UNIVERSITI PUTRA MALAYSIA

POTENTIAL OF ADOPTING SMALL SCALE POSTHARVEST PRACTICES TOWARDS REDUCING PLANTAIN SUPPLY CHAIN FOOD LOSSES IN RIVERS STATE, NIGERIA

KWAMI JUSTINA KENOBI MORRIS

FP 2018 25

POTENTIAL OF ADOPTING SMALL SCALE POSTHARVEST PRACTICES TOWARDS REDUCING PLANTAIN SUPPLY CHAIN FOOD LOSSES IN RIVERS STATE, NIGERIA

By

KWAMI JUSTINA KENOBI MORRIS

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

December 2017

COPYRIGHT

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirements for the degree of Doctor of Philosophy

POTENTIAL OF ADOPTING SMALL SCALE POSTHARVEST PRACTICES TOWARDS REDUCING PLANTAIN SUPPLY CHAIN FOOD LOSSES IN RIVERS STATE, NIGERIA

By

KWAMI JUSTINA KENOBI MORRIS

December 2017

Chairman : Associate Professor Nitty Hirawaty Kamarulzaman, PhD
Faculty : Agriculture

Postharvest losses (PHLs) is the most significant contributor of food losses in developing countries. High PHLs in food staples like plantain pose a threat to food security in Nigeria; therefore, viable strategies to reduce PHLs in agri-food supply chains is in dire need. Conventional postharvest technologies used in modern agri-food supply chains in developed countries require high capital investments and technological competence; most of which is lacking in Nigeria. Although, sophisticated postharvest technologies may not be within the reach of farmers and traders who operate in traditional supply chains, small-scale postharvest practices (SSPPs) such as shade-cooling, hydro-cooling, use of protective transport materials are simpler alternatives to help maintain produce quality, prolong shelf-life and consequently reduce PHLs.

However, the adoption of these SSPPs is low and there is dearth of information in this regard. This study adopted a quantitative approach to investigate the potential adoption of selected SSPPs by plantain farmers and traders who operate in a traditional supply chain in Rivers State, Nigeria. The study intended to determine the influence of adoption factors on farmers and traders intention to use SSPPs. The data used in the study were obatained via face-to-face interviews using two structured questionnaire where one questionnaire was administered to farmers and the other one administered to the traders. The data were analysed using statistical techniques such as descriptive analyses, chi-square, mean ranking, T-test, Pearson's correlation, and partial least square structural equation modelling.

In terms of the losses, the findings of the study revealed that a significant amount of plantain comodity is entirely lost from the food supply chain; this is regarded as the quantitative losses. Furthermore, it was observed that more than half of the produce is reportedly sold at reduced prices due to quality deterioration; this form of losses was interpreted as the amount of qualitative losses. A correlation analysis revealed that use of small-scale postharvest practices had a significant negative relationship with the amount of self-reported quantitative and qualitative losses at both farm and market levels.

With regards to adoption, the results of the chi-square analyses indicated that gender, education level, occupation, harvetsed produce and information sources were significantly associated with farmers adoption whereas experience level and information sources were the significant factors associated with the traders adoption of SSPPs. Based on the mean rankings, the respondents were observed to have low awareness and adoption rates for a majority of the postharvest practices investigated. In addition, the results of t-tests show that adopters demonstarted more positive perceptions of the SSPPs than non-adopters.

Furthermore, an exploratory factor analysis (EFA) revealed six and five factors as representing perceptions towards SSPPs perceptions towards each postharvest practice as relevant to farmers and traders repectively. This implies that when respondents evaluated the usefulness and complexity of a particular postharvest practice, they evaluated the practice as one entity rather than considering the perceived usefulness and ease of use of the postharvest practice as separate dimensions. Factor analysis of the items that measured behaviour towards adoption of SSPPs extracted three factors named as attitudes, motivation and intention. The EFA factor solutions were further confirmed during confirmatory factor analysis during which the measurement models were rigourosly assessed to ensure reliability and validity of constructs and scales.

Assessment of the variables that influence farmers and traders potential to adopt SSPPs with intention to use postharvest practices as the dependent variable, the results of the structural equation modelling found that awareness level, perceptions, attitudes and motivation significantly predicted intention to use SSPPs with 55.4% and 33.4% of the variances accounted for in the data that were obtained from farmers and traders repectively. In addition, attitudes significantly mediated the relationships between plantain farmers and traders intention and their perceptions and motivation towards using SSPPs. A rigourous assessment of the structural models showed that the hypothesized model was supported by empirical data. The model had acceptable predictive relevance and ability to account for moderate to substantial variance in both data sets.

In conclusion, postharvest interventions that aim to be successful must recognize the critical role of understanding their target audience. Technology push must be balanced with an understanding of the potential adopters' preferences in order to attain successful and strategic solutions. In this regard it is recommended that future interventions should ascertain the perceptions held by the potential adopters prior to dissemination of solutions. The strong positive effect of motivation on behavioral intention suggests a necessity to identify and utilize peculiar factors in motivating adoption of postharvest solutions.

Abstrak tesis dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

POTENSI PELAKSANAAN AMALAN LEPAS TUAI BERSKALA KECIL KE ARAH MENGURANGKAN KERUGIAN RANTAIAN BEKALAN MAKANAN PISANG TANDUK DI NEGERI RIVERS, NIGERIA

Oleh

KWAMI JUSTINA KENOBI MORRIS

Disember 2017

Pengerusi : Profesor Madya Nitty Hirawaty Kamarulzaman, PhD
Fakulti : Pertanian

Kerugian lepas tuai (KLT) adalah penyumbang terbesar kerugian makanan di negara-negara membangun. Kerugian lepas tuai (KLT) yang tinggi dalam makanan ruji seperti pisang tanduk menimbulkan ancaman kepada keselamatan makanan di Nigeria; oleh itu, strategi yang berdaya maju untuk mengurangkan KLT dalam rantaian bekalan makanan pertanian sangat diperlukan. Teknologi lepas tuai konvensional yang digunakan dalam rantaian bekalan makanan pertanian moden di negara maju memerlukan pelaburan modal yang tinggi dan kecekapan teknologi; kebanyakannya masih kurang di Nigeria. Walaupun, teknologi lepas tuai yang canggih mungkin tidak dapat dicapai oleh para petani dan peniaga yang beroperasi dalam rantaian bekalan tradisional, amalan lepas tuai berskala-kecil (ALTSK) seperti penyejukan teduh, penyejukan hidro, penggunaan bahan-bahan pengangkutan perlindungan adalah alternatif yang lebih mudah untuk membantu mengekalkan kualiti penghasilan, memanjangkan jangka hayat dan seterusnya mengurangkan KLT.

Walau bagaimanapun, penggunaan ALTSK adalah rendah dan terdapat kekurangan maklumat dalam hal ini. Kajian ini menggunakan pendekatan kuantitatif untuk menyelidik potensi pelaksanaan ALTSK yang dipilih oleh petani yang mengusahakan tanaman pisang tanduk dan peniaga ladang yang beroperasi di rantaian bekalan tradisional di Rivers State, Nigeria. Kajian ini bertujuan untuk mengkaji pengaruh faktor-faktor pelaksanaan terhadap niat petani dan peniaga untuk menggunakan ALTSK. Data yang digunakan dalam kajian ini diperolehi melalui wawancara bersemuka dengan menggunakan dua soal selidik berstruktur di mana satu soal selidik dikhaskan untuk petani dan yang satu lagi dikhaskan untuk peniaga. Data dianalisis dengan menggunakan teknik statistik seperti analisis deskriptif, Khi

kuasa dua, kedudukan min, ujian T, korelasi Pearson, analisis regresi dan pemodelan persamaan struktur berdasarkan varians.

Dari segi kerugian, penemuan kajian mendedahkan bahawa sejumlah komoditi pisang tanduk yang besar hilang sepenuhnya dari rantaian bekalan makanan, ini dianggap sebagai kerugian kuantitatif. Tambahan pula, diperhatikan bahawa lebih separuh daripada hasil dilaporkan dijual pada harga yang dkikurangan disebabkan kemerosotan kualiti; ditafsirkan sebagai jumlah kerugian kualitatif. Analisis korelasi mendedahkan bahawa penggunaan amalan pasca lepas tuai berskala kecil mempunyai hubungan negatif yang signifikan dengan jumlah kerugian kuantitatif dan kualitatif di kedua-dua peringkat ladang dan pasaran.

Berkenaan dengan pelaksanaan, keputusan analisis Khi kuasa dua menunjukkan bahawa jantina, tahap pendidikan, pekerjaan, hasil tuaian dan sumber maklumat sangat berkait rapat dengan pelaksanaan petani manakala tahap pengalaman dan sumber maklumat adalah faktor penting yang berkait dengan peniaga pelaksanaan ALTSK. Berdasarkan kedudukan min, responden diperhatikan mempunyai kesedaran yang rendah dan kadar pelaksanaan untuk sebahagian besar amalan pasca lepas tuai. Di samping itu, keputusan ujian T menunjukkan pengamal mempunyai lebih banyak persepsi positif terhadap ALTSK berbanding bukan pengamal.

Tambahan pula, analisis faktor penerokaan (AFP) mendedahkan enam dan lima faktor sebagai mewakili persepsi terhadap ALTSK dan juga persepsi terhadap setiap amalan lepas tuai yang berkaitan dengan petani dan peniaga. Ini menunjukkan bahawa apabila responden menilai kegunaan dan kerumitan amalan lepas tuai tertentu, mereka menilai amalan sebagai satu entiti daripada mempertimbangkan kegunaan yang dirasakan dan memudahkan penggunaan amalan lepas tuai sebagai dimensi yang berasingan. Analisis faktor terhadap item yang mengukur tingkah laku penggunaan ALTSK mengekstrak tiga faktor iaitu sikap, motivasi dan niat. Penyelesaian faktor AFP disahkan lagi semasa analisis faktor pengesahan yang mana model pengukuran dinilai dengan teliti untuk memastikan kebolehpercayaan dan kesahan konstruk dan skala.

Penilaian pemboleh ubah yang mempegaruhi potensi pelaksanaan ALTSK oleh petani dan peniaga dengan niat penggunaan amalan lepas tuai sebagai pemboleh ubah bergantung, keputusan pemodelan persamaan struktur mendapati bahawa tahap kesedaran, persepsi, sikap dan motivasi dengan jelas meramalkan niat untuk menggunakan ALTSK dengan 55.4% dan 33.4% varians diambilkira dalam data yang diperolehi daripada petani dan peniaga secara beransur-ansur. Di samping itu, sikap secara signifikan menjadi hubungan pengantara antara petani dan niat peniaga dan persepsi dan motivasi mereka terhadap pengunaan ALTSK. Penilaian teliti terhadap model struktur menunjukkan bahawa model hipotesis disokong oleh data empirikal. Model ini mempunyai perkaitan dan keupayaan ramalan yang boleh diterima untuk mengira varians yang sederhana dan besar dalam kedua-dua set data.

Sebagai kesimpulan, campurtangan lepas tuai yang bertujuan untuk berjaya perlu mengenal pasti peranan kritikal untuk memahami audien sasaran mereka. Prkembangan teknologi mestilah seimbang dengan kefahaman tentang keupayaan penerima yang berpotensi untuk mencapai penyelesaian yang berjaya dan strategik. Dalam hal ini disarankan agar campur tangan masa depan perlu memastikan persepsi penerima sebelum penyebaran penyelesaian. Kesan motivasi positif terhadap niat tingkah laku mencadangkan keperluan untuk mengenal pasti dan menggunakan faktor-faktor khusus dalam memotivasi penerapan penyelesaian lepas tuai.

ACKNOWLEDGEMENTS

I thank the Almighty God for giving me the strength to embark and complete this PhD journey.

I am indebted to the Organization for Women in Science for the Developing World (OWSD) for sponsoring this research.

My heartfelt appreciation goes to my supervisor Associate Professor Dr. Nitty Hirawaty Kamarulzaman for her guidance, counsel and immeasurable support throughout this challenging PhD journey.

I would also like to sincerely thank my supervisory committee members: Professor Dr. Zainal Abidin Mohamed, Associate Professor Dr. Nolila Mohd Nawi and Associate Professor Dr. Norsida Man for their helpful comments and suggestions during this process.

My appreciation goes to my parents, siblings and in-laws for their prayers that kept me going when the challenges were tough.

My humble thanks go to my friends and colleagues such as Dr. Gowry Vijayan, Dr. Selvakkumar Vaiappuri, Lai Lai, Stephanie Okogba and others who in one way or the other made this journey exciting.

I am mostly indebted to my dearest husband Dr. Kenobi Isima Morris for his love, support, encouragements during the high and low times in this journey. You are indeed the best companion anyone could wish for.

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

Nitty Hirawaty Kamarulzaman, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malalysia
(Chairman)

Zainal Abidin Mohamed, PhD
Professor
Faculty of Agriculture
Universiti Putra Malalysia
(Member)

Norsida Man, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malalysia
(Member)

Nolila Mohd Nawi, PhD
Associate Professor
Faculty of Agriculture
Universiti Putra Malalysia
(Member)

ROBIAH BINTI YUNUS, PhD
Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

Declaration by Members of Supervisory Committee

This is to confirm that:

- the research conducted and the writing of this thesis was under our supervision;
- supervision responsibilities as stated in Universiti Putra Malaysia (Graduate Studies) Rules 2003 (Revision 2012 – 2013) were adhered to.

Signature: _____
Name of Chairman of Supervisory Committee: Associate Professor Dr. Nitty Hirawaty Kamarulzaman

Signature: _____
Name of Member of Supervisory Committee: Professor Dr. Zainal Abidin Mohamed

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Norsida Man

Signature: _____
Name of Member of Supervisory Committee: Associate Professor Dr. Nolila Mohd Nawi

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

GDP	Gross Domestic Product
ADP	Agriculture Development Project
RBDA	River Basin Development Authority
HYV	High Yielding Varieties
DFRRI	Directorate of Food Roads and Rural Infrastructure
OFN	Operation Feed the Nation
SAP	Structural Adjustment Programme
NDE	The National Directorate of Employment
NFDP	National Fadama Development Project
NPFS	National Program on Food Security
RTEP	Root and Tuber Expansion Programme
PIA	Presidential Initiatives in Agriculture
ATA	Agriculture Transformation Agenda
FAOSTAT	Food and Agriculture Organization
LGA	Local Government Areas
APHLIS	African Postharvest Losses Information System
FAO	Food and Agriculture Organization
NBS	National Bureau of statistics
IITA	International Institute of Tropical Agriculture
AFSCs	Agri-food Supply Chains
GAP	Good Agriculture Practices
DOI	Diffusion of Innovation
TAM	Technology Acceptance Model
PU	Perceived Usefulness
PEOU	Perceived Ease of Use
FMARD	Federal Ministry of Agriculture and Rural Development
RSMA	Rivers State Ministry of Agriculture
IFPRI	International Food Policy Research Institute
RSADP	Rivers State Agriculture Development Programme

GHG	Greenhouse Gas
UNEP	United Nations Environment Programme
FLs	Food Losses
FW	Food Waste
PHLs	Postharvest Losses
TPB	Theory of Planned Behavior
RH	Relative Humidity
FSC	Food Supply Chain
CSA	Commodity System Analysis
SN	Subjective Norm
ACV	Attribute Consequences Values
ZECC	Zero Energy Cooling Chamber
MCAR	Missing Completely at Random
CR	Composite Reliability
EFA	Exploratory Factor Analysis
KMO	Kaiser-Meyer-Oklin
CFA	Confirmatory Factor Analysis
HTMT	Heterotrait-monotrait
SEM	Structural Equation Modeling
PLS	Partial Least Squares
CB-SEM	Covariance Based Structural Equation Modeling
PLS-SEM	Partial least square-structural equation modeling
HOC	High order construct
AVE	Average Variance Extracted
SD	Standard Deviation
SSPPs	Small-Scale Postharvest Practices
OLS	Ordinary Least Squares
VIF	Variance Inflation Factor
GHS	General Household Survey
WHO	World Health Organization

CHAPTER 1

INTRODUCTION

This chapter gives a brief description of the state of Nigerian agriculture sector. The issues and challenges that have embattled the sector are discussed with reference to the food security. Specifically, the chapter focuses on the opportunities for improvement in the plantain supply chain. The chapter also consists of the problem statement, the research questions, the study's objectives and the organization of the thesis.

1.1 The Nigerian Agriculture Sector

The agriculture sector is a significant component of the Nigerian economy. It is a source of livelihood for most Nigerians and the largest employer of labor employing about 70% of the labor force. The sector contributes about 30% of the national GDP (Olayemi *et al.*, 2012; Odetola and Etumnu, 2013). Despite prevalence of bottlenecks, the Nigerian agriculture sector has remained a resilient sector in the country's economy. According to the National Bureau of Statistics, the sector recorded 4.47% and 4.7% growth in the third and first quarters of 2014 and 2015 respectively (NBS, 2016). As a large sector, growth of the Nigerian agricultural sector is dependent on the contribution of key subsectors such as crop production, livestock, fishery and forestry, that make up the entire sector. The major sub-sectors in terms of contributions to economic growth are the crop production followed by livestock.

Generally, the Nigerian agriculture sector mostly comprise of smallholder farmers who contribute about 90% of the total crop production. Thus, smallholders form the backbone of the Nigerian agriculture sector (IFPRI, 2012; Odetola and Etumnu, 2013). Smallholders mainly rely on traditional methods for most of their activities. Reliance on traditional agricultural techniques has adversely affected the developmental potentials of the sector. According to FMARD (FMARD, 2013), the country has a comparative advantage in terms of labor availability, arable land and climatic conditions suitable for production of a variety of agricultural products. Besides, the country's population provides a readily available domestic market for agricultural products which can as well as be channeled to international markets to increase foreign earnings.

Nigeria as a country has hoped to improve the livelihoods of the citizens by strengthening its agriculture sector towards in order to end rural poverty and improve food security as well as increase foreign exchange from agriculture. To this effect, several agricultural policies and initiatives had been formulated and targeted at revamping small-holder production systems in the various sub-sectors of agriculture.

