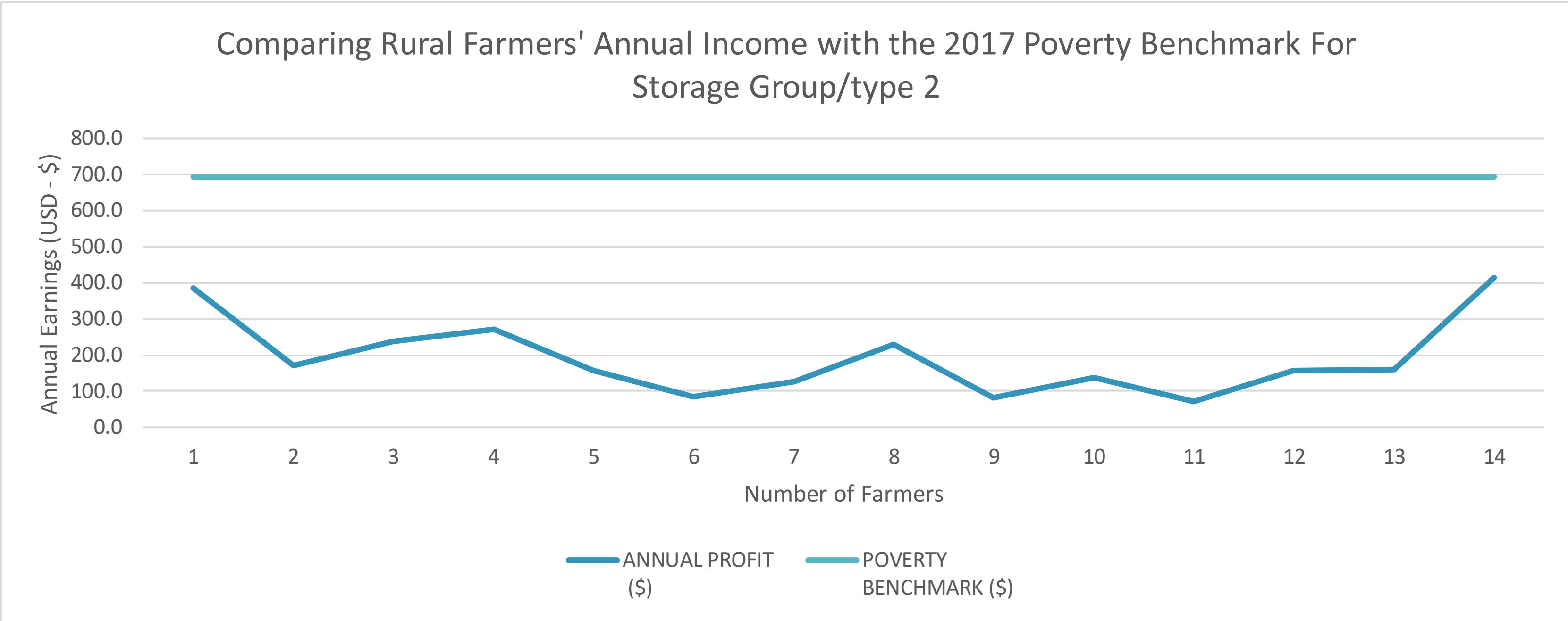
27. Based on the question (26) above, would you instead engage meaningfully with your community or local councils?