Some of the past and surviving agricultural policies and initiatives established after the colonial administration are briefly described in Table 1.1

Table 1.1 : Agricultural Policies and Initiatives in Nigeria

Policy / Initiative	Description	Sources
First National Development Plan (1962 to 1968)	Aim to increase production of export crops and boost export earnings by effective distribution of seeds and integration of modern practices. Successful but did not focus of food crops.	(Asoegwu and Asoegwu, 2007)
Second National Development Plan (1970 to 1974)	Focused on improving rural employment and agricultural ventures by strengthening research and extension services. Poorly executed due to inadequate investments in the sector.	(Asoegwu and Asoegwu, 2007)
Agriculture Development Project (ADP) (1975)	The initiative was to accelerate technology transfer to improve welfare of small-holder farmers and attain food security. Initial coverage in a few localities was successful. Failed due to high emphasis on sophisticated technologies.	(Iwuchukwu and Igbokwe, 2012; Omonijo *et al.*, 2014)
Third National Development Plan (1975 to 1980)	Seek to address the decline in food supplies by strengthening food security in the country. Poor execution and neglect of the sector.	(Asoegwu and Asoegwu, 2007)
Operation Feed the Nation (1976)	The main goal of OFN was to address the food needs of the growing population by raising awareness on food sufficiency and re-engaging youths in agriculture. Unsuccessful as distribution of inputs were prioritized to public establishments over the real farmers who are mostly small-holders.	(Asoegwu and Asoegwu, 2007; Agber, Iortima and Imbur, 2013)
River Basin Development Authorities (RBDAs) (1976)	Targeted at harnessing the economic potentials of existing water bodies in the country through activities such as: fishery, irrigation and others. Unsuccessful due to political interference.	(Agber, Iortima and Imbur, 2013)
The Green Revolution Program (1980)	Aimed to increase food security of basic staples through mechanization and use of high yielding varieties (HYVs), credit facilities and marketing. Delays in project execution, inadequate monitoring and evaluation.	(Asoegwu and Asoegwu, 2007; Agber, Iortima and Imbur, 2013)
Fourth National Development Plan (1981 to 1985)	Its goal was to strengthen the RBDAs and ADPs to produce more food for the country.	(Asoegwu and Asoegwu, 2007)
Directorate of Food Roads and Rural Infrastructure (DFRRI) (1986)	The aim of DFRRI was to enhance sustainable rural development by improving the rural quality of life through provision of basic infrastructures. The initiative has been criticized for lacking focus and accountability.	(Iwuchukwu and Igbokwe, 2012)

Structural Adjustment Programme (SAP) (1986)	The SAP was to drastically reduce food importation in order to encourage local production. The agenda has been criticized for its weak implementation	(Asoegwu and Asoegwu, 2007)
The Directorate of Employment (NDE) (1988)	The NDE targeted reduction of youth unemployment by giving trainings and grants to beneficiaries venturing into agriculture.	(Asoegwu and Asoegwu, 2007)
National Fadama Development Project (NFDP) (1992)	NFDP was created to encourage and improve production in small-scale irrigation farming systems in the low land Savannahs. A bottom-up approach with user participation in all stages of the project led to huge success of the project.	(Iwuchukwu and Igbokwe, 2012)
National Program on Food Security (NPFS) (2002)	The focus of NPFS was to alleviate rural poverty and strengthen food security by promoting simple farm technologies and improvement in extension services. The initiative was not successful due to lack of interest by farmers as the innovations were perceived to be complex.	(Iwuchukwu and Igbokwe, 2012; Dennis *et al.*, 2014)
Root and Tuber Expansion Programme (RTEP) (2003)	RTEP aimed to boost food production by improving farmers access to social services and processing for cheaper food staples.	(Iwuchukwu and Igbokwe, 2012)
Presidential Initiatives in Agriculture (PIA) (2004)	The PIA prioritized large scale production of staple crops such as rice, cassava and vegetables. Lack of focus and continuity by subsequent administrations.	(Asoegwu and Asoegwu, 2007)
National Fadama Development Project (NFDP) II (2005)	NFDP II targeted to improve the livelihoods and productivity of resource poor farmers through promotion of low investment in irrigation technologies, storage, processing and marketing facilities. Bottom-up approach led to strong achievement with about 20% increased income in 50% of participants in some areas.	(Ibeawuchi and Nwachukwu, 2010)
National Fadama Development Project (NFDP) III (2008 to 2013)	NFDP III project focused on improving the income of Fadama users through provision of financial support that enable transfer of technical resources needed to expand their productivity. Unskilled application of technical resources led to undesirable effects.	(Bature *et al.*, 2013)
Agriculture Transformation Agenda (ATA) (2010)	The aim of ATA was to reposition agriculture initiatives as agribusiness and encourage private investments using a holistic approach. Recorded success and continual improvement of the sector including postharvest management.	(FMARD, 2013)

A majority of the initiatives failed to attain the purpose for which they were set up; however, a few had recorded some worthwhile successes. Among the successful agriculture initiatives are those formulated in collaboration with The World Bank. One of such initiative is the Agriculture Development Project, also known as the Agriculture Development Programme (ADP). The Federal Government of Nigeria and the World Bank initiated the ADP to facilitate transfer of agricultural related technologies to small-holder farmers using a training and visit style in order to increase food production as well as farmers income and welfare (Omonijo *et al.*, 2014). Following the success of the first enclaves of the project in the Northern part of Nigeria, the ADP currently operate in all 36 states in Nigeria where each state consist of several zones that target specific localities known as Local Government Areas (LGAs). This vast coverage enabled some successes however, the ADP has been criticized for using the technology push approach in dissemination of agricultural technologies (Agber, Iortima and Imbur, 2013). The technology push approach fails to take into consideration the user perspectives rather, the so called expert opinions is what forms the decision of what technologies are to be diffused (Rogers, 1983). In the case of the ADP strong emphasis on modern or sophisticated technologies that do not fit the local context was noted as the major drawback (Iwuchukwu and Igbokwe, 2012). Exclusion of users or potential users perspectives is a key reason for the failure of most promising technologies (Douthwaite, Keatinge and Park, 2001).

Another important agricultural initiative that was jointly established with the World Bank is the National Fadama Development Project (NDFP) commonly called "Fadama". Fadama is a term in the local dialect used to refer to seasonally flooded low lands in the guinea Savanah vegetation. Fadama lands are cultivated during the dry season by means of local irrigation. Fadama farming systems form an important component of food security as a substantial part of the vegetables consumed in the country are cultivated on these lands (Ibrahim and Omotesho, 2009). Thus, the first NDFP focused on encouraging adoption of small-scale irrigation technologies to improve the livelihoods and output of small-holder farmers who operate under the Fadama system of agriculture. Taking the shortcomings of the ADP into consideration, the project adopted a bottom-up community driven approach where stakeholder participations was an integral aspect of the project even in the early stages (Ibeawuchi and Nwachukwu, 2010; Adebisi-Adelani *et al.*, 2011). While the first Fadama project was successful, an examination of the later projects, Fadama II and III, revealed that numerous constraints ranging from high cost of the promoted technologies, high cost of inputs, lack of credit facilities, presence of middle men, poor harvesting and huge postharvest losses (PHLs) in perishable vegetables undermine the schemes (Oladoja, Akinbile and Adisa, 2006; Adebisi-Adelani *et al.*, 2011; Bature *et al.*, 2013). Apart from the several constraints faced by these farmers, production systems in certain localities under the NDFP II scheme was reported as unsustainable (Ibrahim and Omotesho, 2009). The same NDFP II scheme has been criticized for poor implementation of projects in the South East (Ibeawuchi and Nwachukwu, 2010). It was revealed that the income of farmers who were beneficiaries of the NDFP III did not improve, rather an increase in productive assets and reduction in income were observed (Bature *et al.*, 2013).

Ten years after the first Fadama project, the National Program on Food Security (NPFS) was created in 2002 with the sole purpose of alleviating food insecurity and rural poverty (Asoegwu and Asoegwu, 2007; Iwuchukwu and Igbokwe, 2012). The objectives were to increase farmers output through promotion of simple farm technologies, improve research for agriculture development and better extension service delivery to educate farmers toward better usage of farm resources. Nevertheless, complexity and incompatibility of the promoted innovations were among the setbacks of the scheme (Iwuchukwu and Igbokwe, 2012). Low participation by farmers is another factor that was responsible for the failure of the scheme (Dennis *et al.*, 2014). Besides an evaluation of the impact of the NPFS scheme on youth empowerment in terms of self-employment revealed that non-participating farmers were more self-reliant than participating farmers in Rivers State (Dennis *et al.*, 2014).

Following that the previous initiatives failed to achieve the needed transformation in the agriculture sector, the presidency through the Federal Ministry of Agriculture and Rural Development (FMARD) initiated the Agriculture Transformation Agenda (ATA) in 2010 to reposition agricultural initiatives as agribusiness rather than the usual agricultural production. The aim was to revamp the sector by building needed infrastructures, strengthen commodity value chains and facilitate private investment (FMARD, 2013; Ajani and Igbokwe, 2014). The goal of the ATA is a yearly addition of five (5) metric tons to the national food volume (FMARD, 2013). Overall, the ATA placed emphasis on adoption of improved agricultural practices especially in the crop production subsector as this will improve export potentials to European markets where premium prices can be earned for most of country's horticultural produce.

The Federal Ministry of Agriculture and Rural Development noted that up to USD 20 million of forex earnings could be realized from crop production if objectives are met (FMARD, 2013). In order to achieve the set goals, the ATA mapped out different implementation actions plans for the different commodity groups. For instance, plantain production was part of the horticulture implementation action plan which the overall goal was to improve the performance of horticultural commodity value chains (FMARD, 2013). The horticultural implementation plan highlighted factors such as good management practices in agricultural holdings, quality fruits, efficient operations and consumer assurance as being critical for the success of commodity value chains. Thus the strategy for improving commodity supply chain of horticultural produce involved the use of recommended varieties, private investment in processing facilities, improved market access, value addition to harvested commodities and reduction of PHLs from the rate of between 45 and 51% to 5% (FMARD, 2013).

Through the ATA, farmers received trainings as well as planting materials to boost production. As for plantain, about 32,000 plantain suckers of improved varieties were reportedly distributed to some of the South-South States alongside establishment of plantain gardens. One hundred and twenty-five famers and

extension agents were trained on plantain production targeted at domestic and foreign markets. The Federal Ministry of Agriculture and Rural Development also reported distribution of 25,000 copies of technical manual on Good Agricultural Practices (GAP) for horticultural crops, among which is plantain.

In the first years of the ATA, through the inputs given to farmers during the 2012/2013 dry and wet seasons, an addition of over 15.5 million metric tons of food were achieved within these two years (FMARD, 2013). In 2012 alone, a total of 1,840,000 tons of food were added into the food stock. Crops such as rice, maize, cassava, yam and plantain were the main contributors to this food increase. According to the National Bureau of Statistics, the Nigerian agriculture sector contributed about 26.79% of the GDP in the third quarter of 2015 (NBS, 2016).

The present administration based on a recent report by the Federal Ministry of Agriculture had acknowledged that postharvest losses of perishable food crops could reach up to 60% and the ministry is committed to build on the success of ATA while addressing key gaps (FMARD, 2016). It was also acknowledged that postharvest handling is essential for the development of commodity value chains and a necessity capable of addressing the challenges of postharvest losses (FMARD, 2016).

Among the numerous food crops grown in Nigeria, horticultural crops mostly grown in the Southern part of the country constitute a significant part. Horticultural produce undergo metabolic processes even after harvest and these processes lead to moderate or high perishability (Kitinoja and AlHassan, 2012). Moderate to high perishability can lead to inferior quality of produce for consumers; thus, commodity supply chains cannot be developed without proper postharvest management. The lesser the amounts of high quality produce that reach consumers the more likely the losses and thus an indication of food insecurity. Postharvest handling is therefore an important part of the country's food security attainment and the Federal Ministry of Agriculture and Rural Development has made known its intention to enhance access to information and knowledge on postharvest handling in the food distribution systems (FMARD, 2016).

Several authors have explained that lack of postharvest infrastructure in developing countries is the key reason for high postharvest losses in the food systems (Hodges, Buzby and Bennett, 2010; Parfitt, Barthel and Macnaughton, 2010; Balaji and Arshinder, 2016). While this assumption is correct, there are two different set of challenges in this assumption. First there is no guarantee that provision of postharvest infrastructure will ascertain proper utilization that averts losses. Secondly, there is no clear strategy by agricultural governing bodies on provision of such infrastructure in the foreseeable future. Although part of the agenda of the ATA was the development of postharvest infrastructures such as storage facilities in order to reduce postharvest and market losses; actual deployment of postharvest technologies only applied to some grains such as maize where 12000 hermetic bags were distributed to small-scale maize farmers in addition to organization of zonal

workshops on pre and postharvest handling against mycotoxins (FMARD, 2013). Postharvest challenges in horticultural produce were hardly addressed during the implementation of the ATA; even though this group of food crops are known to suffer the most postharvest losses in tropical regions especially (Gustavsson *et al.*, 2011; Rutten, 2013). If the agriculture sector intends to adequately cater for the food needs of the country, adequate attention to postharvest management is essential to minimize losses while increase in food production is being targeted at the same time.

The objective of good postharvest handling is to ensure that the quality of the agricultural produce is preserved as it travels along the distribution system. Harnessing the potentials of proper postharvest handling in commodity chains of fresh produce is capable of strengthening the Nigerian agriculture sector. To this end, the Nigerian Government intends to collaborate with private investors towards improving food distribution systems of fresh produce in order to curtail losses (FMARD, 2016). Apparently, most of such partnerships are usually entered with medium and large-scale players in the agriculture sector. Thus, excluding the smallholders even though they consist a majority of the production in the country's agriculture sector. Most of the smallholder farmers and traders have little to no formal education and poor access to extension services (Kainga and Seiyabo, 2012); as such they may not be exposed to information on the importance of appropriate postharvest handling which is essential to maintaining the quality of their produce.

Despite the different agriculture initiatives in Nigeria, agricultural food supply chains are challenged with poor postharvest management coupled with the lack of postharvest infrastructure as notorious with developing countries (see Figure 1.8). Thus, the current state of the Nigerian agricultural sector is one that is plagued with poor quality of food and high postharvest losses. As at 2013, high postharvest losses up to 50% for fruits and vegetables, 30% losses for tubers and 20% losses for grains were reported (FAO, 2013). According to the Ministry of Agriculture and Rural Development, poor quality of fresh produce results from contamination with chemicals and spoilage due to pests and diseases (FMARD, 2016). Currently, there are no clear strategies in place to properly address the postharvest losses in the country. Although the current administration noted that reduction of the farm to fork time in food distribution systems will curtail losses of fresh produce (FMARD, 2016). However, the rapid rural urban migration as youths go in search of greener pastures (Omonijo *et al.*, 2014) is likely to increase food miles, the distance in which food travels from its production origin to its point of consumption (Hill, 2008).

Currently, Nigeria has a population estimated at 182 million (NPC, 2017) and the country is among those with a projected high rate of population growth (United Nations, 2015) in the coming years. Reports show that about 780 million people around the globe struggle with food insecurity; of which a high number are resident in developing countries (FAO, IFAD and WFP, 2015). A majority of the countries with extreme level of food insecurity are located in Sub-Saharan Africa of which is Nigeria is one. The latest world hunger report indicates that the hunger severity in Nigeria is categorized as serious (see Figure 1.1) (IFPRI, 2016); meaning there is

urgent need for viable strategies to abate hunger crisis. The expected high rate of population growth in Nigeria will further exacerbate the challenge of food insecurity.

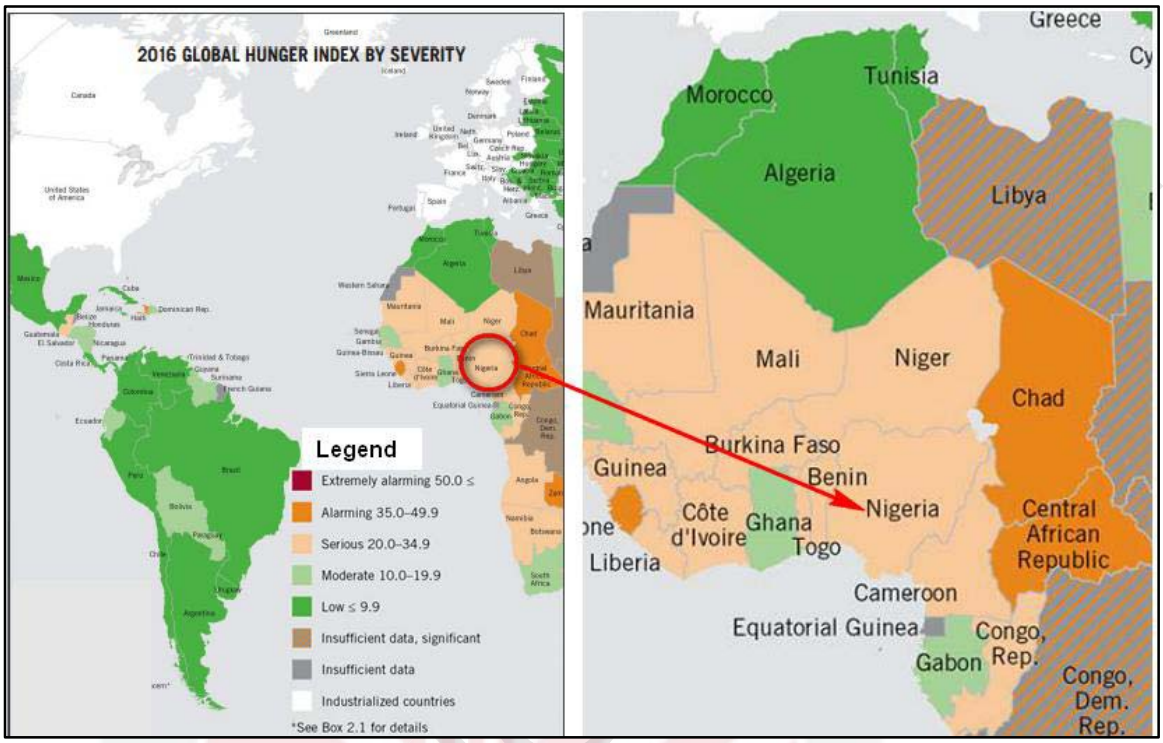

Figure 1.1 : World Hunger Index
Source: Adapted from IFPRI (2016)

In spite of the food insecurity that exist globally, literature suggests that about one-third of the food produced for consumption never gets eaten but ends up discarded as food losses and waste (FAO, 2011; HLPE, 2014). The economic and social implications of food insecurity is indeed a serious problem that needs urgent attention. A recent meta-analysis study remarked that food losses in Sub-Saharan Africa is relatively high and reduction of postharvest losses is a key pathway to food security in the continent (Affognon *et al.*, 2015). High postharvest losses in the midst of serious food insecurity coupled with high rate of population growth further heightens the necessity for the agriculture sector to ensure effectiveness of food systems in Nigeria.

1.2 Plantain as a Food Security Crop

Plantain (*Musa paradisiaca*) which is also known as cooking banana is an important economic food crop and a staple food for both the rural and urban populace (Ferris, Ortiz and Vuylsteke, 1999; Adejoro, Odubanjo and Fagbola, 2010; Akinyemi, Aiyelaagbe and Akyeampong, 2010). Average annual consumption of plantain by Africans is estimated at 21 kg per capita; with the consumption in East African countries such as Uganda, Rwanda and Burundi as high between 191 to 220 kg per

capita (Oladejo and Sanusi, 2008; IITA, 2014). Annual plantain consumption in Nigeria is 8.5 kg per capita (FAO, no date). Overall, the consumption of plantain is ranked third position among starchy staples in Nigeria (Akinyemi, Aiyelaagbe and Akyeampong, 2010). The crop heavily consumed by persons of all socio-economic class either in the form of a meal or snacks (Ben-Chendo, Eze and Asiabaka, 2013). Increase in disposable income is known to encourage diversification of diet in favor of meat and vegetables demand while consumption of starchy foods reduces (Bennett, 1941; Parfitt, Barthel and Macnaughton, 2010; Thyberg and Tonjes, 2016). Unlike other foods which follow the Bennett's law that "consumption of starchy staples declines at the household income increases" (Bennett, 1941), plantain consumption in West Africa has actually doubled in the last two decades, from less than 6 million tons consumed in 1990 to more than 12 million tons in 2009 (Cauthen *et al.*, 2013). While increased population could have contributed to this increase, a survey of Nigerian women who were responsible for house hold food purchases revealed that a majority would like to increase their consumption of plantain if prices were more affordable (Ajayi and Aneke, 2002). Similarly, another study in Cameroon where 355 house wives were asked to indicate their preference among selected starchy staples (plantain, cassava, rice, cocoyam, maize) if prices were the same, reported that 55% of the respondents chose plantains as their first choice while 72% would include plantains among their top three favorite foods (Dury *et al.*, 2002). The same study further reported that a majority of respondents from North Cameroon, where plantain is relatively expensive, chose plantain as the first choice of food they would buy if they had more income. This trend indicates that plantain consumption in West Africa is likely to increase with an increased income level; contrary to the Bennett's law.

In terms of per capita consumption, plantain is regarded to be important relative to other staples (Olumba and Rahji, 2014). The high consumption patterns in the continent signify high prospects for increased plantain production. Although plantain consumption is ranked third among starchy staples in Nigeria, the lower consumption values in terms of per capita consumption of other countries in Sub-Saharan Africa e.g. Uganda; indicates a possibility for the country to be an exporter within the continent (Baruwa, Masuku and Alimi, 2011). Besides, plantains are a useful raw material for the production of local snacks like chips, fritters, dodo, bole, gluten-free flour and cakes. It is one of the perennial starchy staple that is available throughout the year. This makes plantain an important food security crop and a good alternative staple especially when other staples are out of reach due to off seasons (Cauthen *et al.*, 2013).

It is a paradoxical situation that plantain postharvest supply chains in Nigeria record high losses despite domestic demand not being adequate to cater for as many persons that want to increase their consumption. For instance, Adeniyi and Ayandiji (2014) in their study on plantain and banana distribution reported that postharvest losses during transportation amounted to 46.45%, losses during sales were 19.95% and losses during marketing were 33.6%. In Rivers State, plantain postharvest losses was reported to be 27% (Olayemi *et al.*, 2012), meanwhile a previous study by Olorunda

and Aworth (1996) reported plantain postharvest losses in another part of Nigeria as 40%. High losses could also be part of the reason for non-affordability of the produce even when people desire to increase their consumption.

The total world production of plantain in 2014 is 30.668 million metric tons with Sub-Saharan Africa alone accounting for 20.107 million metric tons (FAOSTAT, 2017). Cauthen *et al.* (2013) explained that although the volume of banana exported from Sub-Saharan Africa exceeds that of plantains, the production of plantain far exceeds that of banana in the continent. This implies that most of the plantain produced are consumed locally; an indication of the important role of the crop in food security. According to the FAO (2017) world production value of plantains increased from 9.460 billion USD in 2010 to 11.584 billion USD in 2014 (Figure 1.2).

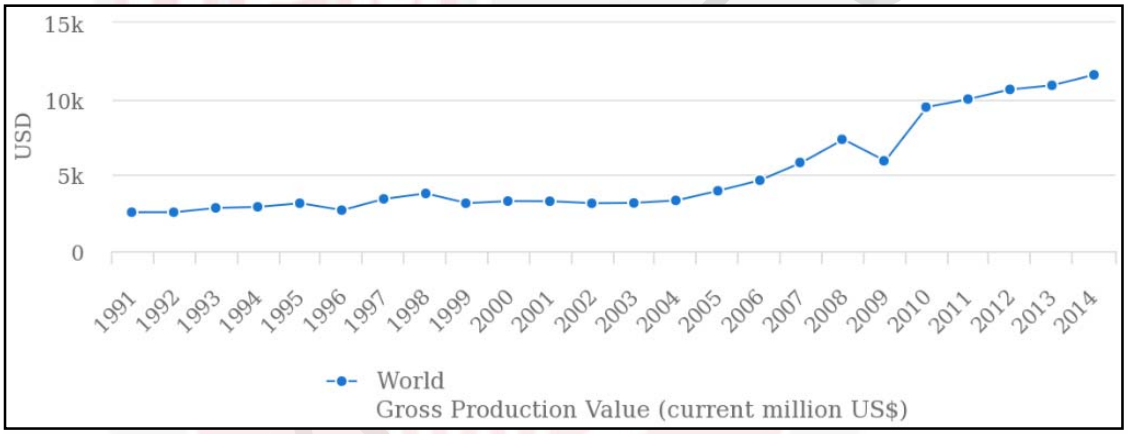

Figure 1.2 : Value of Worldwide Plantain Production
Source: FAOSTAT (2017)

On a regional basis, South America and Sub-Saharan Africa are the regions known for high production (Figure 1.4). It is imperative to note that Sub-Saharan Africa alone contributed about 68% of the global plantain production between 1994 and 2014 while South America contributed about 28% of the production share followed by 4% of the production share for Asia, while Oceania had a less than 1% production share (Figure 1.4) (FAOSTAT, 2017).

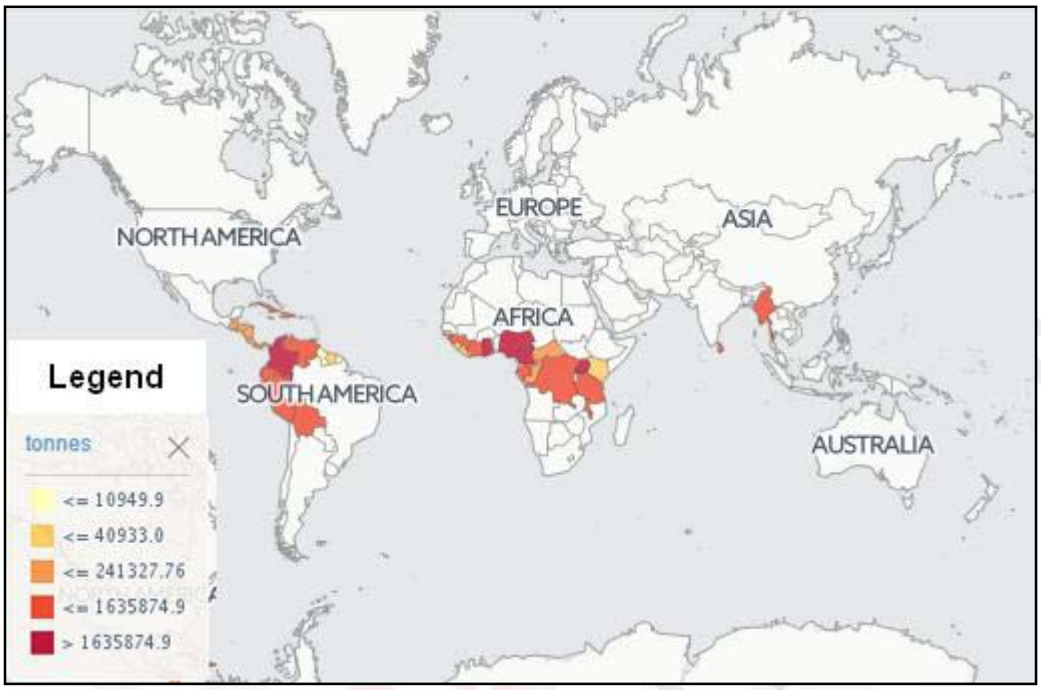

Figure 1.3 : Plantain Production Regions
Source: FAOSTAT (2017)

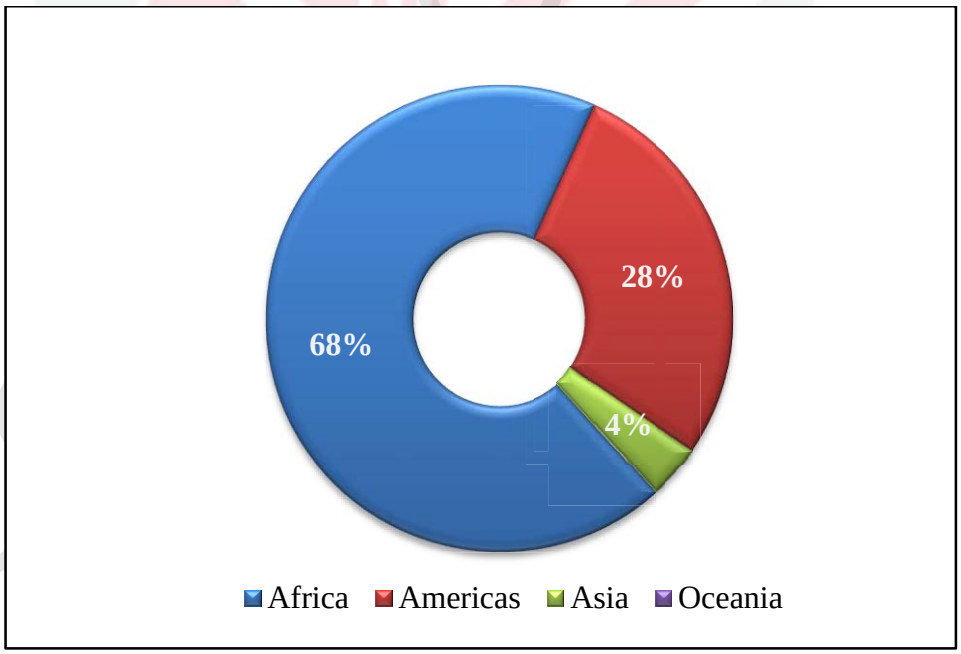

Figure 1.4 : Average Plantain Production Share by Region (1994 – 2014)
Source: FAOSTAT (2017)

Based on production volume by individual countries, Nigeria is among the top ten producing countries in a decreasing order: Uganda, Ghana, Colombia, Nigeria, Cameroun, Peru, Cote d'Ivoire, Democratic Republic of Congo, Ecuador, and Myanmar. Furthermore, it can be observed that African countries constitute a majority of the top ten plantain producing countries (Figure 1.5). West Africa alone accounted for about 32% of global production in 2011 (Cauthen *et al.*, 2013) at the same time Sub-Saharan Africa is home to highest consumers of the commodity with approximately 70 million people around the continent who depend on plantain for a substantial part of their daily carbohydrate requirements (IITA, 2010). Again, this further strengthens the standpoint of plantain production as a significant component of food security.

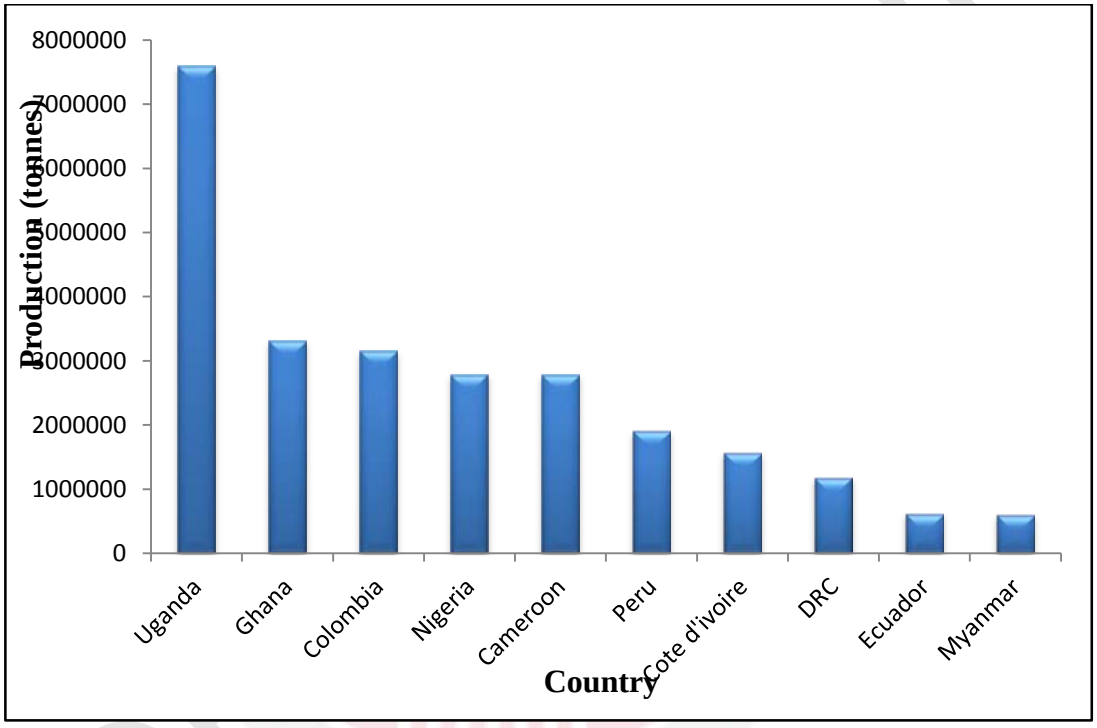

Figure 1.5 : Top Ten Producers of Plantain
Source: FAOSTAT (2017)

Plantain production in Nigerian is estimated to be 3.04 million tons valued at 3.8 billion USD for the year 2014 (FAOSTAT, 2017). Although, the production trend in the country indicates that the volume produced has almost doubled (from 1.665 million tons in 1994 to 3.0399 million tons in 2014) during the last two (2) decades (Figure 1.6); economic growth of the Nigerian plantain industry has been comparatively slow when compared to other West African countries like Ghana; which recorded a rapid production growth from insufficient production to being a net exporter of plantain.

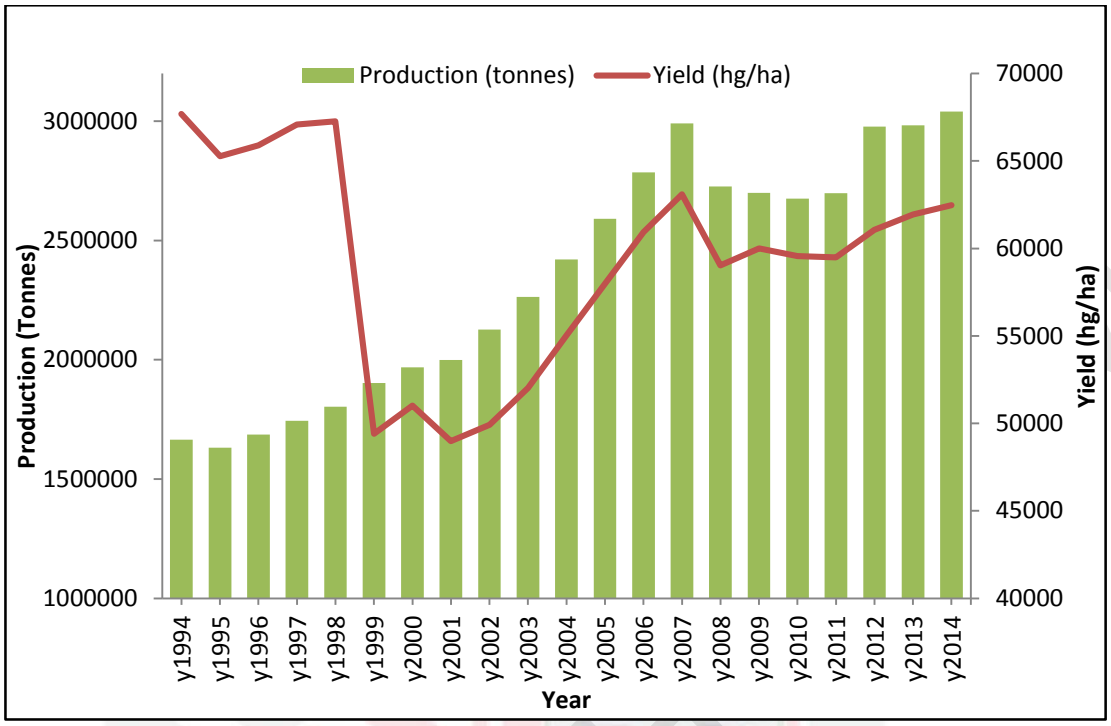

Figure 1.6 : Plantain Production Trend in Nigeria
Source: FAOSTAT (2017)

In Nigeria, domestic demands for plantain are hardly met and exports are still insignificant partly because production fate lies in the hands of smallholder farmers most of whom do not have access to extension services (Kainga and Seiyabo, 2012; Olayemi *et al.*, 2012). Apart from that, plantain production in Nigeria is plagued with high perishability and losses which can go as high as over 20% to 60% (Olayemi *et al.*, 2012; FAO, no date). Although increasing production is one way to increase the country's production output, the notorious high rate of postharvest losses in plantain is considered a major constraining factor to its production and marketing in Nigeria (Ladapo and Oladele, 2011; Olayemi *et al.*, 2012). As such measures to reduce plantain postharvest losses are likely to have immediate positive impacts in meeting demands and as well food security.

1.2.1 The Plantain Postharvest Supply Chain

A supply chain encompasses the network of activities of all parties directly or indirectly involved in meeting a customer's need or want either in the form of a product or service (Chopra and Meindl, 2007). Therefore food supply chain (FSC) refers to the network of activities and businesses concerned with the production, harvesting and handling of food produce until it gets to the final consumer (Bourlakis *et al.*, 2014). A postharvest system on the other hand refers to the postharvest operations carried out on an agricultural produce starting from harvest until when it stops respiring (Prussia and Shewfelt, 1993). This definition excludes

food products that have been processed to other forms as they are no longer living tissues (Prussia and Shewfelt, 1993). Thus, the plantain supply chain would consist of the input suppliers, producers, wholesalers, retailers and consumers as the main players. Logically, the plantain postharvest system excludes the input suppliers and begins with the farmers who are the producers that sell the commodity to the wholesalers and retailers from which the consumers obtain the commodity (Figure 1.7).

Although Parfitt *et al*., (2010) argued that FSC and postharvest systems can mean the same thing. Considering the definition of what a supply chain entails and based on the focus of this study, which is on the postharvest handling activities involved with plantain fresh produce after harvest, the term postharvest supply chain was rather appropriate to refer to the postharvest activities of supply chain players from when the produce was harvested until it has been sold to the intended customer through the various distribution channels. From Figure 1.7, the longest distribution channel shows the flow of the plantain commodity along the various points of postharvest handling in the supply chain. It can be observed that the first point of the physical produce is from the farmers from which the commodity then travels until it gets to the consumer. Since these activities can only occur after the produce has been harvested; the network of activities and players make up the plantain postharvest supply chain (Adu-amankwa and Boateng, 2011).

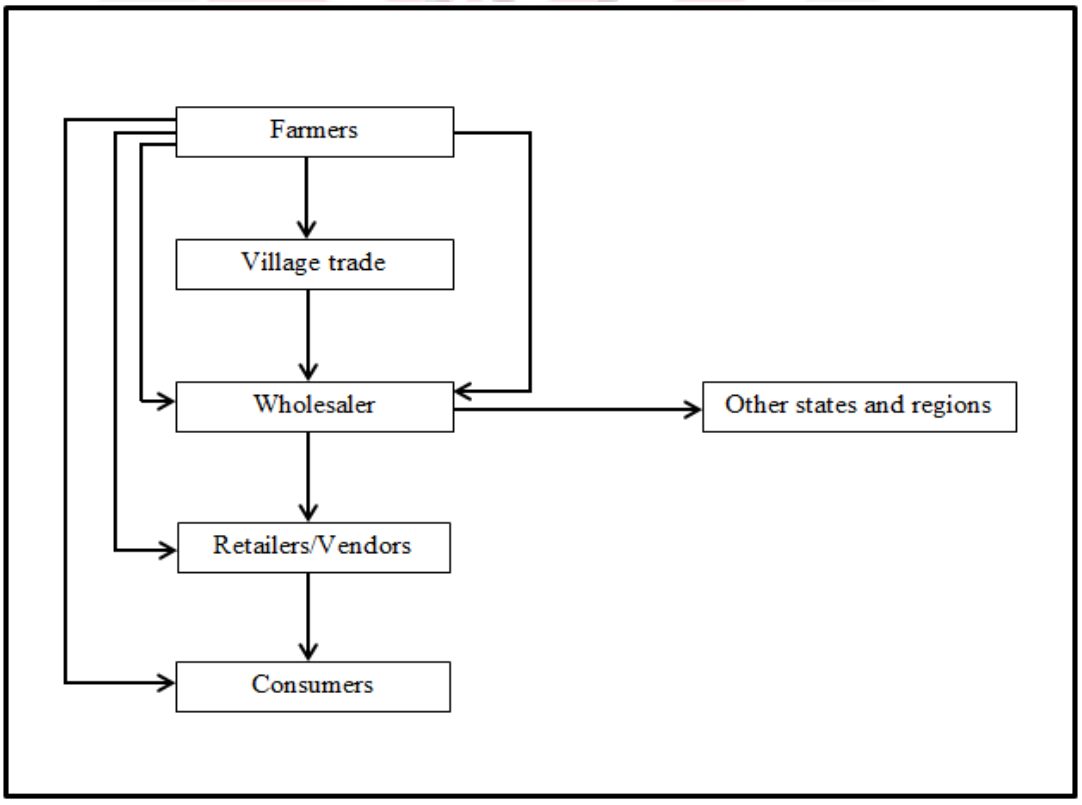

Figure 1.7 : Plantain Distribution Channels in Nigeria
Source: Adapted from Akinyemi *et al*. (2010)

Another approach to understanding the plantain FSC is in terms of the value that is added as the commodity moves along the supply chain from production to consumption. A study on plantain value chain mapping by Adeoye *et al*. (2013), provides an explicit description based on the value added activities performed in each stage of the FSC. The plantain value chain was segmented into three main parts as the upstream segment which consists of the input suppliers and producers/farmers; the midstream segment made up of the farm gate and market assemblers, wholesalers, processors and exporters and the downstream segment made up of the retailers and final consumers. The midstream segment performed most of the value-added activities while the input suppliers were the least contributors to the plantain value chain. Plantain farmers in Nigeria mostly sell their produce at farm gate with no additional value added, therefore even though they invested the most in terms of time, labor and inputs, they were not benefiting from regional trade (Adeoye *et al.*, 2013).

The midstream segment also exerted a dominating influence in the plantain supply chain in terms of market price determination and demand manipulation through cartel activities (Adeoye *et al.*, 2013). A similar scenario was also reported for plantain supply chain in Ghana, where middle men known as market queens dominate and influence postharvest activities in a way that negatively affect the rate of returns of plantain traders (Adu-amankwa and Boateng, 2011).

In terms of composition for the various segments in the plantain supply chain, Ben-Chendo *et al*. (2013) reported that males dominate plantain production whereas plantain trading is female dominated. Whether production or trading, the profitability of plantain as an economic activity has been confirmed by several studies conducted in Southern Nigeria (Adetunji and Adesiyan, 2008; Fakayode *et al.*, 2011; Kainga and Seiyabo, 2012). Additionally, Baruwa *et al*. (2011) remarked that plantain production has the advantage of low usage of machinery and labor. This gives room for the possibility of lower production cost as compared to other agricultural crops, such as rice. Nevertheless, poor postharvest handling is a major constraining factor that has limited plantain production in Nigeria (Akinyemi, Aiyelaagbe and Akyeampong, 2010; Ladapo and Oladele, 2011).