APPENDIX C

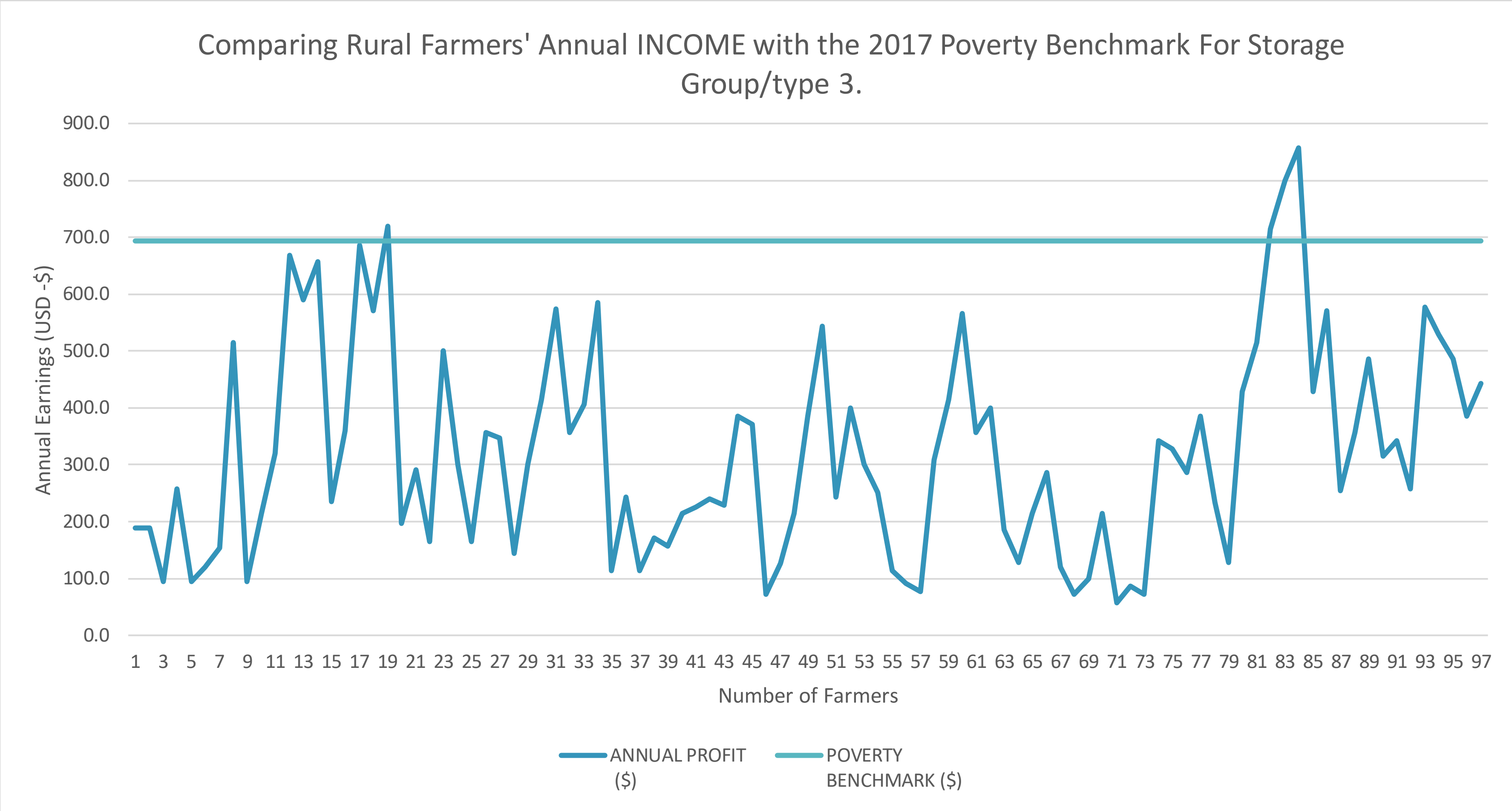
The farmers who earned above the 2017 poverty benchmark group came from those in the highlighted storage group/types in the table below:

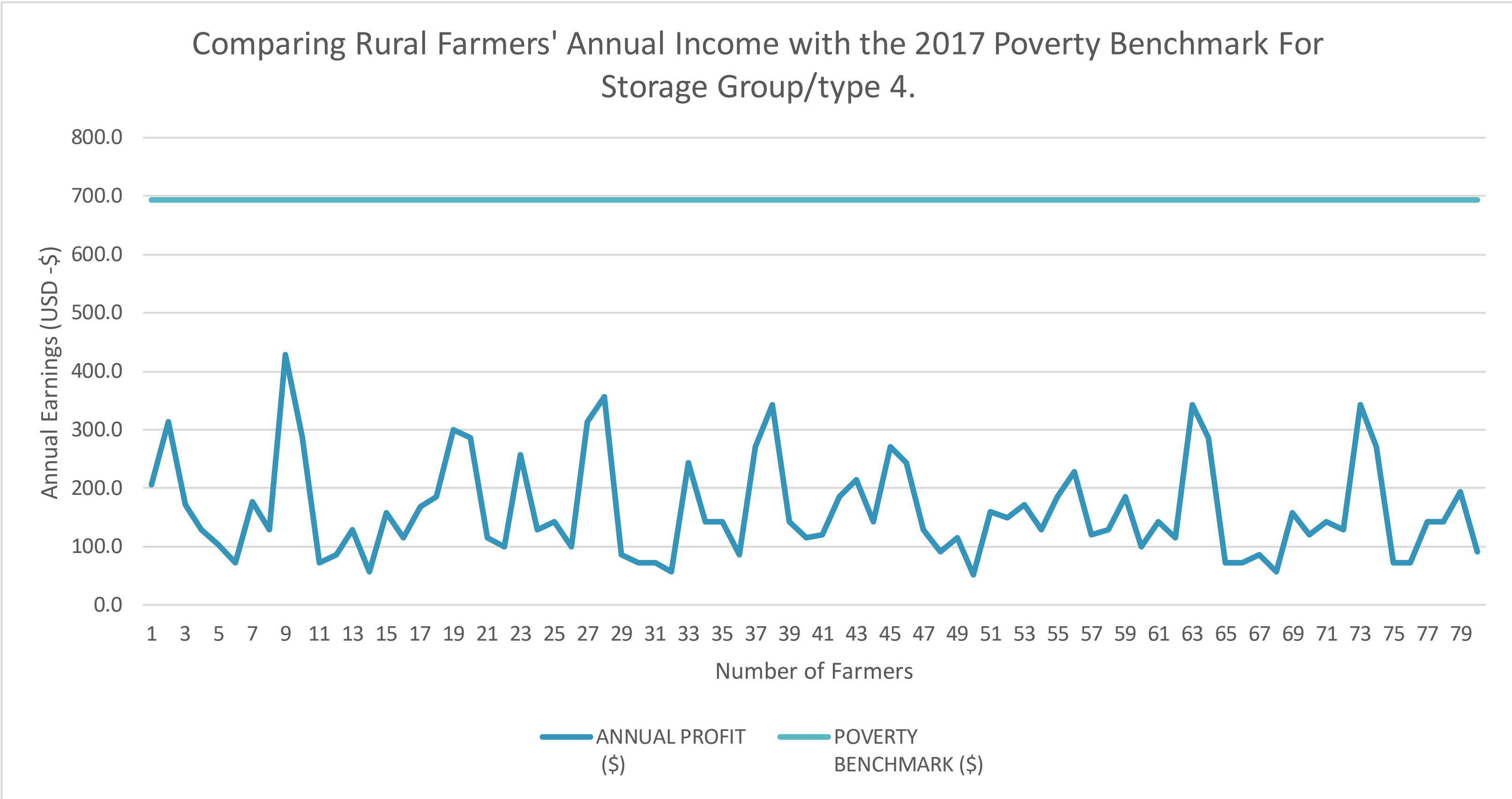
Storage Groups/type	Storage type descriptions	Mean Annual Earning (Naira - ₦)	Mean Annual Earning ($)*	The 2017 Poverty Benchmark ($)	Number of Farmers in the category	Mean Length of Storage (Weeks)
1	Concrete blocks with zinc roofs (pics or woven bags)	166667	476.2	693.5	6	18.0
2	Open spreading of grains at home without bagging	67143	191.8	693.5	14	5.3
3	Woven bags then stored in any available space at home	112374	321.1	693.5	97	12.0
4	Mud walls and thatch roofs	56975	162.8	693.5	80	7.2
5	Thatch walls and thatch roofs	57274	163.6	693.5	55	8.1
6	No-storage farmers - grain sold shortly after harvest	31115	88.9	693.5	48	0.0