Albeit it is not uncommon to observe that most agricultural commodities in Africa are challenged with poor postharvest systems stemming from the non-existence of postharvest infrastructure coupled with inappropriate transportation facilities and postharvest handling (Hodges, Buzby and Bennett, 2010; Parfitt, Barthel and Macnaughton, 2010; Venus *et al.*, 2013). Even when increase in production resulted from modern farming technologies, the welfare of farmers did not improve as a result of high postharvest losses in the postharvest supply chains (Ladapo and Oladele, 2011). Furthermore, high transportation costs with several unpredictable stops greatly increase occurrence of postharvest losses in perishable commodities like plantain (Tchango *et al.*, 1999; Bayeri and Nwachukwu, 2003; Idah, Ajisegiri and Yisa, 2007). Besides, poor quality at harvest, short shelf life and high perishability hasten produce quality deterioration along the supply chain. Therefore,

despite plantain having high economic value and capability of contributing positively to food security (CBN, 2003; Adeoye *et al.*, 2013; Ebiowei, 2013), its potentials are threatened mainly by the challenges in the postharvest system which then reflects the state of the entire commodity supply chain and agriculture sector as a whole.

1.3 Modern versus Traditional Agricultural Food Supply Chains

Proper supply chain management is essential to deliver the desired product that is needed by a customer and at a profit. Nevertheless, agricultural food supply chains (AFSCs) are generally different from other supply chains due to the specific characteristic of product perishability that further increase the difficulties of supply chain management. For fresh produce especially, biological changes in the produce coupled with seasonality in production, sensory attributes, physiological mechanisms, appearance, and product safety issues interactively increase the uncertainty of product quality (Aramyan *et al.*, 2007). Thus, managing AFSCs is more challenging than that of other manufactured goods (Aung and Chang, 2014).

In today's competitive business environment, customer satisfaction is an important and fundamental objective of any venture, be it agricultural or non-agricultural. This is why AFSCs in developed countries have taken advantage of modern technologies to maintain fresh produce quality and manage their AFSCs by reducing the uncertainties of perishability that are particular with agricultural commodities (Figure 1.8). The AFSCs in developed countries are regarded as modern AFSCs characterized by high usage of sophisticated infrastructures and automated systems (Yakovleva, 2007). Activities are carried out in a systematic manner based on standard operating procedures and high processing. Modern AFSCs distinctively have the presence of large farm ventures and retail firms as the key players with huge investment capital as needed for large capital infrastructures (Parfitt, Barthel and Macnaughton, 2010; Gonzales, Aban and Acedo-Jr, 2014). Furthermore, modern AFSCs utilize indicators ranging from profitability, waste elimination, product/produce quality, efficiency of resource usage, customer satisfaction and many others to evaluate and improve performance either at the supply chain or organization levels (Aramyan *et al.*, 2007). Recent advances in modern ASFCs have even reached the extent of using intelligent food logistics systems to provide better monitoring and traceability (Jedermann *et al.*, 2014), all in a bid to have better control and management of the peculiarities that pertain to fresh food ASFCs while at the same time create more value for customers.

On the contrary, AFSCs in developing countries are strikingly different from their modern counterparts in terms of operations and performance. In Nigeria for example, AFSCs are characterized by little to no usage of modern technologies. Operations are rather through traditional methods and a majority of the stakeholders are of smallholder type. In this case, the AFSCs consist of fragmented production units, undifferentiated products with low value addition, multi-layered distribution

channels with multiple intermediaries; hence, they are called traditional AFSCs (Gonzales, Aban and Acedo-Jr, 2014; Balaji and Arshinder, 2016). Most of the players in traditional AFSCs are smallholders with poor knowledge and little to no investment capital opportunities coupled with rudimentary infrastructure (Figure 1.8). Moreover, poor planning and management practices, inefficient harvesting, handling, storage and transportation methods are the common challenges in the postharvest systems of traditional AFSCs. As mentioned earlier, these challenges that predominates traditional postharvest systems translate into the high postharvest losses in the traditional AFSCs. Thus, contrary to their modern counterparts, there is little to no control over quality coupled with poor management of produce peculiarities and uncertainties in the traditional AFSCs.

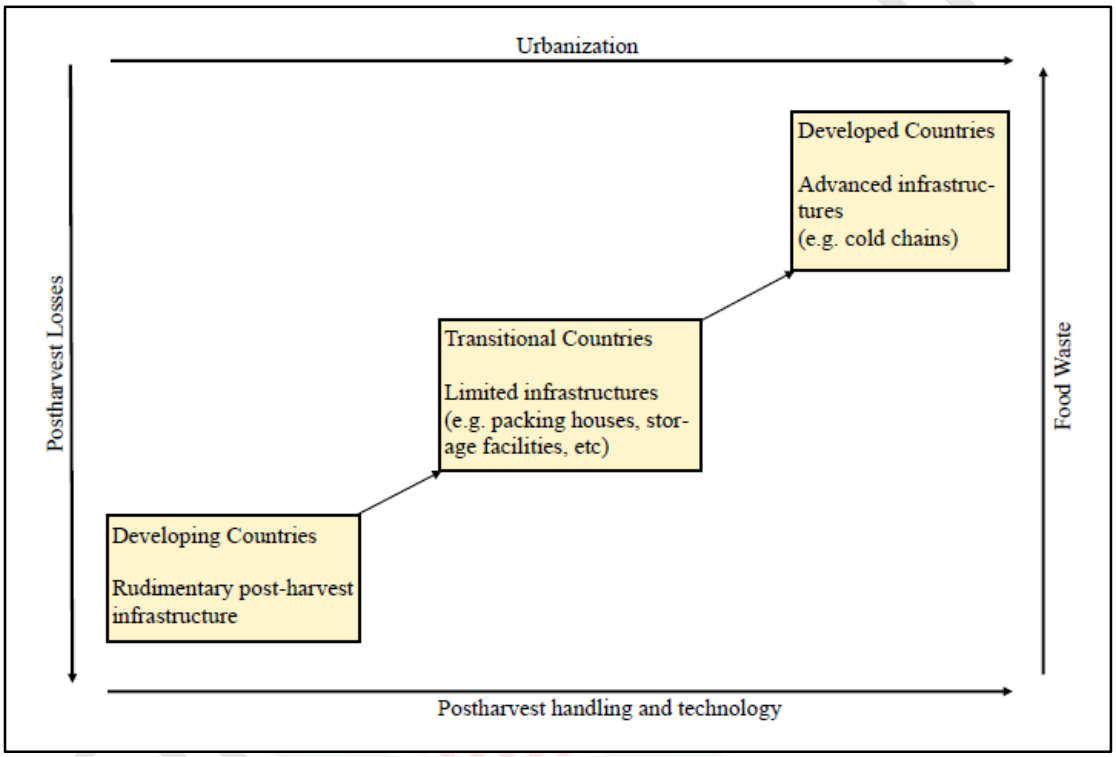

Figure 1.8 : Postharvest Infrastructure and Food Supply Chain Development
Source: Adapted from Parfitt *et al*. (2010)
Note: Arrows depict an increase in the specific concept

A comparison of food losses in traditional and modern/mechanized grain postharvest chains is shown in Figure 1.9. It can be observed that the crude operational processes in the traditional postharvest chains, details of which can be found in Rembold *et al.* (2011) and Hodges *et al*. (2010), led to more grain losses for most activities than that of mechanized postharvest chains. As synonymous with the statement by Parfitt *et al*. (2010) that *"*PHLs are partly a function of the technology available in a country, as well as the extent to which markets have developed". In other words, adequacy of postharvest infrastructure corresponds to the level of AFSCs development and the availability and usage of postharvest infrastructures in the food supply chain. Thus,

as shown earlier in Figure 1.8, adequate postharvest infrastructures are more common to developed countries as compared to transitional and less developed countries. Additionally, with a lack of appropriate infrastructures such as good road networks, feeder roads that enable access to farms, storage and packing houses, packaging materials, cold chains etc. it is not surprising that traditional postharvest supply chains have continued to perform poorly with high postharvest losses as the evidence.

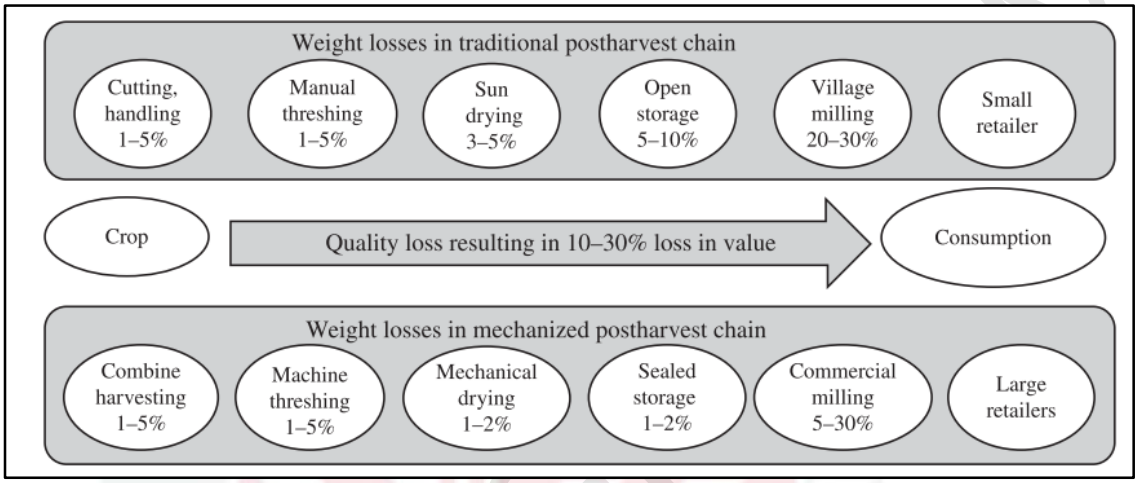

Figure 1.9 : Traditional Versus Mechanized Postharvest Chain
Source: Hodges *et al*. (2010)

In Nigeria for instance, a recent multi country food loss studies revealed that 100 kg/capita/year of food was lost annually between 1992 to 2011 and that postharvest losses is a bane to food production in the Global South (Bahadur *et al.*, 2016). Indeed, high losses in agriculture food produce create great concern and its consequences on food security are already devastating in Nigeria. Apart from food security, food losses threaten the economic growth of developing countries and also perpetrate negative environmental impacts. Moreover, high postharvest losses negatively impact farmers livelihoods by reducing their profit margins and at the same time exert adverse impacts such as reduction in food volume and a corresponding increase in price per unit of food (Gustavsson *et al.*, 2011; Shukla and Jharkharia, 2013). The ripple effect is a further reduction in purchasing power for families with low income levels.

With up to half of the produced food wasted along the postharvest supply chain, such huge losses will indeed impede food security. Whether in the form of reduction in quality or discarded for reasons of food not being suitable for consumption, high losses in staple food like plantain will certainly affect the country adversely. Thus, reduction of PHLs is a win-win for farmers, consumers (Kader, 2005), the environment and the country as a whole; this is a viable approach to achieve food security (FAO, 2011; Affognon *et al.*, 2015).

Some authors have suggested that building of more sustainable food systems which attach high importance to food quality both in supply chain design and implementation (van der Vorst *et al.*, 2007; Luning and Marcelis, 2009; van der Vorst, Tromp and Zee, 2009) is essential especially in the global-south where AFSCs are plagued with avoidable food losses (Bahadur *et al.*, 2016). Other authors have recognized the need for a more holistic approach to reducing food losses, noting that a using technical focus alone is insufficient (Grolleaud, 2002; World Bank, 2011; Papargyropoulou *et al.*, 2014).

Integration of postharvest technologies has proven to be effective at maintaining and managing produce quality in modern AFSCs. Such modern postharvest technologies involve capital intensive infrastructures such as cold chains. While this is easy in modern supply chains, it can be challenging for traditional supply chains which mostly lack coordination in the first place. Moreover, economies of scale among other factors limit the suitability of such sophisticated technologies in traditional AFSCs. Thus, even though a lack of postharvest facilities are reported as the trigger factors of food losses in Nigeria (Idah, Ajisegiri and Yisa, 2007; Adewumi *et al.*, 2009; Ladapo and Oladele, 2011; Olayemi *et al.*, 2012) and other West-African countries (Olayemi *et al.*, 2010; Adu-amankwa and Boateng, 2011; Venus *et al.*, 2013), it is debatable that simply increasing infrastructure will eliminate food losses. Besides, food losses cannot be allowed to continue due to non-existence of infrastructures that only support technologically inclined approach of reducing food losses, as that could take years and even decades with far reaching consequences that are likely to exacerbate food insecurity and affect millions of people. Previous efforts to provide and integrate large scale postharvest technologies had been futile, therefore simpler postharvest handling techniques is rather recommended (Kitinoja, 2013a).

1.3.1 Small-Scale Postharvest Practices

Ajani and Igbokwe (2014) noted that the Nigeria agriculture sector can be transformed by the introduction of low-cost need-based adaptive technologies. Small-scale postharvest practices (SSPPs) are low-cost adaptive alternative postharvest handling techniques for smallholders who operate in traditional AFSCs (Kitinoja and Kader, 2003; Saran, Roy and Kitinoja, 2012). SSPPs range from handling practices that target maintenance of produce quality through reduction in variable ambient temperature to those that are directed towards improving aesthetic properties and market appearance.

Small-scale postharvest solutions can range from simple techniques for instance hydro-cooling, shade cooling practices which are useful in management of temperature which is an important factor in maintaining produce quality (Kitinoja, 2013b; Singh *et al.*, 2014) to more technical solutions that involve the use of traditionally fabricated postharvest technologies such as zero-energy cooling chamber (ZECC), coalbot powered cold rooms, ventilated rooms where produce are

kept on clean floor (WFLO, 2010). Likewise, the use of plastic crates, ventilated boxes and other appropriate packaging during transportation is recommended for all fresh produce as this will minimize mechanical damage and maintain market quality of produce (Kitinoja and Cantwell, 2010).

Basically, good postharvest practices should ensure a combination of practices that target optimum ambient conditions for the produce as well as minimize any physical or mechanical damage and maintain desirable appearance. It should be noted that the effectiveness of a postharvest technology is not dependent on its sophistication. In fact 81% of small-scale postharvest practices identified and tested in four countries both in Asia and Sub-Saharan Africa were reported to be appropriate and effective for small-scale operations (WFLO, 2010). Thus, the profitability of plantain as a food crop with high economic potentials can be further strengthened by improving the performance of the postharvest supply chain through adaptable and appropriate small-scale postharvest management solutions that do not require technically inclined infrastructures.

Despite the existence of a variety of appropriate small-scale postharvest solutions adoption or usage of these small-scale postharvest practices is considerably low in developing countries (Kitinoja *et al.*, 2011). In Nigeria specifically, respondents were reluctant to adoption of plastic crates in the transporting of perishable produce according to a study conducted in Kano (Adegbola, Bamishaiye and Olayemi, 2011). In general, there is no evidence of adoption of appropriate small-scale postharvest practices in most of the commodity supply chains including that of plantain. There is a dearth of information on the factors that facilitate adoption of small-scale postharvest practices.

1.3.2 Assessment of Postharvest Losses in Traditional Supply Chains

Another challenge in traditional AFSCs is the lack of monitoring systems and consistency owing to the poor coordination in the AFSCs disallow strategic interventions. It is such that even when interventions could have been successful the lack of consistent loss measurement methods coupled with poor coordination and little or no record keeping makes it difficult to monitor losses and identify hot spots for proper targeting; this further intensifies the challenges of such fragmented supply chains (Shukla and Jharkharia, 2013). In traditional AFSCs most of the food losses are referred to as postharvest losses (PHLs). Therefore, the first step to solving the problem of postharvest losses is to ascertain what stage in the postharvest supply chain exhibit the most losses (Kader, 2005) and what factors trigger their occurrence.

Triggers of postharvest losses are broadly grouped into primary and secondary causes. Primary causes refer to those that directly influence the produce to bring about changes that lead to deterioration while the secondary causes are indirect to the produce by facilitating the primary causes to cause deterioration (Atanda *et al.*,

2011). In other words the primary causes are biological whereas the secondary causes are non-biological (Kader, 2005). As earlier mentioned, the paucity of data on the extent to which causative factors contribute to losses and the exact amount of losses in specific commodities is a major challenge. In a meta-analysis of postharvest losses in Sub-Saharan Africa, it was observed that a large amount of postharvest research were unpublished and the commonality of methodological inconsistencies challenged comparisons of studies outcomes (Affognon *et al.*, 2015). In broad terms, postharvest losses are assessed based on the deterioration in quality of food produce as well as the quantity from the total production that did not make it to the final consumer (Grolleaud, 2002; Hodges, 2012).

1.3.3 Qualitative and Quantitative Postharvest Losses

Postharvest losses occur in quantitative and qualitative forms (Hodges, Buzby and Bennett, 2010). Qualitative losses occur as a result of either altered physical condition, perceived substandard value, deterioration in texture, flavor and/or nutritional value whereas quantitative losses refers to the amount of physical produce that is discarded due to being unfit for human consumption (Grolleaud, 2002; Hodges, Buzby and Bennett, 2010). Kasso and Bekele (2016) assessed postharvest losses and quality deterioration of horticultural produce in Ethiopia based on the amount of produce that was damaged and the extent of the damage respectively. Similarly, other authors reported postharvest losses in Asia as the amount of produce discarded as well as produce sold at reduced price due to poor quality (Genova *et al.*, 2006).

Generally, it is easy to estimate quantitative postharvest losses, however, estimation of qualitative losses is more complicated (Shewfelt, 1999; Kader, 2005). This is because changes in quality is determined by a number factors (Hodges, 2012). The complications associated with assessment of qualitative losses is the reason why the African postharvest losses information system (APHLIS), a network model that assess grain losses considers qualitative losses only in extreme cases and still convert the values of extreme qualitative losses into quantitative losses. It could be part of the reason why emphasis on reducing postharvest losses in developing countries tends to focus on only quantitative losses even when deterioration in produce quality is problem as well.

Another problem with the methodological inconsistencies of postharvest loss assessment is that designing interventions can be risky due to conflicting PHLs figures for most commodities. Plantain for instance, 40% of losses in terms of discarded volume (i.e. quantitative PHLs) were reported in Nigeria by Olorunda and Aworth (1996), whereas another study by Akalumbe *et al.* (1996) in the same year published postharvest losses in bananas and plantain fruits to be 17% in South East and South West of Nigeria collectively. The later study also noted an amount of 3% economic value losses for fruits traded in Southeast part of Nigeria. Another study on plantain and banana postharvest losses in Lagos metropolis market (located in the

Southwest) reported that wholesalers reported losses of 6.62% per lorry trip during peak season and 2.5% per lorry trip during off season (Adewumi *et al.*, 2009). This as well indicates that market seasons are influential to amount of PHLs experienced. Meanwhile, relatively higher plantain postharvest losses of 27% had been reported in Rivers State (Olayemi *et al.*, 2012).

Ajayi and Mbah (2007) explained that variations in postharvest losses are as result of differences in postharvest technologies being practiced in the different production areas. The differences in postharvest losses figures could also have stemmed from methodological inconsistencies arising from differences in the definitions of what actually constitute losses and/or a combination of both which may lead to exaggeration of loss figures (Tyler, 2014; Affognon *et al.*, 2015).

It should be noted that plantains are consumed by different social classes in almost all stages of ripeness; therefore, the possibility of losses being exaggerated or under-represented should not be dismissed. People of lower social class rely on low priced food to survive and would not be able to afford highly priced food. Produce that already show signs of quality deterioration would be restricted to lower markets because they are likely not to meet quality standards of more competitive markets. Thus, the reduction in produce quality denies a commodity the market opportunity to command premium prices. This situation may lead to what is called economic food loss, a scenario where reduced prices are earned for produce that should otherwise command higher or premium prices, (Hodges, Buzby and Bennett, 2010). There is also the tendency for lower food prices to be synonymous with poor quality food in a scenario where a majority of food produce is of low quality and only a few is of high quality. Lack of purchasing power for good quality and nutritious food is an indication of food insecurity not necessarily food availability (Gustavsson *et al.*, 2011). Every human being has the right to safe and nutritious food therefore relegating low quality produce to lower markets will further increase the gap between the poor and the rich; implying that people of lower social class will not have adequate access to good quality and nutritious food. As such, reduction in the amount of poor quality as well as discarded quantity of fresh agricultural produce should be the focus of proper postharvest management in traditional food supply chains. Based on these thoughts, this study recognized both quantitative and qualitative postharvest losses by referring to qualitative losses as the amount of produce that sold for lower price as a result of reduced market quality whereas the amount of produce that were discarded constituted quantitative losses (Genova *et al.*, 2006).

Usually, agriculture policies in Nigeria and most African countries tend to favor increasing food production by expanding cultivation on arable land. Even when policies mention reduction of postharvest losses as among key target areas like in the ATA (FMARD, 2013), it is observed that no proper attention is given to postharvest management of horticultural produce. It should be noted that increasing food production without proper postharvest management will lead to even more losses and wastage of already constrained and depleted natural resources.

1.4 Problem Statement

Fertile arable land, climatic conditions that favor production of many tropical food crops especially in the Southern Nigeria provides the country with the capacity to adequately produce most of its food staples and as well enjoy export earnings from agriculture. Sadly, this is not the case. According to the latest world hunger report, the country is suffering from serious food insecurity (IFPRI, 2016). Worsening matters is that the recent population estimate projects a high rate of population growth for Nigeria by 2050 (United Nations, 2015). No doubt, that the anticipated growth in population will further heighten the food insecurity situation. Thus, it is extremely important that food systems in the country be efficient enough to sustain the food needs of the populace in an effective manner. Regrettably, the agriculture sector has continued to suffer from non-holistic food security policies coupled with poor implementation which have led to unsuccessful food security interventions (Iwuchukwu and Igbokwe, 2012). In Rivers State for instance, the National food security programme that was intended to strengthen food production is reported to have no significant impact due to low participation by farmers (Denis *et al.*, 2014). In fact, the current situation shows that the food systems in Nigeria are far from being effective as the commodity postharvest chains for most fresh produce are plagued with high postharvest losses; where up to 50% of the food produced is lost along the commodity chain (FAO, 2013; FMARD, 2013). This means that half of what is produced in the food systems never gets consumed. A recent multi-country study estimated food loss in Nigeria to be over 100 kg/capita/year and recommended that food losses can be averted by improving the necessary infrastructures (Bahadur *et al.*, 2016).

In Nigeria particularly postharvest losses of most perishable staple food commodities stem from the poor state of the postharvest systems. For instance, a panel data study by Mbuk *et al.* (2011) although only focused on tomato retailers in Uyo (a South-South state) found that postharvest losses were over 50% and inappropriate postharvest handling contributed to losses. Adeniyi and Ayandiji (2014) assessed plantain and banana postharvest losses on the basis of the activities carried out in the distribution system; they found that losses during transportation amounted to 46.45% while losses during sales were 19.95% and losses during marketing were 33.6%. In Rivers State, a study which utilized an investigative survey approach reported that the mean postharvest loss values for several staple commodities in the state were 37.33% for yam; 33% for leafy vegetables; 27.67% for cassava; 27% for plantains and 20.33% for maize (Olayemi *et al.*, 2012). These postharvest research are clear evidence that postharvest losses is a problem to Rivers State and Nigeria as a whole; and thus worthy of proper attention in the fight against food insecurity.

One way for the agriculture sector to be more effective in production of staple foods is through efficient utilization of improved practices in part of the country where the staple has high production. Plantain is a staple food for which a substantial number of persons around the African continent depend on to meet their daily carbohydrate requirements (IITA, 2010). Consumed in different forms in Nigeria, plantain ranks

third position among starchy staples (Akinyemi *et al.*, 2010; Ben-Chendo *et al.*, 2013). Information in the literature indicates that Nigerian households desire to increase their plantain consumption due to the associated health benefits; however many cannot afford to (Ajayi and Aneke, 2002). Gustavsson *et al.* (2011) explained that food insecurity may not necessarily mean supply inadequacy but also a reduced ability to adequately access food. The Federal Ministry of Agriculture and Rural Development (FMARD) acknowledged that low purchasing power by low income earners is one challenge of food insecurity facing Nigeria (FMARD, 2016). Although an increased production can be helpful at addressing food inaccessibility, plantain production in Nigeria is plagued with high perishability and losses can go as high as 20% to 60% (Olayemi *et al.*, 2012). For a staple food with unmet domestic demands as well as insignificant exports, existence of high losses (Ladapo and Oladele, 2011) begs for immediate action to identify where the most losses occur and loss reduction strategies that allow increased production efforts to exert a net positive effect. Nevertheless, the fate of plantain production lies solely in the hands of smallholder farmers; most of whom may not be educated coupled with a lack of access to extension services (Kainga and Seiyabo, 2012). In Rivers State which is one of the high production areas for plantain, Olayemi *et al.* (2012) found that plantain farmers experienced an average loss of 27% and do not consult any extension experts when faced with postharvest problems. While the study provides a useful understanding of the estimated losses for staple foods in the state, the assessment of several staple commodities at once gave less room for an in-depth understanding of the forms of losses and proposed strategies for reduction of the losses. Moreover, the study only targeted farmers, which is just one group in the postharvest chains. Thus, the loss estimates cannot account for the total losses in the postharvest systems to guide intervention in the postharvest chain.

Another challenge is that reported food losses are in conflicting figures that pose a difficulty in designing interventions that are based on accurate information. For instance, plantain postharvest losses in Nigeria have been reported from as low as 5% to as high as 27% (Adewumi *et al.*, 2009; Olayemi *et al.*, 2012) and even 40% in a much previous studies Olorunda and Aworth (1996). Conflicting values in postharvest losses imply that losses are either truly variable, exaggerated or underreported (Tyler, 2014; Affognon *et al.*, 2015). Thus, to avoid misguided solutions, strategic interventions should rather be based on evidence of losses from specific localities or parts of the postharvest chain that are more prone to loss incidences.

Targeted increased investment towards reduction of postharvest losses in developing countries is among the recommendations highlighted to ensure effectiveness and sustainability of food systems (Smil, 2004; Lipinski *et al.*, 2013). This would require significant effort to manage postharvest quality of agricultural produce. Such effort agrees with identification and incorporation of postharvest management strategies in food security policies especially those that pertain to high production areas for staple foods. Currently, little information exists to guide evidence based decisions in inclusion of postharvest quality management in food security policies.

Postharvest quality management of agricultural produce involves the utilization of appropriate postharvest technologies. Conventional postharvest technologies require sophisticated infrastructures like cool chains; mostly suitable for large scale operations and may not even be compatible with small-scale operations. Therefore, forcing such sophisticated large scale postharvest technologies will only lead to failed interventions. As such, need-based postharvest solutions more suitable to small-scale operations are needed as alternatives to maintain postharvest quality, reduce losses and improve the effectiveness of postharvest systems for staple foods like plantain in Rivers State. Small-scale postharvest practices (SSPPs) due to their potentials to reduce losses are appropriate alternatives to manage produce quality in smallholder systems (Bachmann and Earles, 2000; Kitinoja and Kader, 2003; Kitinoja and AlHassan, 2012). Small-scale postharvest practices (SSPPs) are beneficial at strengthening food security and improving the profits of small scale supply chain players.

A few papers have made useful contribution towards giving an understanding on the adoption scenario of small scale postharvest technologies in Nigeria. The study by Mbuk *et al.* (2011) found that a simple postharvest handling practice of storing fresh tomatoes overnight with paper coverings negatively correlated with the amount of spoilage reported by marketers; however, a low adoption of the practice 6.7% was observed in the study area, Akwa-Ibom State of Nigeria. Similarly another study observed that reasons for non-adoption of re-usable plastic crates in Kano State, Nigeria were related to difficulty in changing old habits, lack of awareness among other factors (Adegbola, Bamishaiye and Olayemi, 2011). These studies failed to study the factors that affect adoption of postharvest practices. There is hardly any study to guide evidence based postharvest interventions in Rivers State which is a high production area for a variety of staple foods; hence the current study. The goal of the current study was to extend the effort made by previous authors by estimating the plantain losses at farm and market levels and their relationship to the use of small-scale postharvest practices. While behavioral theories have been applied to the understand changes in various human behaviors including adoption of several agriculture technologies, the same is yet to be done for postharvest management in smallholder systems. Therefore, to address the inclusion of postharvest management in the Rivers State, the current study investigated the potential adoption of small-scale postharvest practices in the postharvest chain by determining the factors that influence adoption intention. This is to enable an increase in adoption through addressing of influential factors that have limited potential adopters from using small-scale postharvest practices.

1.5 Research Questions

In order to achieve the general objective of this study, it is imperative to address the research questions that have been developed. The research questions were developed to elucidate on the potential adoption of small-scale postharvest practices in urgently reducing plantain postharvest losses and strengthening the inclusion of postharvest

management in Rivers State, which is one of the high production areas for Nigerian staple foods. Thus the research questions addressed in this study are as follows:

1. What are the average plantain postharvest losses experienced by farmers and traders in the supply chain?
2. What is the relationship between postharvest loss incidence and usage of small-scale postharvest practices in Rivers State?
3. What is the current awareness-knowledge level and adoption rate of the selected small-scale postharvest practices?
4. What variables are associated with adoption of small-scale postharvest practices?
5. Are adopters and non-adopters different in their perceptions of small-scale postharvest practices?
6. Can adoption decision factors related to smallholder plantain farmers and traders behavior towards small-scale postharvest practices be meaningfully factorized?
7. What are the simultaneous effects of adoption decision factors (such as awareness-knowledge, perceptions, attitudes and motivation) on intention to use small-scale postharvest practices in Rivers State?

1.6 Objectives of the Study

The general objective of the study is to investigate the potential adoption of small-scale postharvest practices towards reducing losses in plantain supply chain in Rivers State, Nigeria.

The specific objectives of the study are as follows:

1. To estimate the losses at farm and market levels and their relationship with adoption of small-scale postharvest practices.
2. To ascertain the awareness level and adoption rate of selected small-scale postharvest practices in the postharvest chain.
3. To determine the personal factors that are associated with adoption of small-scale postharvest practices.
4. To model the adoption decision factors, and evaluate their influence on smallholder plantain farmers and traders intention to use small-scale postharvest practices.

1.7 Justification of the Study

The hunger situation in Nigeria is categorized as being serious even when most food commodity supply chains record high postharvest losses. Considering how food losses can reduce the available food, drive food prices high and subsequently reduce

purchasing power of low income households while at the same reducing smallholder agribusiness income, integration of appropriate small-scale postharvest practices in the commodity supply chains of staple foods is necessary to prevent most of the food from being lost. Preventing as much food loss as possible will be extremely beneficial to reduce the number of people who do not have adequate food to lead food secured lives. Besides, the expected high rate of population growth calls for steps to be taken to increase the food volume in the country.

The concept of sustainability is concerned with improving the quality of life for the current generation without hampering the future generations' ability to meet their needs. Sustainable food systems are among important aspects of sustainable development of any country. There has been a growing interest towards improving food security in Rivers State and Nigeria as a whole. It is unarguably true that reducing postharvest losses will increase the sustainability of food systems in Nigeria. Therefore, instead of solely targeting to increase food production, priority should be given to the already produced food. More resources and attention should be channeled towards preventing avoidable food losses in order to reduce waste of precious resources being used in food production.

Nigeria already has a large number of food insecure persons, and with the projected population growth, food losses cannot be allowed to continue if the country intends to achieve a sustainable development. This necessitates reduction of postharvest losses as an immediate and sustainable approach to food security. Since modern postharvest infrastructures are currently lacking and as food insecurity continues to worsen, investigating alternative strategies has become very essential. Adoption of small-scale postharvest practices are cheap alternatives to maintaining fresh produce quality, therefore an understanding of the factors that promote adoption is necessary.

The current study is based on the premise that although postharvest losses result due to lack of modern postharvest infrastructure, appropriate small-scale postharvest practices if properly utilized can serve as urgent solutions to reduce food losses in the country. The study, being the first of its kind, assumes that there is a difference in the postharvest losses experienced by supply chain players who at least carry out some form of small-scale postharvest practices notwithstanding how minimal and those who do not. Therefore, the study examined the factors associated with adoption of small-scale postharvest practices. Intending to increase acceptance and consequently adoption of SSPPs, the study evaluated the influence of adoption decision factors on supply chain players intention to use small-scale postharvest practices.

The results of this study is expected to stimulate a re-think in the direction of postharvest research. In addition, findings of the study will also enable policy makers make evidence based decisions on interventions strategies aimed at reducing losses and improving the food systems. Overall, the study will fill the knowledge gap in the adoption literature regarding adoption of postharvest management

practices in smallholder agriculture systems. The study also lays the foundation for future food production studies in Rivers State which is a high production area for a number of staple foods. Overall, the study positively contributes towards improving the performance of traditional AFSCs.

1.8 Scope of the Study

Nigeria has always had an interest towards food security to feed its rapidly increasing population. Increasing food production is one way to increase food security; decreasing postharvest losses is another way to boost food security. The latter is critical because without properly addressing the challenges of postharvest losses in the commodity supply chains, any efforts to increase production will be undermine by the poor postharvest systems and this can lead to an undesired viscous cycle. Therefore the second approach to improvement of food security was the focus of this study.

Food loss is a complex phenomenon and proper understanding of strategies to curb losses in the traditional supply chains, known to be fragmented and complicated calls for a multidisciplinary approach. This study synthesized knowledge form several fields such as supply chain food quality management, postharvest horticulture, human behavior and decision making, adoption of innovations etc. in order to achieve this multidisciplinary approach. The study mainly employed quantitative approach to understand the concepts being investigated. Overall, the study seeks to draw attention to the potentials of small-scale postharvest practices in preventing avoidable losses.

Plantain is one of the most consumed starchy staple in Nigeria and is readily available throughout the year. According to the IITA, more than 70 million people in Sub-Saharan Africa derived their daily carbohydrate requirement from plantains. Plantain, as a staple food in Nigeria, is consumed in different forms by people from all social class. Although demand for plantain is always high and production is throughout the year, the plantain commodity supply chain is plagued by high postharvest losses.

Apart from being a crop that significantly contributes to food security, plantain production and trading is an economically viable activity for smallholders in the Southern region of the country. Hence its selection for studies towards reducing postharvest losses is appropriate. Production of plantain in Nigeria is concentrated only in the Southern part of the country (Akinyemi, Aiyelaagbe and Akyeampong, 2010) due to favorable production conditions such as climatic factors, fertile forests, laterite soils, etc. High yielding plantain production regions are located in South-South states: Bayelsa, Rivers State, Akwa Ibom, and South-West states: Osun, Ogun (Cauthen *et al.*, 2013).

Rivers State was selected as the focus area for this study because agriculture is a dominant economic activity of the people coupled the state's potentials for agricultural development. Moreover, the state is one of the high yielding production zones for plantain with cultivation in almost all upland localities in the state (Fakayode *et al.*, 2011). Nevertheless, high postharvest losses pose as a challenge to the state's plantain production efforts.

1.9 Organization of the Thesis

This thesis reports findings of the current study 'the adoption potential of small-scale postharvest practices towards reducing plantain supply chain losses in Rivers State, Nigeria'. The thesis is divided into six (6) chapters. Chapter one contains the introduction which gives an overview of the Nigerian agricultural sector and challenges encountered in policies that should have developed the sector. The first chapter further discusses the challenges that prevail in traditional agricultural food supply chains as obtainable in the fresh produce commodity in Nigeria and how these challenges relates to food security in the country. The chapter further explains the rationale behind the study, the problem statement, the research questions and the objectives.

Chapter two consists of the literature review based on previous studies and relevant information from which ideas were drawn to systematically design the study. The two broad focus of the literature review were on the postharvest literature and adoption behavior towards new innovations or technologies. In chapter three, the thesis explains the conceptual framework, hypothesized relationships and the methodological details involved in conducting the study.

Chapter four and five present the results and discussions of the findings for the farmers and traders groups, respectively to ease a clear understanding of both supply chain player groups. Chapter six (6) is the last chapter which contains a general conclusion of the discussed results. Relevant recommendations are also given in chapter six. A brief discussion on the limitations of the study is given alongside suggestions for further research that will improve the findings of the study.

REFERENCES

Abass, A.B., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N. and Bekunda, M. (2014) 'Postharvest Food Losses in a Maize-Based Farming System of Semi-Arid Savannah Area of Tanzania', *Journal of Stored Products Research*, 57, pp. 49 -57.

Adebisi-Adelani, O., Olajide-Taiwo, F. B., Adeoye, I. B. and Olajide-Taiwo, L. O. (2011) 'Analysis of Production Constraints Facing Fadama Vegetable Farmers in Oyo State , Nigeria', *World Journal of Agricultural Sciences*, 7(2), pp. 189–192.

Adegbola, A., Bamishaiye, E. I. and Olayemi, F. (2011) 'Factors Affecting the Adoption of the Re-Usable Plastic Vegetable Crate in Three Local Government Areas of Kano State, Nigeria', *Asian Journal of Agricultural Sciences*, 3(4), pp. 281–285.

Adejoro, M. A., Odubanjo, A. O. and Fagbola, B. O. (2010) 'Research Focus on Banana and Plantain (Musa spp.): Nigerian Perspectives', in Dubois, T. (ed.) *International conference on banana & Plantain in Africa*. Acta Hort. 879, ISHS, pp. 859–864.

Adeniyi O.R. and Ayandiji A. (2014) 'Economic Analysis of Postharvest Losses in Plantain (and Banana): A Case Study of South Western Nigeria', *British Journal of Applied Science and Technology,* 4 (31), pp. 4456 - 4467.

Adeoye, I. B., Oni, O. A., Yusuf, S. A. and Adenegan, K. O. (2013) 'Plantain Value Chain Mapping in Southwestern Nigeria', *Journal of Economics and Sustainable Development*, 4(16), pp. 137–146.

Adepoju, A. O. (2014) 'Post-harvest losses and welfare of tomato farmers in Ogbomosho , Osun state , Nigeria', *Journal of Stored Products and Postharvest Research*, 5(2), pp. 8–13. doi: 10.5897/JSPPR2014.0160.

Adesina, A.A. and Chianu, J. (2002) 'Determinants of farmers' adoption and adaptation of alley farming technology in Nigeria', *Agroforestry Systems,* 55 (2) pp 99 – 112.

Adetunji, M. O. and Adesiyan, I. O. (2008) 'Economic Analysis of Plantain Marketing in Akinyele Local Government Area in oyo State, Nigeria', *International Journal of Agricultural Economics & rural Development*, 1(1), pp. 15–21.

Adewumi, M. O., Ayinde, O. E., Falana, O. I. and Olatunji, G. B. (2009) 'Analysis of postharvest losses among Plantain/Banana (Musa Spp . L .) marketers in Lagos State, Nigeria.', *Nigerian Journal of Agriculture, Food and Environment*, 5(2–4), pp. 35–38.

Adrian, A. M. (2006) *Factors Influencing Adoption and Use of Precision Agriculture*. Auburn University.

Adrian, A. M., Norwood, S. H. and Mask, P. L. (2005) 'Producers' perceptions and attitudes toward precision agriculture technologies', *Computers and Electronics in Agriculture*, 48(3), pp. 256–271. doi: 10.1016/j.compag.2005.04.004.

Adu-amankwa, P. A. and Boateng, B. A. (2011) 'Postharvest status of plantain in some selected markets in Ghana', *Journal of Research in Agriculture*, 1(1), pp. 6–10.

Adugna Debela., Gerba Daba., Diriba Bane and Kassaye Tolessa (2011) 'Identification of Major Causes of Postharvest Losses among Selected Fruits in Jimma Zone for Proffering Veritable Solutions', *International Journal of Current Research*, 3(11), pp. 040-043. ISSN: 0975-833X. Available online @ http://www.journalcra.com

Affognon, H., Mutungi, C., Sanginga, P. and Borgemeister, C. (2015) 'Unpacking Postharvest Losses in Sub-Saharan Africa: A Meta-Analysis', *World Development*, 66, pp. 49–68. doi: 10.1016/j.worlddev.2014.08.002.

Afthanorhan, W. mohamad A. W. (2014) 'Hierarchical component using reflective-formative measurement model in Partial Least Square Structural Equation Modeling (PLS-SEM)', *International Journal of Mathematics and Statistics Invention (IJMSI)*, 2(2), pp. 55–71.

Agber, T., Iortima P.I., and Imbur, E. N. (2013) 'Lessons From Implementation of Nigeria'S Past National Agricultural Programs for the Transformation Agenda', *American Journal of Research Communication*, 1(10), pp. 238–253.

Ahmad, M. S. and Siddiqui, M. W. (2016) 'Factors Affecting Postharvest Quality of Fresh Fruits', in *Postharvest Quality Assurance of Fruits*. Switzerland: Springer International Publishing. doi: 10.1007/978-3-319-21197-8.

Ajani, E. N. and Igbokwe, E. M. (2014) 'A Review of Agricultural Transformation Agenda in Nigeria : The Case of Public and Private Sector Participation', *Research Journal of Agriculture and Environmental Management*, 3(5), pp. 238–245.

Ajayi, A. R. and Aneke, M. . (2002) 'Consumption and expenditure patterns of banana and plantain consumers in Nsukka Urban, Nigeria. InfoMusa', *InfoMusa*, 11(1), pp. 50–53.

Ajayi, A. R. and Mbah, G. O. (2007) 'Identification of indegenious ripening technologies of banana and plantain fruits among women – marketers in Southeastern Nigeria', *Agro-Science Journal*, 6(2), pp. 60–66.