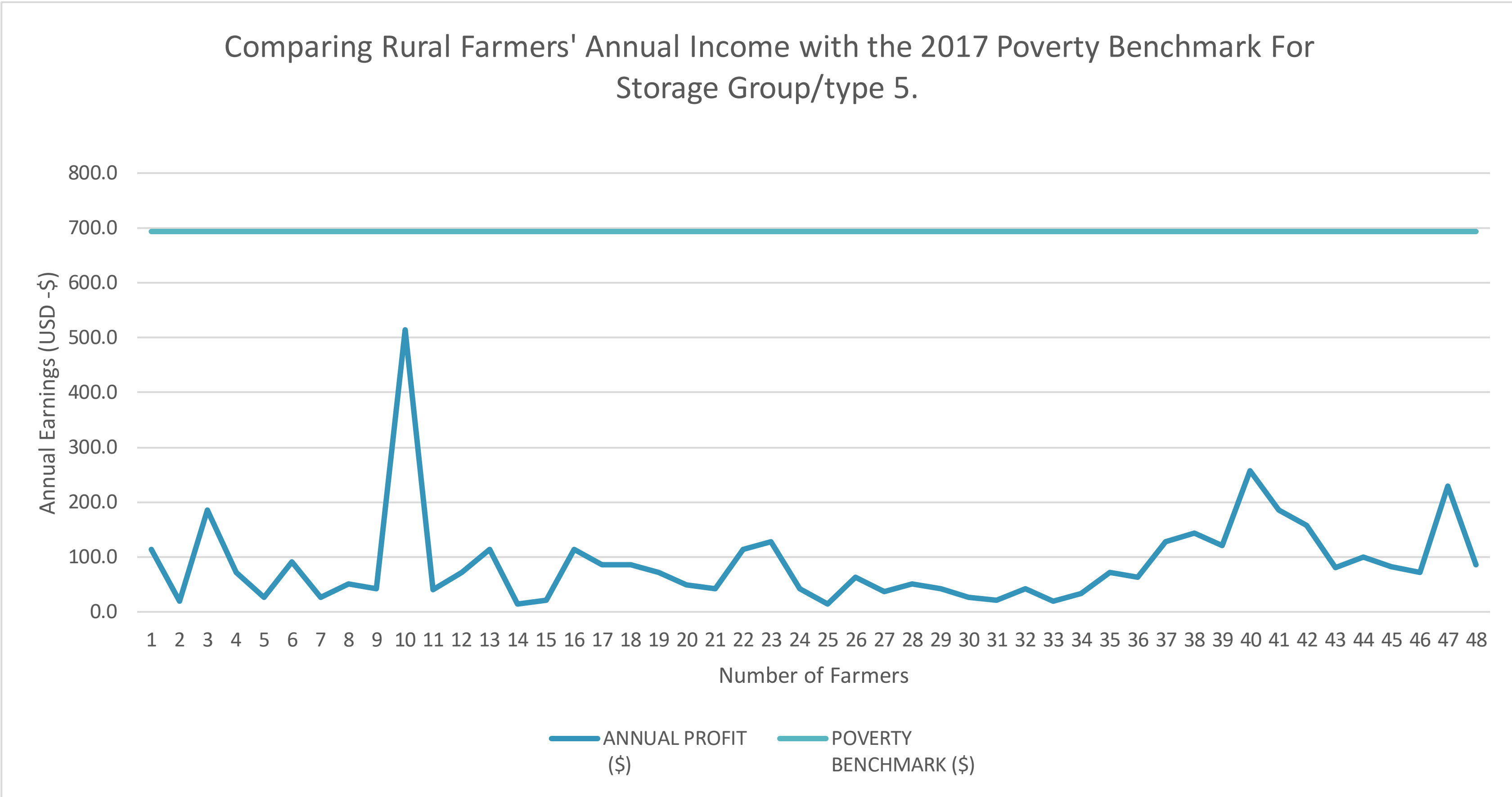

Comparing Rural Farmers' Annual Income with the 2017 Poverty Benchmark For Storage Group/type 1
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Annual Income (USD - $)
1
2
3
4
5
6
Number of Farmers
ANNUAL PROFIT ($)
POVERTY BENCHMARK ($)

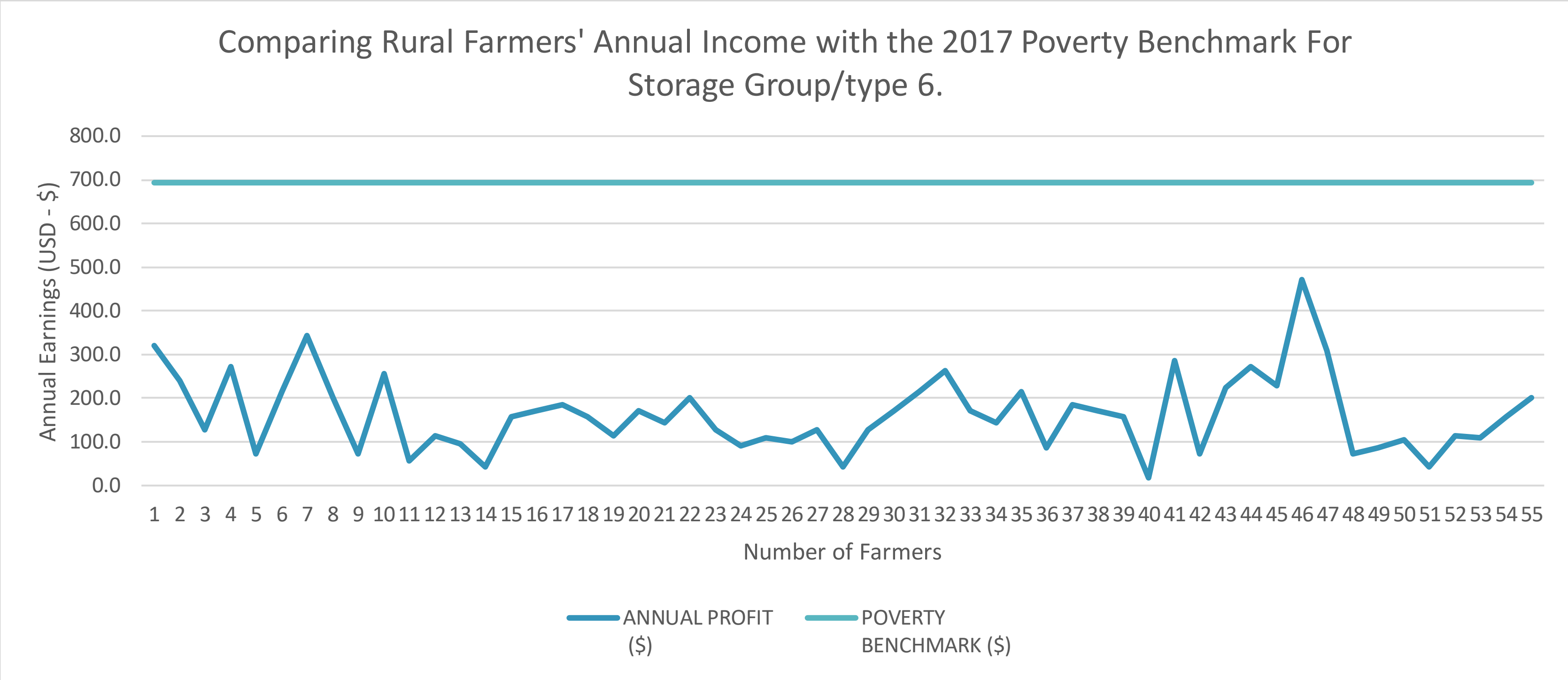


Comparing Rural Farmers' Annual Income with the 2017 Poverty Benchmark For Storage Group/type 2
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
Annual Earnings (USD - $)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Number of Farmers
ANNUAL PROFIT ($)
POVERTY BENCHMARK ($)


Comparing Rural Farmers' Annual INCOME with the 2017 Poverty Benchmark For Storage Group/type 3.
Annual Earnings (USD -$)
900.0
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79 81 83 85 87 89 91 93 95 97
Number of Farmers
ANNUAL PROFIT ($)
POVERTY BENCHMARK ($)


Comparing Rural Farmers' Annual Income with the 2017 Poverty Benchmark For Storage Group/type 4.
Annual Earnings (USD -$)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39 41 43 45 47 49 51 53 55 57 59 61 63 65 67 69 71 73 75 77 79
Number of Farmers
ANNUAL PROFIT ($)
POVERTY BENCHMARK ($)


Comparing Rural Farmers' Annual Income with the 2017 Poverty Benchmark For Storage Group/type 5.
Annual Earnings (USD -$)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
Number of Farmers
ANNUAL PROFIT ($)
POVERTY BENCHMARK ($)


Comparing Rural Farmers' Annual Income with the 2017 Poverty Benchmark For Storage Group/type 6.
Annual Earnings (USD - $)
800.0
700.0
600.0
500.0
400.0
300.0
200.0
100.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55
Number of Farmers
ANNUAL PROFIT ($)
POVERTY BENCHMARK ($)