Ajzen, I. (1971) 'Attitudinal vs . Normative Messages : An Investigation of the Differential Effects of Persuasive Communications on Behavior Author (s): Icek Ajzen Published by : American Sociological Association Stable URL : http://www.jstor.org/stable/2786416 Attitudi', *Sociometry*, 34(2), pp. 263–280.

Akalumbe, Y. O. S., Ferris, D., Vuylsteke, R., Ortiz and Okunmadewa, F. Y. (1996) 'Socio-economic analysis of farm retail prices and post-harvest losses of plantain in southern Nigeria.', in *Musa Research MUSAFRICA, No. 3, pp. 12-13.*, pp. 12–13.

Akinyemi, S. O. S., Aiyelaagbe, I. O. O. and Akyeampong, E. (2010) 'Plantain (Musa spp .) Cultivation in Nigeria : a Review of Its Production , Marketing and Research in the Last Two Decades', in Dubois, T. (ed.) *InterC on Banana & Plantain in AfricaC on Banana & Plantain in Africa*. Acta Hort. 879, ISHS, pp. 211–218.

Ali, J. (2012) 'Factors Influencing Adoption of Postharvest Practices in Vegetables', *International Journal of Vegetable Science*, 18(1), pp. 29–40. doi: 10.1080/19315260.2011.568998.

Alonso, M.A.S; Paquin, Jean-Paul and Mangin, Jean-Pierre L. (2002) 'Modelling Perceived Quality in Fruit Products: Their Extrinsic and Intrinsic Attributes', *Journal of Food Products Marketing*, 8(1), pp. 29-48

Arah, I. K., Kumah, E. K., Anku, E. K. and Amaglo, H. (2015) 'An Overview of Post-Harvest Losses in Tomato Production in Africa : Causes and Possible Prevention Strategies', *Journal of Biology, Agriculture and Healthcare*, 5(16), pp. 78–89.

Aramyan, L. H., Lansink, A. G. J. M. O., Vorst, J. G. a. J. Van Der and Kooten, O. Van (2007) 'Performance measurement in agri-food supply chains: a case study', *Supply Chain Management: An International Journal*, 12(4), pp. 304–315. doi: 10.1108/13598540710759826.

Ary, D., Jacobs, L. C., Sorenson, C. and Razavieh, A. (2010) *Introduction to Research in Education*. 8th edn. Edited by C. Shortt, T. WIlliam, C. Cox, and L. Stewart. Wadsworth, USA: Cengage Learning.

Asoegwu, S. N. and Asoegwu, A. O. (2007) 'An Overview of Agricultural Mechanization and Its Environmental Management in Nigeria', IX(6), pp. 1–22.

Atanda, S. A., Pessu, P. O., Agoda, S., Isong, I. U. and Ikotun, I. (2011) 'The concepts and problems of post – harvest food losses in perishable crops', *African Journal of Food Science*, 5(11), pp. 603–613.

Aulakh, J., Regmi, A., Fulton, J. and Alexander, C. (2013) 'Estimating Post-Harvest

Food losses: Developing a Consistent Global Estimation Framework', in *Agriculture & Applied Economics Association's AAEA & CAES Joint Annual Meeting*. Washington, DC: Food and Agriculture Organization of the United Nations.

Aung, M. M. and Chang, Y. S. (2014) 'Temperature management for the quality assurance of a perishable food supply chain', *Food Control*, 40(1), pp. 198–207. doi: 10.1016/j.foodcont.2013.11.016.

Awang, Z., Afthanorhan, A. and Mamat, M. (2015) 'The Likert scale analysis using parametric based Structural Equation Modeling (SEM)', *Computational Methods in Social Sciences*, 4(1), pp. 13–21.

Bachmann, J. and Earles, R. (2000) 'Postharvest Handling of Fruits and Vegetables: horticultural technical note', *Appropriate Technology Transfer for Rural Areas*.

Bahadur, K. K., Haque, I., Legwegoh, A. F. and Fraser, E. D. G. (2016) 'Strategies to reduce food loss in the global south', *Sustainability (Switzerland)*, 8(7), pp. 1–13. doi: 10.3390/su8070595.

Balaji, M. and Arshinder, K. (2016) 'Modeling the causes of food wastage in Indian perishable food supply chain', *Resources, Conservation and Recycling*. Elsevier B.V., 114, pp. 153–167. doi: 10.1016/j.resconrec.2016.07.016.

Banks, N. H. (2009) *Postharvest Handling : A Systems Approach*. Second Edi, *Postharvest Handling*. Second Edi. Elsevier Inc. doi: 10.1016/B978-0-12-374112-7.00001-9.

Baruwa, O. I., Masuku, M. B. and Alimi, T. (2011) 'Economic Analysis of Plantain Production in Derived Savannah Zone of Osun State , Nigeria', *Asian Journal of Agricultural Sciences*, 3(5), pp. 401–407.

Bart Minten., Thomas Reardon., Sunipa Das Gupta., Dinghuan Hu and K.A.S Murshid (2016) ' Wastage in Food Value Chains in Developing Countries: Evidence from the Potato Sector in Asia' *Food Security in a Food Abundant World*, pp. 225-238.

Batista, G. E. A. P. A. and Monard, M. C. (2003) 'An analysis of four missing data treatment methods for supervised learning', *Applied Artificial Intelligence*, 17(5–6), pp. 519–533. doi: 10.1080/713827181.

Bature, Y. M., Sanni, A. A., Adebayo, F. O., District, C. B., Assembly, N. and Policy, F. (2013) 'Analysis of Impact of National Fadama Development Projects on Beneficiaries Income and Wealth in FCT , Nigeria', *Journal of Economics and Sustainable Development*, 4(17), pp. 11–24.

Bauer, R. A. (1960) 'Consumer behavior as risk taking', in *Risk Taking and*

Information Handling in Consumer Behavior, pp. 389–398.

Bayeri, K. P. and Nwachukwu, I. (2003) 'Storage methods influenced occurrence and severity of crown rot and anthracnose diseases on plantain (Musa spp. ABB) fruits during storage and post storage. p.201–204. In: A.S. Fasina, A.O. Olufolaji and V.C. Umeh (eds', in *Proceeding of the 21st Annual Conference of the Horticultural Society of Nigeria.* Lagos: Ess-Jay Business and Publishing Centre.

Becker, J. M., Klein, K. and Wetzels, M. (2012) 'Hierarchical Latent Variable Models in PLS-SEM: Guidelines for Using Reflective-Formative Type Models', *Long Range Planning*. Elsevier Ltd, 45(5–6), pp. 359–394. doi: 10.1016/j.lrp.2012.10.001.

Ben-Chendo, G. N., Eze, C. C. and Asiabaka, C. C. (2013) 'Value Addition to Plantain by Women Entrepreneurs in Imo State ', *Developing Country Studies*, 3(10), pp. 130–139.

Bennett, M. K. (1941) 'WHEAT IN NATIONAL DIETS', *Wheat Studies of the Food Research Institute*, 18(2), pp. 37–76.

Beretta, C., Stoessel, F., Baier, U. and Hellweg, S. (2013) 'Quantifying food losses and the potential for reduction in Switzerland', *Waste Management*, 33(3), pp. 764–773. doi: http://dx.doi.org/10.1016/j.wasman.2012.11.007.

Betz, A., Buchli, J., Göbel, C. and Müller, C. (2015) 'Food waste in the Swiss food service industry – Magnitude and potential for reduction', *Waste Management*, 35, pp. 218–226.

Bokusheva, R., Finger, R., Fischler, M., Berlin, R., Marín, Y., Pérez, F. and Paiz, F. (2012) 'Factors determining the adoption and impact of a postharvest storage technology', *Food Security*, 4(2), pp. 279–293. doi: 10.1007/s12571-012-0184-1.

Bourlakis, M., Maglaras, G., Gallear, D. and Fotopoulos, C. (2014) 'Examining sustainability performance in the supply chain: The case of the Greek dairy sector', *Industrial Marketing Management*, 43(1), pp. 56–66. doi: 10.1016/j.indmarman.2013.08.002.

Boz, I. and Akbay, C. (2005) 'Factors influencing the adoption of maize in Kahramanmaras province of Turkey', *Agricultural Economics*, 33(SUPPL. 3), pp. 431–440. doi: 10.1111/j.1574-0864.2005.00305.x.

Burns, R. B. and Burns, R. A. (2008) *Business Research Methods and Statistics Using SPSS*. London, UK: Sage Publications Inc.

Buzby, J. C., Farah Wells, H. and Hyman, J. (2014) *The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels*

in the United States, *USDA-ERS Economic Information Bulletin*. doi: 10.2139/ssrn.2501659.

Cauthen, J., Jones, D., Gugerty, M. K. and Anderson, C. L. (2013) 'Banana and Plantain Value Chain: West Africa EPAR Brief No. 239'. Evans School Policy And Research, pp. 1–25.

CBN (2003) *Statistical Bulletins and Annual Report*.

Chambers, R. and Jiggins, J. (1986) *Agricultural research for resource poor farmers: a parsimonious paradigm.* 220. Brighton, England. Available at: https://opendocs.ids.ac.uk/opendocs/handle/123456789/860.

Chen, D. and Chen, H. W. (2013) 'Using the Köppen classification to quantify climate variation and change: An example for 1901–2010', *Environmental Development*, 6, pp. 69–79. doi: http://dx.doi.org/10.1016/j.envdev.2013.03.007.

Chin, W. (1998) 'The partial least squares approach to structural equation modeling', *Modern methods for business research*, 295(2), pp. 295–336. doi: 10.1016/j.aap.2008.12.010.

Chin, W. W. (2010) 'How to Write Up and Report PLS Analyses', in *Handbook of Partial Least Squares*, pp. 655–690. doi: 10.1007/978-3-540-32827-8_29.

Chin, W. W. and Chin, W. W. (2010) *Handbook of Partial Least Squares*. doi: 10.1007/978-3-540-32827-8.

Chopra, S. and Meindl, P. (2007) *Supply Chain Management*. New Jersey: Pearson Prentice Hall.

Cohen, J. (1988) 'Statistical power analysis for the behavioral sciences', *Statistical Power Analysis for the Behavioral Sciences*, p. 567. doi: 10.1234/12345678.

Costello, A. B. and Osborne, J. W. (2005) 'Best practices in exploratory factor analysis:Four recommendations for getting the most from your Analysis', *Practical Assessment, Research & Evaluation*, 10(5), pp. 1–9. doi: 10.1.1.110.9154.

Creswell, J. W. (2003) *Research design: Qualitative,Quantitative and Mixed Methods Approaches*. Second, *Sage Publications*. Second. Sage Publications Inc.

Creswell, J. W. (2012) *Planning, Conducting and Evaluating Quantitative and Qualitative Research*. Fourth. PEARSON.

Creswell, J. W. (2014) *RESEARCH DESIGNS: Qualitative, Quantitative and Mixed Methods Approaches*. Fourth. United Kingdom: Sage Publications Inc.

D'Antoni, J. M., Mishra, A. K. and Joo, H. (2012) 'Farmers' perception of precision technology: The case of autosteer adoption by cotton farmers', *Computers and Electronics in Agriculture*, 87, pp. 121–128. doi: 10.1016/j.compag.2012.05.017.

Davis, F. D., Bagozzi, R. P. and Warshaw, P. R. (1989) 'User Acceptance of Computer Technology : A Comparison of Two Theoretical Models', *Management Science*, 35(8), pp. 982–1003.

Dennis, N. H., Kelvin, N., Igbara, F. N. and Turakpe Morrison, J. (2014) 'Agricultural Employment in Rivers State , Nigeria : A Case of National Programme for Food Security .', *Journal of Economics and Sustaianble Development*, 5(25), pp. 128–136. doi: ISSN 2222-2855.

Dibsdall, L., Lambert, N., Bobbin, R. and Frewer, L. (2003) 'Low-income consumers' attitudes and behaviour towards access, availability and motivation to eat fruit and vegetables', *Public Health Nutrition*, 6(2), pp. 159–168. doi: 10.1079/PHN2002412.

Douthwaite, B., Keatinge, J. D. H. and Park, J. R. (2001) 'Why promising technologies fail: The neglected role of user innovation during adoption', *Research Policy*, 30(5), pp. 819–836. doi: 10.1016/S0048-7333(00)00124-4.

Dury, S., Bricas, N., Tchango-Tchango, J., Temple, L. and Bikoi, A. (2002) 'The determinants of urban plantain consumption in Cameroon.', *Food Quality and Preference*, 13(2), pp. 81–88.

Ebiowei, K. P. (2013) 'Budgetary analysis of banana (Musa sapientum L .) and Plantain (Musa paradisiaca L .) production', *Journal of Agricultural and Crop Researchop Research*, 1(4), pp. 55–60.

Edirimanna, E. R. S. ., Amarathunga, D. K., Amarasena, B. G. and Kirinde, T. (2015) 'Effect of Bagging Materials and Bag Colour on Fruit', *Annals of Sri Lanka Department of Agriculture*, 17, pp. 297–302.

Egyir, I. S., Sarpong, D. B. and Obeng-Ofori, D. (2011) *Monitoring and Evaluation System for Post Harvest Losses (Pilot Study)*. Accra, Ghana.

Emana, B., Afari-Sefa, V., Nenguwo, N., Ayana, A., Kebede, D. and Mohammed, H. (2017) 'Characterization of pre- and postharvest losses of tomato supply chain in Ethiopia', *Agriculture and Food Security*. BioMed Central, 6(1), pp. 1–11. doi: 10.1186/s40066-016-0085-1.

Evans, D. (2011) 'Blaming the consumer – once again: the social and material contexts of everyday food waste practices in some English households', *Critical Public Health*, 21(4), pp. 429–440. doi: 10.1080/09581596.2011.608797.

Evans, D. (2012) 'Beyond the Throwaway Society: Ordinary Domestic Practice and a Sociological Approach to Household Food Waste', *Sociology*, 46(1), pp. 41–56. doi: 10.1177/0038038511416150.

Fakayode, B. S., Rahji, M. A. Y., Ayinde, O. and Nnom, G. O. (2011) 'An economic assessment of plantain production in Rivers State , Nigeria', *International Journal of Agricultural Economics & Rural Development*, 4(2), pp. 28–36.

FAO (2011) *Global food losses and food waste: extent, causes and prevention*, *SAVE FOOD!* Rome: Food and Agriculture Organization of the United Nations. doi: 10.1098/rstb.2010.0126.

FAO (2012) 'Value Creation development and post-harvest loss reduction for smallholder farmers', in *FAO Regional Conference for Asia and The Pacific*. Hanoi, Vietnam, pp. 1–43.

FAO (no date) 'Strengtheing Nigeria's Plantain value chain to curtail postharvest losses'. Abuja, Nigeria: FAO Nigeria Country Office, pp. 1–2. doi: TCP/NIR/3302.

FAO (2013) *FAO Country Programming framework (CPF) 2013-2017*. Abuja, Nigeria.

FAO, IFAD and WFP (2015) *The State of Food Insecurity in the World: Meeting the 2015 international hunger targets: taking stock of uneven progress.*, *FAO Publications*. Rome. doi: I4646E/1/05.15.

FAOSTAT (2017) *Plantain Production Statistics: Nigeria*, *Food and Agriculture Organisation of the United Nations Statistics Division*.

Faturoti, B. O., Emah, G. N., Isife, B. I., Tenkouano, A. and Lemchi, J. (2006) 'Prospects and determinants of adoption of IITA plantain and banana based technologies in three Niger Delta States of Nigeria', *African Journal of Biotechnology*, 5(14), pp. 1319–1323.

Ferguson, E. and Cox, T. (1993) 'Exploratory Factor Analysis: A Users' Guide', *International Journal of Selection and Assessment*, 1(2), pp. 84–94. doi: 10.1111/j.1468-2389.1993.tb00092.x.

Ferris, R. S. B., Ortiz, R. and Vuylsteke, D. (1999) 'Fruit quality evaluation of plantains , plantain hybrids , and cooking bananas', *Postharvest Biology and Technology*, 15, pp. 73–81.

Field, A. (2005) 'Factor Analysis Using SPSS', in *Research Methods II*.

Field, A. (2009) *Discovering Statistics Using SPSS*. Third. Sage Publications Inc.

Fishbein, M. and Ajzen, I. (1975) *Belief, Attitude, Intention and Behavior: An*

Introduction to Theory and Research. Reading Mass Addison-Wesley.

Flight, R. L., D'Souza, G. and Allaway, a W. (2011) 'Characteristics-based innovation adoption: Scale and model validation', *Journal of Product and Brand Management*, 20(5), pp. 343–355. doi: 10.1108/10610421111157874.

FMARD (2013) *Agricultural Transformation Agenda: SCORE CARD*. Abuja, Nigeria.

FMARD (2016) *The Agriculture Promotion Policy (2016 - 2020): Building on the Successes of the ATA, Closing Key Gaps*. Abuja, Nigeria.

Folorunso, O. and Ogunseye, S. O. (2008) 'Applying an Enhanced Technology Acceptance Model to Knowledge Management in Agricultural Extension Services', *Data Science Journal*, 7 (March), pp. 31–45. doi: 10.2481/dsj.7.31.

Fornell, C. and Larcker, D. F. (1981) 'Evaluating Structural Equation Models with Unobservable Variables and Measurement Error', *Journal of Marketing Research*, 18(1), p. 39. doi: 10.2307/3151312.

Friedland, W. H. (2001) 'Reprise on Commodity Systems Methodology', *International Journal of Sociology of Agriculture and Food*, 9(1), pp. 82–103.

General Household Survey (2013). Report by National Bureau of Statistics Nigeria. Available at http://nso.nigeria.opendataforafrica.org/xvokkfg/national-summary-data-page-nsdp [Accessed on 28th December, 2017]

General Household Survey (2016). Report by National Bureau of Statistics Nigeria. Available at http://www.nigerianstat.gov.ng/nada/index.php/catalog/51/related_materials [Accessed on 28th December, 2017]

Genova, C., Weinberger, K. and Acedo, A. (2007) 'Understanding Postharvest Losses in Vegetables Using an Upstream Supply Chain Approach in South East Asia', in *Tropentag, 'Utilisation of diversity inland use systems: Sustainable and organic approaches to meet human needs'*. Witzenhausen.

Genova, C., Weinberger, K., Chanthasombath, T., Inthalungdsee, B., Sanatem, K. and Somsak, K. (2006) *Postharvest loss in the supply chain for vegetables - The case of tomato, yardlong bean, cucumber and chili in Lao PDR*. 17. Taiwan.

Ghani, W. A. W. A. K., Rusli, I. F., Biak, D. R. A. and Idris, A. (2013) 'An application of TPB to study the influence of participation in source separation of food waste', *Waste Management*, 33, pp. 1276–1281. doi: 10.1016/j.wasman.2012.09.019.

Gjerris, M. and Gaiani, S. (2013) 'Household food waste in Nordic countries : Estimations and ethical implications', *Etikk i praksis. Nordic Journal of Applied Ethics*, 7(1), pp. 6–23. doi: 10.5324/eip.v7i1.1786.

Gonzales, L. M. R., Aban, M. L. and Acedo-Jr, A. L. (2014) 'Supply Chain Mapping and Postharvest Losses of Cabbage in Traditional and Modern Chains in', in *International Conference on Chemical, Environment & Biological Sciences (CEBS)*, pp. 147–151.

Graham-Rowe, E., Jessop, D. C. and Sparks, P. (2014) 'Identifying motivations and barriers to minimising household food waste', *Resources, Conservation and Recycling*. Elsevier B.V., 84, pp. 15–23. doi: 10.1016/j.resconrec.2013.12.005.

Graham-Rowe, E., Jessop, D. C. and Sparks, P. (2015) 'Predicting household food waste reduction using an extended theory of planned behaviour', *Resources, Conservation and Recycling*. Elsevier B.V., 101, pp. 194–202. doi: 10.1016/j.resconrec.2015.05.020.

Grolleaud, M. (2002) *Post-harvest losses: discovering the full story. Overview of the phenomenon of losses during the Post-harvest System, Rome: FAO*.

Gruber, V., Holweg, C. and Teller, C. (2015) 'What a waste! Exploring the Human Reality of Food Waste from the Store Manager's Perspective', *Journal of Public Policy & Marketing*, pp. 1–50.

Gustavsson, J., Cederberg, J., Sonesson, J., van Otterdijk, J. and Meybeck, A. (2011) *Global food losses and food waste*. Rome.

Hair, J. F., Black, W. C., Babin, B. J. and Anderson, R. E. (2010) *Multivariate Data Analysis*. 7th Editio. New Jersey: Pearson Prentice Hall.

Hair, J. F., Hult, G. T. M., Ringle, C. M. and Sarstedt, M. (2014) *A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*. United Kingdom: Sage Publications Inc.

Hair, J. F., Ringle, C. M. and Sarstedt, M. (2013) 'Partial Least Squares Structural Equation Modeling: Rigorous Applications, Better Results and Higher Acceptance', *Long Range Planning*, 46(1–2), pp. 1–12. doi: 10.1016/j.lrp.2013.01.001.

Hair, J. F., Sarstedt, M., Pieper, T. M. and Ringle, C. M. (2012) 'The Use of Partial Least Squares Structural Equation Modeling in Strategic Management Research: A Review of Past Practices and Recommendations for Future Applications', *Long Range Planning*. Elsevier Ltd, 45(5–6), pp. 320–340. doi: 10.1016/j.lrp.2012.09.008.

Halloran, A., Clement, J., Kornum, N., Bucatariu, C. and Magid, J. (2014)

‘Addressing food waste reduction in Denmark’, *Food Policy*, 49(P1), pp. 294–301. doi: 10.1016/j.foodpol.2014.09.005.

Hanssen, O. J., Syversen, F. and Stø, E. (2016) ‘Edible food waste from Norwegian households - Detailed food waste composition analysis among households in two different regions in Norway’, *Resources, Conservation and Recycling*. Elsevier B.V., 109, pp. 146–154. doi: 10.1016/j.resconrec.2016.03.010.

Harman, H. H. (1961) ‘Modern Factor Analysis’, *Journal of the American Statistical Association*, 56(294), pp. 444–446. doi: 10.2307/2282293.

Henseler, J., Hubona, G. and Ray, P. A. (2016) ‘Using PLS path modeling in new technology research: updated guidelines’, *Industrial Management & Data Systems*. Emerald, 116(1), pp. 2–20. doi: 10.1108/IMDS-09-2015-0382.

Henseler, J., Ringle, C. M. and Sarstedt, M. (2014) ‘A new criterion for assessing discriminant validity in variance-based structural equation modeling’, *Journal of the Academy of Marketing Science*, 43(1), pp. 115–135. doi: 10.1007/s11747-014-0403-8.

Henseler, J., Ringle, C. M. and Sinkovics, R. R. (2009) ‘The use of Partial Least Squares Path Modeling in International Marketing’, *Advances in International Marketing*, 20(4), pp. 319–323. doi: 10.1016/0167-8116(92)90003-4.

Herath, C. S. (2010) ‘Motivation as a potential variable to explain farmers’ behavioral change in agricultural technology adoption decisions’, *Ekonomika A Management*, 13(3), pp. 62–71.

Hic, C., Pradhan, P., Rybski, D. and Kropp, J. P. (2016) ‘Food Surplus and Its Climate Burdens’, *Environmental Science and Technology*, 50(8), pp. 4269–4277. doi: 10.1021/acs.est.5b05088.

Hill, H. (2008) ‘Food Miles : Background and Marketing’. National Sustainable Agriculture Information Service, pp. 1–12.

HLPE (2014) *Food Losses and Waste in the Context of Sustainable Food Systems. A Report by the High Level Panel of Experts on Food Security and Nutrition of the Committee on World Food Security.* Rome, Italy. doi: 65842315.

Hodges, R. J. (2012) *Postharvest Weight Losses of Cereal Grains in Sub-Saharan Africa, African postharvest Losses Information System*.

Hodges, R. J., Buzby, J. C. and Bennett, B. (2010) ‘Postharvest losses and waste in developed and less developed countries: opportunities to improve resource use’, *The Journal of Agricultural Science*, 149(S1), pp. 37–45. doi: 10.1017/S0021859610000936.

Holak, S. L. and Lehmann, D. R. (1990) 'Purchase Intentions and the Dimensions of Innovation-An exploratory model', *Journal of Product Innovation Managemnt*, 7, pp. 59–73.

Ibeawuchi, E. I. and Nwachukwu, C. C. (2010) 'An investigation on the impact of FADAMA II project implementation in Imo State ANIVS , FCRMI , Lecturer , Department of Project Management Technology , Federal', *Amreical Journal of Scientific and Industrial Research*, 1(3), pp. 532–538. doi: 10.5251/ajsir.2010.1.3.532.538.

Ibrahim, H. and Omotesho, O. A. (2009) 'An Assessment of the Sustainability of Vegetable Production under FADAMA in the Northern Guinea Savannah Zone of Nigeria', *Electronic Journal of Environmental Agricultural and Food Chemistry*, 8(11), pp. 2–9.

Idah, P. A., Ajisegiri, E. S. A. and Yisa, M. G. (2007) 'Fruits and Vegetables Handling and Transportation in Nigeria', *AU Journal of Technology*, 10(3), pp. 175–183.

IFPRI (2012) *A review of literature on food security, social capital and agricultural productivity in Nigeria*. 21. Abuja, Nigeria.

IFPRI (2016) *2016 Global hunger index: Getting to zero hunger*. Washington, DC. doi: 10.2499/9780896292284.

IITA (2010) *Annual Report 2009/2010*. Available at http://www.iita.org/knowledge/publications/annual-reports/ (Retrieved on 25th May, 2017)

IITA (2014) *Banana & Plantain, IITA Research to Nourish Africa*. Availabe at http://www.iita.org/research/banana_plantain (Accessed on 3rd April, 2016).

Israel, G. D. (2012) 'Determining Sample Size', *PEOD*, 6, p. 5.

Iwuchukwu, C. J. and Igbokwe, E. M. (2012) 'Lessons from Agricultural Policies and Programmes in Nigeria', *Journal of Law, Policy and Globalization*, 5, pp. 2224–3259. doi: ISSN 2224-3240.

Jedermann, R., Nicometo, M., Uysal, I. and Lang, W. (2014) 'Reducing food losses by intelligent food logistics.', *Philosophical transactions. Series A, Mathematical, physical, and engineering sciences*, 372, p. 20130302. doi: 10.1098/rsta.2013.0302.

Jonathan Kaminski and Luc Christianensen (2014) ' Post-Harvest Loss in Sub-Saharan Africa - What Do Farmers Say?' *Policy Research Working Paper* 6831, World Bank, Washington DC.

Kader, A. A. (2000) 'Pre and postharvest factors affecting postharvest life of fresh

produce quality, nutritional value and implications for human health.', in *Proceedings of the International Congress Food Production and Quality of Life*. Sassari, Italy.

Kader, A. A. (2003) 'A Perspective on Postharvest Horticulture (1978 – 2003)', *Horticultural Science*, 38(5), pp. 1004–1008.

Kader, A. A. (2005) 'Increasing Food Availability by Reducing Postharvest Losses of Fresh Produce', in Mencarelli, F. and Tonutti, P. (eds) *5th International Postharvest Symposium*. Verona (Italy), pp. 2169–2176.

Kader, A. K. and Rolle, R. S. (2004) *The role of post-harvest management in assuring the quality and safety of horticultural produce, Fao Agricultural Services Bulletin*.

Kainga, P. E. and Seiyabo, I. T. (2012) 'Economics of Plantain Production in Yenagoa Local Government Area of Bayelsa State', *Journal of Agriculture and Social Research*, 12(1), pp. 114–123.

Kaiser, H. F. (1970) 'A second generation little jiffy', *Psychometrika*, 35(4), pp. 401–415. doi: 10.1007/BF02291817.

Kaiser, H. F. and Rice, J. (1974) 'Little Jiffy, Mark IV', *Educational and Psychological Measurement*, 34(1), pp. 111–117. doi: 10.1177/001316447403400115.

Karahanna, E., Straub, D. W., Chervany, N. L. and Karahanna, E. (1999) 'Information Technology Adoption Across Time : A Cross-Sectional Comparison of Pre- Adoption and Post-Adoption Beliefs', *MIS Quarterly*, 23(2), pp. 183–213. doi: 10.2307/249751.

Gudila A. Kereth., Monica Lyimo., Hadijah A. Mbwana., Richard J. Mongi and Carolyne C. Ruhembe (2013) ' Food Science and Quality Management, 11. ISSN 2225-0557.

Khorshidi, J., Tabatabaei, M. F. and Ahmadi, F. M. (2010) 'Storage Temperature Effects on the Postharvest Quality of Apple (Malus domestica Borkh. cv. Red Delicious)', *New York Science Journal*, 3(3), pp. 3–6.

Kim, H.-Y. (2013) 'Statistical notes for clinical researchers: assessing normal distribution (2) using skewness and kurtosis.', *Restorative dentistry & endodontics*, 38(1), pp. 52–54. doi: 10.5395/rde.2013.38.1.52.

King, W. R. and He, J. (2006) 'A meta-analysis of the technology acceptance model|', *Information & Management*|, 43|, p. 740–755|.

Kitinoja, L. (2013a) 'Innovative Small-scale Postharvest Technologies for reducing losses in Horticultural Crops', *Ethiopian Journal of Applied Science and*

Technology, 1(1), pp. 9–15.

Kitinoja, L. (2013b) 'Use of cold chains for reducing food losses in developing countries', *PEF White Paper*, 6(13), pp. 1–16.

Kitinoja, L. and AlHassan, H. Y. (2012) 'Identification of appropriate postharvest technologies for small scale horticultural farmers and marketers in sub-Saharan Africa and South Asia -Part 1. Postharvest losses and quality assessments', in Cantwell, M. I. and Almeida, D. P. F. (eds) *Proc. XXVIIIth IHC – IS on Postharvest Technology in the Global Market*. Acta Horticulturae, pp. 31–40. doi: Acta Hort. 934, ISHS 2012.

Kitinoja, L. and Cantwell, M. (2010) *Identification of appropriate postharvest technologies for improving market access and incomes for small horticultural farmers in Sub-Saharan Africa and, ... in three parts for the IHC Postharvest ...*.

Kitinoja, L. and Kader, A. A. (2003) *Small-Scale Postharvest Handling Practices: A Manual for Horticultural Crops (4*. 4th edn, *Postharvest Technology Research and Information Center*. 4th edn. Carlifornia: University of Carlifornia, Davis.

Kitinoja, L. and Kader, A. A. (2015) 'Measuring postharvest losses of fresh fruits and vegetables in developing countries'. Postharvest Education Foundation, pp. 1–26. doi: 10.13140/RG.2.1.3921.6402.

Kitinoja, L., Saran, S., Roy, S. K. and Kader, A. a (2011) 'Postharvest technology for developing countries: challenges and opportunities in research, outreach and advocacy.', *Journal of the science of food and agriculture*, 91(4), pp. 597–603. doi: 10.1002/jsfa.4295.

Klarner, P., Sarstedt, M., Hoeck, M. and Ringle, C. M. (2013) 'Disentangling the effects of team competences, team adaptability, and client communication on the performance of management consulting teams', *Long Range Planning*. Elsevier Ltd, 46(3), pp. 258–286. doi: 10.1016/j.lrp.2013.03.001.

Knowles, E. and Kerkman, D. (2007) 'An Investigation of Students' Attitude and Motivation toward Online Learning', *Student Motivation*, 2.

Kumar, D. K., Basavaraja, H. and Mahajanshetti, S. B. (2006) 'An economic analysis of post-harvest losses in Vegetables in Karnataka', *Indian Journal of Agricultural Economics*, 61(1), pp. 134–146.

Kummu, M., de Moel, H., Porkka, M., Siebert, S., Varis, O. and Ward, P. J. (2012) 'Lost food, wasted resources: Global food supply chain losses and their impacts on freshwater, cropland, and fertiliser use', *Science of The Total Environment*, 438, pp. 477–489. doi: http://dx.doi.org/10.1016/j.scitotenv.2012.08.092.

Ladapo, M. A. and Oladele, O. I. (2011) 'Effect of Knowledge, Attitude and Constraints on Postharvest losses among plantain farmers and wholesalers in south-western Nigeria', *Life Science Journal*, 8(2), pp. 476–482.

Lagerkvist, C. J., Ngigi, M., Okello, J. J. and Karanja, N. (2012) 'Means-End Chain approach to understanding farmers' motivations for pesticide use in leafy vegetables: The case of kale in peri-urban Nairobi, Kenya', *Crop Protection*. Elsevier Ltd, 39, pp. 72–80. doi: 10.1016/j.cropro.2012.03.018.

LaGra, J. (1990) *A Commodity Systems Assessment Methodology for Problem and Project Identification*. Moscow, Idaho: Postharvest Institue for Perishables.

Lebersorger, S. and Schneider, F. (2014) 'Food loss rates at the food retail, influencing factors and reasons as a basis for waste prevention measures', *Waste Management*, 34(11), pp. 1911–1919. doi: 10.1016/j.wasman.2014.06.013.

Lee, W. (1971) 'Chapter one', in *Decision theory and human behavior*, pp. 1–21.

Lee, Y., Hsieh, Y. and Hsu, C. (2011) 'Adding Innovation Diffusion Theory to the Technology Acceptance Model: Supporting Employees â€™ Intentions to use E-Learning Systems E-learning and TAM The Technology Acceptance Model (TAM)', *Educ. Technol. Soc.*, 14(4), pp. 124–137.

Lemchi, J. I., Ezedinma, C. I., Tshiunza, M. and Faturoti, B. O. (2005) 'Agroeconomic evaluation of black Sigatoka resistant hybrid plantains under smallholder management systems', *African Journal of Biotechnology*, 4(October), pp. 1045–1053.

Lenth, R. V (2001) 'Some practical guidelines for effective sample size determination', *The American Statistician*, 55(3), pp. 187–193. doi: 10.1198/000313001317098149.

Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R. and Searchinger, T. (2013) *Reducing food loss and waste, World Resources Institute Working Paper, June*. UNEP. Available at: http://staging.unep.org/wed/2013/docs/WRI-UNEP-Reducing-Food-Loss-and-Waste.pdf.

Liu, G. (2014) 'Food losses and food waste in China: a first estimate', *OECD Food, Agriculture and Fisheries Papers*, (66), pp. 1–29. doi: 10.1787/5jz5sq5173lq-en.

Lowry, P. B. and Gaskin, J. (2014) 'Partial least squares (PLS) structural equation modeling (SEM) for building and testing behavioral causal theory: When to choose it and how to use it', *IEEE Transactions on Professional Communication*, 57(2), pp. 123–146. doi: 10.1109/TPC.2014.2312452.

Luning, P. a. and Marcelis, W. J. (2007) 'A conceptual model of food quality management functions based on a techno-managerial approach', *Trends in Food Science & Technology*, 18(3), pp. 159–166. doi: 10.1016/j.tifs.2006.10.021.

Luning, P. a. and Marcelis, W. J. (2009) 'A food quality management research methodology integrating technological and managerial theories', *Trends in Food Science & Technology*. Elsevier Ltd, 20(1), pp. 35–44. doi: 10.1016/j.tifs.2008.09.013.

Lütke entrup, M., Günther, H.-O., Van Beek, P., Grunow, M. and Seiler, T. (2005) 'Mixed-Integer Linear Programming approaches to shelf-life-integrated planning and scheduling in yoghurt production', *International Journal of Production Research*, 43(23), pp. 5071–5100. doi: 10.1080/00207540500161068.

Maheswari, R., Ashok, K. R. and Prahadeeswaran, M. (2008) 'Precision Farming Technology, Adoption Decisions and Productivity of Vegetables in Resource-Poor Environments', *Agricultural Economics Research Review*, 21, pp. 415–424.

Marcoulides, G. A. and Saunders, C. (2006) 'Editor's comment: PLS: A Silver Bullet?' MIS Quarterly, pp. iii–x.

Marra, M., Pannell, D. J. and Abadi Ghadim, A. (2003) 'The economics of risk, uncertainty and learning in the adoption of new agricultural technologies: where are we on the learning curve?', *Agricultural Systems*, 75(2–3), pp. 215–234. doi: 10.1016/S0308-521X(02)00066-5.

Martins, A. G., Goldsmith, P. and Moura, A. (2014) 'Managerial factors affecting post-harvest loss : the case of Mato Grosso Brazil', 3(4). doi: 10.5836/ijam/2014-04-03.

Mbuk, E. M., Bassey, N. E., Udoh, E. S. and Udoh, E. J. (2011) 'Factors influencing postharvest loss of tomatoe in urban market in Uyo, Nigeria', *Nigerian Journal of Agriculture, Food and Environment*, 7(2), pp. 40–46.

Meena, M. S., Prasad, M. and Singh, R. (2009) 'Constraints Perceived by Rural Agro-Processors in Adopting Modern Post-Harvest Technologies', *Indian Res. J. Ext.*, 9(January), pp. 1–5.

Meijer, S. S., Catacutan, D., Ajayi, O. C., Sileshi, G. W. and Nieuwenhuis, M. (2015) 'The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa', *International Journal of Agricultural Sustainability*. Taylor & Francis, 13(1), pp. 40–54. doi: 10.1080/14735903.2014.912493.

Mekoya, A., Oosting, S. J., Fernandez-Rivera, S. and Van Der Zijpp, A. J. (2008)

‘Farmers’ perceptions about exotic multipurpose fodder trees and constraints to their adoption’, *Agroforestry Systems*, 73(2), pp. 141–153. doi: 10.1007/s10457-007-9102-5.

Mikel, W. B. and Newman, M. (2011) ‘Solutions to Global Food Security: Reducing Post-Harvest Food Losses’, in *Global Issues: 65th Annual Meat Conference*, pp. 1–2.

Mohammed Kasso and Afework Bekele (2016) 'Postharvest Loss and Quality Deterioration of Horticultural Crops in Dire Dawa Region, Ethiopia' *Journal of the Saudi Society of Agricultural Sciences*, In Press

Moore, G. C. and Benbasat, I. (1991) ‘Development of an instrument to measure the perceptions of adopting an information technology innovation’, *Information Systems Research*, 2(3), pp. 192–222. doi: 10.1287/isre.2.3.192.

Moretti, C. L., Mattos, L. M., Calbo, A. G. and Sargent, S. A. (2010) ‘Climate changes and potential impacts on postharvest quality of fruit and vegetable crops: A review’, *Food Research International*, 43(7), pp. 1824–1832. doi: http://dx.doi.org/10.1016/j.foodres.2009.10.013.

Mukaka, M. M. (2012) ‘A guide to appropriate use of Correlation coefficient in medical research.’, *Malawi Medical Journal*, 24(3), pp. 69–71. doi: 10.1016/j.cmpb.2016.01.020.

NBS (2016) *Gross Domestic Product of Nigeria, GDP, National Accounts*.

Noordzij, M., Tripepi, G., Dekker, F. W., Zoccali, C., Tanck, M. W. and Jager, K. J. (2010) ‘Sample size calculations: Basic principles and common pitfalls’, *Nephrology Dialysis Transplantation*, 25(5), pp. 1388–1393. doi: 10.1093/ndt/gfp732.

NPC (2017) *Population Forecast, Nigeria’s Population*. Available at http://population.gov.ng/ [Accessed on 13th June, 2017]

Nunnally, J. C. and Bernstein, I. H. (1994) *Psychometric Theory, McGraw-Hill, New York*.

Odetola, T. and Etumnu, C. (2013) ‘Contribution of Agriculture to Economic Growth in Nigeria’, in *The 18th Annual Conference of the African Econometric Society (AES)*. Accra, Ghana, pp. 1–28.

Oelofse, S. H. and Nahman, A. (2013) ‘Estimating the magnitude of food waste generated in South Africa’, *Waste Management & Research*, pp. 1–28. doi: 10.1177/0734242X12457117.

Okoedo-Okojie, D. U. and Onemolease, E. A. (2009) ‘Factors Affecting the Adoption of Yam Storage Technologies in the Northern Ecological Zone of

Edo State , Nigeria', *Journal of Human Ecol*, 27(2), pp. 155–160.

Oladejo, J. A. and Sanusi, W. A. (2008) 'Marketing Analysis of Plantain in Owo and Ose Local Government Areas of Ondo state , Nigeria Produced by IJAERD Press - Nigeria , 2008', *International Journal of Agricultural Economics & rural Development*, 1(2), pp. 93–101.

Oladoja, M. A., Akinbile, L. A. and Adisa, B. O. (2006) 'Assessment of the environment-related problems and prospects of vegetable production in peri – urban areas of Lagos State , Nigeria', *Journal of Food Agriculture & Environment*, 4(October), pp. 271–275.

Olayemi, F. F., Adegbola, J. A., Bamishaiye, E. I. and Awagu, E. F. (2012) 'Assessment of postharvest losses of selected crops in Rivers State Nigeria.pdf', *Asian Journal of Rural Development*, 2(1), pp. 13–23. doi: 10:3923/ajrd.2012.13.23.