APPENDIX D

Table showing the earnings of each farmer as obtained from the empirical study

SUMMARY OF THE FARMERS' ADOPTED STORAGE TYPES AND THEIR NUMBERS		
Storage groups/type	Storage type descriptions	Number of farmers in the category
1	Concrete blocks with zinc roofs (pics or woven bags)	6
2	Open spreading of grains at home without bagging	14
3	Woven bags then stored in any available space at home	97
4	Mud walls and thatch roofs	80
5	Thatch walls and thatch roofs	55
6	No-storage farmers - grain sold shortly after harvest	48

INDIVIDUAL FARMERS' ANNUAL EARNINGS/INCOME						
S/N	Annual Income ($) 1	Annual Income ($) 2	Annual Income ($) 3	Annual Income ($) 4	Annual Income ($) 5	Annual Income ($) 6
1	728.6	385.7	188.6	205.7	114.3	320
2	428.6	171.4	188.6	314.3	18.6	241.1
3	685.7	238	94.3	171.4	185.7	128.6
4	271.4	272	257.1	128.6	71.4	271.4
5	442.9	155.7	94.3	102.9	27.1	71.4
6	300	85.7	120	71.4	91.4	214.3
7		127.5	154.3	177.1	27.1	342.9

8		228.6	514.3	128.6	51.4	200
9		82.5	94.3	428.6	42.9	71.4
10		137.1	214.3	285.7	514.3	257.1
11		71.4	320.6	71.4	40	57.1
12		157.1	667.9	85.7	71.4	114.3
13		158.6	589.3	128.6	114.3	96.4
14		414.3	657.1	57.1	14.3	42.9
15			235.7	157.1	21.4	157.1
16			360	114.3	114.3	171.4
17			685.7	168.6	85.7	185.7
18			571.4	185.7	85.7	157.1
19			720	300	71.4	114.3
20			196.4	285.7	48.6	171.4
21			291.4	114.3	42.9	142.9
22			164.3	100	114.3	200
23			500	257.1	128.6	128.6
24			300	128.6	42.9	91.4
25			164.3	142.9	14.3	108.6
26			357.1	100	62.9	100
27			346.4	314.3	37.1	128.6
28			144.3	357.1	51.4	42.9
29			300.7	85.7	42.9	128.6
30			414.3	71.4	25.7	171.4
31			574.3	71.4	21.4	214.3
32			357.1	57.1	42.9	262.9

33			405.7	242.9	20	171.4
34			585.7	142.9	34.3	142.9
35			114.3	142.9	71.4	214.3
36			242.9	85.7	62.9	85.7
37			113.1	271.4	128.6	185.7
38			171.4	342.9	142.9	171.4
39			157.1	142.9	120	157.1
40			214.3	114.3	257.1	17.7
41			226.3	120	185.7	285.7
42			240	185.7	157.1	71.4
43			228.6	214.3	80	225
44			385.7	142.9	100	271.4
45			371.4	271.4	82.9	228.6
46			71.4	242.9	71.4	471.4
47			125.7	128.6	228.6	308.6
48			214.3	91.4	85.7	71.4
49			385.7	114.3		85.7
50			542.9	51.4		105.7
51			242.9	160		42.9
52			400	148.6		114.3
53			300	171.4		108.6
54			251.4	128.6		157.1
55			114.3	185.7		200
56			91.4	228.6		
57			77.1	120		

58			308.6	128.6		
59			414.3	185.7		
60			565.7	100		
61			357.1	142.9		
62			400	114.3		
63			185.7	342.9		
64			128.6	285.7		
65			214.3	71.4		
66			285.7	71.4		
67			120	85.7		
68			71.4	57.1		
69			100	157.1		
70			214.3	120		
71			57.1	142.9		
72			85.7	128.6		
73			71.4	342.9		
74			342.9	271.4		
75			328.6	71.4		
76			285.7	71.4		
77			385.7	142.9		
78			234.3	142.9		
79			128.6	194.3		
80			428.6	91.4		
81			514.3			
82			714.3			

83			800			
84			857.1			
85			428.6			
86			571.4			
87			254.3			
88			357.1			
89			485.7			
90			314.3			
91			342.9			
92			257.1			
93			577.1			
94			528.6			
95			485.7			
96			385.7			
97			442.9			