Olayemi, F. F., Adegbola, J. a, Bamishaiye, E. I. and Daura, a M. (2010) 'Assessment of Post- Harvest Challenges of Small Scale Farm Holders of Tomatoes , Bell and Hot Pepper in Some Local Government Areas of Kano State , Nigeria', *Bayero Journal of Pure and Applied Sciences*, 3(2), pp. 39–42. doi: 10.4314/bajopas.v3i2.63217.

Olorunda, A. O. and Aworth, O. C. (1996) 'Overview of Musa research in postharvest technology at the department of food technology, University of Ibadan, Ibadan, Oyo State.', in Qrtiz, R. and Akoroda, M. O. (eds) *In: Plantain and Banana Production and Research in West and Central Africa. Proceedings of a Regional Workshop (IITA)*, pp. 75–76.

Olumba, C. C. and Rahji, M. A. . (2014) 'An Analysis of the Determinants of the Adoption of Improved Plantain Technologies in Anambra State , Nigeria', *Journal of Agriculture and Sustainability*, 5(2), pp. 232–245.

Omonijo, D. O., Toluwase, S. O. W., Oludayo, O. A. and Uche, O. O. (2014) 'Impacts of Agricultural Development Programme (ADP) on Rural Dwellers in Nigeria : A Study of Isan-Ekiti', *International Research Journal of Finance and Economics*, (128), pp. 41–55.

Opara, L. U., Al-Said, F. A. and Al-Abri, A. (2007) 'Assessment of what the consumer values in fresh fruit quality: Case study of Oman', *New Zealand Journal of Crop and Horticultural Science*, 35(2), pp. 235–243. doi: 10.1080/01140670709510190.

Ostlund, L. E. (1974) 'Perceived Innovation Attributes as Predictors of Innovativeness', *Journal of Consumer Research*, 1(2), p. 23. doi: 10.1086/208587.

Pankratz, M., Hallfors, D. and Cho, H. (2002) 'Measuring perceptions of innovation

adoption: the diffusion of a federal drug prevention policy.', *Health education research*, 17(3), pp. 315–326. doi: 10.1093/her/17.3.315.

Papargyropoulou, E., Lozano, R., K. Steinberger, J., Wright, N. and Ujang, Z. Bin (2014) 'The food waste hierarchy as a framework for the management of food surplus and food waste', *Journal of Cleaner Production*, 76, pp. 106–115. doi: 10.1016/j.jclepro.2014.04.020.

Parfitt, J., Barthel, M. and Macnaughton, S. (2010) 'Food waste within food supply chains: quantification and potential for change to 2050.', *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, 365(1554), pp. 3065–81. doi: 10.1098/rstb.2010.0126.

Parizeau, K., von Massow, M. and Martin, R. (2015) 'Household-level dynamics of food waste production and related beliefs , attitudes , and behaviours in Guelph , Ontario', *Waste Management*. Elsevier Ltd, 35, pp. 207–217. doi: 10.1016/j.wasman.2014.09.019.

Park, S. Y. (2009) 'An Analysis of the Technology Acceptance Model in Understanding University Students ' Behavioral Intention to Use e-Learning Research hypotheses', *Educational Technology & Society*, 12, pp. 150–162.

Pattanayak, S. K., Mercer, D. E., Forest, U. S., Sills, E. O., Carolina, N., Cassingham, K. and Geological, U. S. (2003) 'Taking Stock of Agroforestry Adoption Studies', *Agroforestry Systems*, 57, pp. 173–186.

Pereira, M. de A. (2011) *Lincoln University Digital Thesis Understanding technology adoption and non-adoption : a case study of innovative beef farmers from Mato Grosso do Sul State ,*. Lincoln University.

Pickens, J. (2005) 'Attitudes and Perceptions', in Borkowski, N. (ed.) *Organizational behavior in health care*. Sudbury: Jones and Bartlett Publishers, pp. 43–75.

Porter, S. D., Reay, D. S., Higgins, P. and Bomberg, E. (2016) 'A half-century of production-phase greenhouse gas emissions from food loss & waste in the global food supply chain', *Science of the Total Environment*. Elsevier B.V., 571, pp. 721–729. doi: 10.1016/j.scitotenv.2016.07.041.

Preacher, K. J. and Hayes, A. F. (2008) 'Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models', *Behavior Research Methods*, 40(3), pp. 879–891. doi: 10.3758/BRM.40.3.879.

Prusky, D. (2011) 'Reduction of the incidence of postharvest quality losses, and future prospects', *Food Security*, 3(4), pp. 463–474. doi: 10.1007/s12571-011-0147-y.

Prussia, S. E. and Shewfelt, R. L. (1993) 'Systems approach to postharvest handling', in *Postharvest Handling: A systems Approach*. Academic Press, Inc., pp. 43–68.

Quested, T. E., Marsh, E., Stunell, D. and Parry, a D. (2013) 'Resources , Conservation and Recycling Spaghetti soup : The complex world of food waste behaviours', *'Resources, Conservation & Recycling'*, 79, pp. 43–51. doi: 10.1016/j.resconrec.2013.04.011.

Reddy, G. P., Murthy, M. R. K. and Meena, P. C. (2010) 'Value Chains and Retailing of Fresh Vegetables and Fruits, Andhra Pradesh', *Agricultural Economics Research Review*, 23, pp. 455–460.

Rehman, T., McKemey, K., Yates, C. M., Cooke, R. J., Garforth, C. J., Tranter, R. B., Park, J. R. and Dorward, P. T. (2007) 'Identifying and understanding factors influencing the uptake of new technologies on dairy farms in SW England using the theory of reasoned action', *Agricultural Systems*, 94(2), pp. 281–293. doi: 10.1016/j.agsy.2006.09.006.

Rembold, F., Hodges, R., Bernard, M., Knipschild, H. and Leo, O. (2011) *The African Postharvest Losses Information System (APHLIS)*. Luxembourg: Publications Office of the European Union. doi: 10.2788/40345.

Rogers, E. M. (1983) *Diffusion of Iinnovations. 3rd Edition*. THE FREE PRESS Collier Macmillan Poblishers London. doi: 82-70998.

Rogers, E. M. (2003) *Diffusion of Innovations*. 5th Edition. New York: Free Press, New York.

Rogers, E. M., Medina, U. E., Rivera, M. A. and Wiley, C. J. (2005) 'Complex Adaptive Systems and the Diffusion of Innovations', *The Innovation Journal: The Public Sector Innovation Journal*, 10(3).

Róth, E., Berna, a., Beullens, K., Yarramraju, S., Lammertyn, J., Schenk, a. and Nicolaï, B. (2007) 'Postharvest quality of integrated and organically produced apple fruit', *Postharvest Biology and Technology*, 45(1), pp. 11–19. doi: 10.1016/j.postharvbio.2007.01.006.

Rutten, M. M. (2013) 'What economic theory tells us about the impacts of reducing food losses and/or waste: implications for research, policy and practice', *Agriculture & Food Security*, 2(1), p. 13. doi: 10.1186/2048-7010-2-13.

Saran, S., Roy, S. K. and Kitinoja, L. (2012) 'Appropriate postharvest technologies for small scale horticultural farmers and marketers in sub-Saharan Africa and South Asia -Part 2. Field trial results and identification of research needs for selected crops', in Cantwell, M. I. and Almeida, D. P. F. (eds) *Proc. XXVIIIth IHC – IS on Postharvest Technology in the Global Market*. Acta Horticulturae, pp. 41–52. doi: Acta Hort. 934, ISHS 2012.

Scheirer, M. A. N. N. (1990) 'The Life Cycle of an Innovation : Adoption versus Discontinuation of the Fluoride Mouth Rinse Program in Schools', *Journal of Health and Social Behavior*, 31(2), pp. 203–215.

Schill, P. F., Afreh-Nuamah, K., Gold, C. S. and Green, K. R. (2000) 'Farmers' perceptions of constraints to plantain production in Ghana', *International Journal of Sustainable Development & World Ecology*, 7(1), pp. 12–24. doi: 10.1080/13504500009470025.

Schott, A. B. S. and Andersson, T. (2015) 'Food waste minimization from a life-cycle perspective', *Journal of Environmental Management*, 147, pp. 219–226.

Scott, S. D., Plotnikoff, R. C., Karunamuni, N., Bize, R. and Rodgers, W. (2008) 'Factors influencing the adoption of an innovation: an examination of the uptake of the Canadian Heart Health Kit (HHK)', *Implementation Science*, 3(41), pp. 1–8. doi: 10.1186/1748-5908-3-41.

Sharifzadeh, M., Zamani, G. H., Khalili, D. and Karami, E. (2012) 'Agricultural Climate Information Use : An Application of the Planned Behaviour Theory', *Journal of Agricultural Science & Technology*, 14, pp. 479–492.

Sharma, R. R., Pal, R. K., Asrey, R., Sagar, V. R., Dhiman, M. R. and Rana, M. R. (2013) 'Pre-harvest fruit bagging influences fruit color and quality of apple cv. Delicious', *Agricultural Sciences*, 4(9), pp. 443–448. doi: 10.4236/as.2013.49059.

Sharma, R. R., Reddy, S. V. R. and Jhalegar, M. J. (2014) 'Pre-harvest fruit bagging: A useful approach for plant protection and improved post-harvest fruit quality - A review', *Journal of Horticultural Science and Biotechnology*, 89(2), pp. 101–113. doi: 10.1080/14620316.2014.11513055.

Shewfelt, R. L. (1999) 'What is quality ?', *Postharvest Biology and Technology*, 15(June 1998), pp. 197–200.

Shukla, M. and Jharkharia, S. (2013) 'Agri-fresh produce supply chain management: a state-of-the-art literature review', *International Journal of Operations & Production Management*, 33(2), pp. 114–158. doi: 10.1108/01443571311295608.

Siegrist, M. (2008) 'Factors influencing public acceptance of innovative food technologies and products', *Trends in Food Science & Technology*. Elsevier Ltd, 19(11), pp. 603–608. doi: 10.1016/j.tifs.2008.01.017.

Silvennoinen, K., Katajajuuri, J.-M., Hartikainen, H., Heikkilä, L. and Reinikainen, A. (2014) 'Food waste volume and composition in Finnish households', *British Food Journal*, 116(6), pp. 1058–1068. doi: 10.1108/BFJ-12-2012-0311.

Singh, A. and Masuku, M. (2014) 'Sampling Techniques & Determination of Sample Size in Applied Statistics Research: an Overview', *International Journal of Economics, Commerce and Management, United Kingdom*, II(11), pp. 1–22.

Singh, V., Hedayetullah, M., Zaman, P. and Meher, J. (2014) 'Postharvest Technology of Fruits and Vegetables: An Overview', *Journal of Post-Harvest Technology*, 2(2), pp. 124–135. doi: 10.1002/9780470751060.ch12.

Smil, V. (2004) 'Improving Efficiency and Reducing Waste in Our Food System', *Environmental Sciences*, 1(May 2015), pp. 17–26. doi: 10.1076/evms.1.1.17.23766.

Sobel, M. E. (1982) 'Asymptotic confidence intervals for indirect effects in structural equation models', *Sociological Methodology*, 13, pp. 290–312. doi: 10.2307/270723.

Stancu, V., Haugaard, P. and Lähteenmäki, L. (2016) 'Determinants of consumer food waste behaviour: Two routes to food waste', *Appetite*, 96, pp. 7–17. doi: 10.1016/j.appet.2015.08.025.

Stefan, V., Herpen, E. van, Tudoran, A. A. and Lahteenmaki, L. (2013) 'Avoiding food waste by Romanian consumers-The improtance of Planning and Shopping routines', *Food Quality and Preference*, 28, pp. 375–381.

Tabachnick, B. G. and Fidell, L. S. (2007) *Using multivariate statistics, Pearson*. doi: 10.1037/022267.

Taylor, S. and Todd, P. A. (1995) 'Understanding information technology usage: A test of competing models', *Information Systems Research*, pp. 144–176. doi: 10.1287/isre.6.2.144.

Tchango, T. J., A.Bikoï, Achard, R., Escalant, J. V. and Ngalani, J. A. (1999) *Banana (Plantain) Post-harvest Operations*.

van Teijlingen, E. and Hundley, V. (1998) 'The importance of pilot studies.', *Nursing standard : official newspaper of the Royal College of Nursing*, 16(40), pp. 33–36. doi: 10.7748/ns2002.06.16.40.33.c3214.

The World Bank (2015) *Is Post-Harvest Loss Significant in Sub-Saharan Africa?* Available at *http://www.worldbank.org/en/programs/africa-myths-and-facts/publication/is-post-harvest-loss-significant-in-sub-saharan-africa [*Accessed 20th May, 2017].

Thyberg, K. L. and Tonjes, D. J. (2016) 'Drivers of food waste and their implications for sustainable policy development', *Resources, Conservation and Recycling*. Elsevier B.V., 106, pp. 110–123. doi: 10.1016/j.resconrec.2015.11.016.

Tipmontian, J., Suryaprakasa Rao, K. and Rajmohan, M. (2012) 'Selection of Handling of Route in Postharvest Supply Chain using Fuzzy Delphi Method and Dynamic Programming.', *Journal of Applied Sciences Research*, 8(8), pp. 4207–4214.

Touré-Tillery, M. and Fishbach, A. (2014) 'How to Measure Motivation: A Guide for the Experimental Social Psychologist', *Social and Personality Psychology Compass*, 8/7(10). doi: 10.1111/spc3.12110.

Tran, D.-H., Yen, C.-R. and Chen, Y.-K. H. (2015) 'Effects of bagging on fruit characteristics and physical fruit protection in red pitaya (Hylocereus spp.)', *Biological Agriculture & Horticulture*, 31(3), pp. 158–166. doi: 10.1080/01448765.2014.991939.

Tyler, P. S. (2014) *Misconception of food losses, United nations University Press*.

United Nations (2015) *World Population Prospects - Population Division, World Population Prospects - 2015 Revision*.

Venkatesh, V. and Davis, F. D. (2000) 'A Theoretical Extension of the Technology Acceptance Model : Four Longitudinal Field Studies', *Management Sciences INFORMS*, 46(2), pp. 186–204.

Venkatesh, V. and Davis, F. D. (2000) 'A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies', *Management Science*, 46, pp. 186–204.

Venkatesh, V., Morris, M. G., Davis, G. B. and Davis, F. D. (2003) 'User Acceptance of Information Technology: Toward a Unified View', *Source: MIS Quarterly*, 27(3), pp. 425–478. doi: 10.2307/30036540.

Venkatesh, V., Thong, J. Y. L. and Xu, X. (2012) 'Consumer Acceptance and Use of Information Technology : Extending the Unified Theory', *MIS Quarterly*, 36(1), pp. 157–178.

Venus, V., Asare-Kyei, D. K. K., Tijskens, L. M. M. M. M., Weir, M. J. C. J. C., De Bie, C. a. J. M. A. J. M., Ouedraogo, S., Nieuwenhuis, W., Wesselman, S. L. M. L. M., Cappelli, G. a. A. and Smaling, E. M. a. M. A. (2013) 'Development and Validation of a Model to Estimate Postharvest Losses During Transport of Tomatoes in West Africa', *Computers and Electronics in Agriculture*. Amsterdam, The Netherlands, The Netherlands: Elsevier Science Publishers B. V., 92, pp. 32–47. doi: 10.1016/j.compag.2012.11.011.

Visschers, V. H. M., Wickli, N. and Siegrist, M. (2016) 'Sorting out food waste behaviour: A survey on the motivators and barriers of self-reported amounts of food waste in households', *Journal of Environmental Psychology*. Elsevier Ltd, 45, pp. 66–78. doi: 10.1016/j.jenvp.2015.11.007.

van der Vorst, J. G. A. J., van Kooten, O., Marcelis, M. and Luning, P. (2007) 'Quality Controlled Logistics in Food Supply Chain Networks: integrated decision-making on quality and logistics to meet advanced customer demands', in *Proceedings of the Euroma 2007 Conference.* Ankara, Turkey.

van der Vorst, J. G. A. J., Tromp, S.-O. and Zee, D.-J. van der (2009) 'Simulation modelling for food supply chain redesign; integrated decision making on product quality, sustainability and logistics', *International Journal of Production Research*. Taylor & Francis, 47(23), pp. 6611–6631. doi: 10.1080/00207540802356747.

WFLO (2010) *Identification of appropriate postharvest technologies for improving market access and incomes for small horticultural farmers in Sub-Saharan Africa and, ... in three parts for the IHC Postharvest ...*.

Whitehair, K. J., Shanklin, C. W. and Brannon, L. A. (2013) 'Written Messages Improve Edible Food Waste Behaviors in a University Dining Facility', *Journal of the Academy of Nutrition and Dietetics*. Elsevier, 113(1), pp. 63–69. doi: 10.1016/j.jand.2012.09.015.

WHO (2015) Country Statistics, Nigeria. Available at http://www.who.int/countries/nga/en/ [Accessed on 2nd January, 2018].

Wisdom, J. P., Chor, K. H. B., Hoagwood, K. E. and Horwitz, S. M. (2014) 'Innovation Adoption: A review of thoeries and constructs', *Adm Policy Ment Health*, 41(4), pp. 480–502. doi: 10.1007/s10488-013-0486-4.Innovation.

World Bank (2011) *MISSING FOOD: The Case of Postharvest Grain Losses in Sub-Saharan Africa*. Washington, DC: The World Bank. doi: Report No. 60371-AFR.

Yakovleva, N. (2007) 'Measuring the Sustainability of the Food Supply Chain: A Case Study of the UK', *Journal of Environmental Policy & Planning*, 9(1), pp. 75–100. doi: 10.1080/15239080701255005.

Yong, A. G. and Pearce, S. (2013) 'A Beginner's Guide to Factor Analysis: Focusing on Exploratory Factor Analysis', *Tutorials in Quantitative Methods for Psychology*, 9(2), pp. 79–94.

Yoo, S. J., Han, S. and Huang, W. (2012) 'The roles of intrinsic motivators and extrinsic motivators in promoting e-learning in the workplace: A case from South Korea', *Computers in Human Behavior*. Elsevier Ltd, 28(3), pp. 942–950. doi: 10.1016/j.chb.2011.12.015.

Zerihun, M. F., Muchie, M. and Worku, Z. (2014) 'Determinants of agroforestry technology adoption in Eastern Cape Province, South Africa', *Development Studies Research*. Taylor & Francis, 1(1), pp. 382–394. doi:

10.1080/21665095.2014.977454.

Zhang, B. B., Guo, J. Y., Ma, R. J., Cai, Z. X., Yan, J. and Zhang, C. H. (2015) 'Relationship between the bagging microenvironment and fruit quality in "guibao" peach [prunus persica (L.) batsch]', *Journal of Horticultural Science and Biotechnology*, 90(3), pp. 303–310. doi: 10.1080/14620316.2015.11513187.

LIST OF PUBLICATIONS

Journal publications

Kwami Justina K. Morris and Nitty Hirawaty Kamarulzaman., (2014) 'A Conceptual Framework for Estimating Postharvest Losses in Food Supply Chains: The Case of Plantain Fruits in Nigeria', *International Journal of Business and Economics Research,* 3(6-1): 31-37. doi: 10.11648/j.ijber.s.2014030601.15

Kwami Justina Morris., Nitty Hirawaty Kamarulzaman., Nolila Mohd Nawi., Zainal Abidin Mohamed and Norsida Man (2018). Adoption Intention of Small-scale Postharvest Practices among Plantain Farmers and Traders in South-South Nigeria, *Journal of Agribusiness in Developing and Emerging Economies,* (Manuscript Submitted)

Conferences

Kwami Justina K. Morris and Nitty Hirawaty Kamarulzaman (2015) 'Users Perceptions and Acceptance of Small Scale Postharvest Technologies in Developing countries: A Conceptual Framework', Conference Proceedings, *3rd International Symposium on Applied Engineering and Sciences*, *SAES2015* Canselori Putra, UPM Serdang, Malaysia.

Kwami Justina Morris., Nitty Hirawaty Kamarulzaman., Norsida Man., Nolila Mohd Nawi., and Zainal Abidin Mohamed (2016) 'Readiness towards Small-Scale Postharvest Techniques for Reducing Plantain Postharvest Losses in Nigeria: A Pilot Study', Proceedings, *International Agriculture Congress, IAC2016,* Hotel Bangi-PutraJaya, Malaysia

Kwami Justina Morris., Nitty Hirawaty Kamarulzaman., Nolila Mohd Nawi., Zainal Abidin Mohamed and Norsida Man (2018) 'Knowledge, Attitudes, Perceptions and Intention of Plantain Supply Chain Players towards Small-scale Postharvest Practices for Reducing Food Losses in Southern Nigeria. International Conference on Agribusiness in Emerging Economies, ICAB18384, TERI University, New Delhi, India.