DETERMINANTS OF ADOPTION OF GREENHOUSE TECHNOLOGIES AMONG TOMATO FARMERS IN THREE SELECTED STATES OF NIGERIA

BY

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CERTIFICATION

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DEDICATION

At the Centre of It All, God, it's You that I see. Thank You Lord for this Great Success, Your Name I will forever Praise.

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ABSTRACT

In Nigeria, demand for tomato exceeds its domestic supply and only about 50 percent of total production reaches the market due to postharvest loss. This causes scarcity, price inflation and importation of tomato products. Therefore, Greenhouse Technologies (GHTs) were promoted by various state governments and entrepreneurs to address the problems of fresh tomato scarcity and unfavourable pricing. However, there is lack of empirical evidence on farmers' adoption and associated factors influencing adoption of GHTs in Nigeria. Hence, determinants of adoption of GHTs among tomato farmers in three selected states of Nigeria were investigated.

A three-stage sampling procedure was used to select 240 respondents for the study. Plateau, Lagos and Ogun states were purposively selected based on wide acceptability of GHTs by governments and entrepreneurs. A simple random sampling technique was used to select 70% of GHTs farmers from a list of Greenhouse Farmers' Association of Nigeria and major Greenhouse service providers in each state to give 158 registered GHTs users: Plateau, 59; Lagos, 65; Ogun, 34. A list of unregistered GHTs farmers was generated through snowball technique and simple random sampling was used to select 70% from each state to give 82 users: Plateau, 32; Lagos, 37; Ogun, 13. Interview schedule was used to obtain data on the respondents' personal and farm enterprise characteristics (age, sex, greenhouse farming experience, type of greenhouse structure used and yield), sources of information, knowledge, attitude towards use of GHTs, GHTs management practice, level of adoption and constraints to use of GHTs. Indices of knowledge (low: 1.00-10.42; high: 10.43-19.00), attitude (unfavourable: 56.00-89.45; favourable: 89.46-108.00), GHTs management practice (poor: 0.00-4.50; good: 4.51-7.00) and adoption of GHTs (low: 23.00-58.99; high: 59.00-75.00) were generated. Data were analysed using descriptive statistics, ANOVA and linear regression at $\alpha_{0.05}$.

Respondents were aged 35.73±10.85 years, male (72.7%), had 3.06±2.38 years greenhouse farming experience, used high-cost type of greenhouse structure (48.1%) and obtained yield of 7.34±4.23kg/plant. Fellow farmers: $\bar{x}$=1.27; and greenhouse service providers: $\bar{x}$=1.26, were most preferred information sources. Proportion of respondents (P) with high knowledge of GHTs was 62.5%. Attitude to use of GHTs was favourable: P=56.9%, management practices was good: P=51.9% and GHTs adoption was high: P=53.2%. Constraints to use of GHTs were high initial investment in construction of greenhouse: $\bar{x}$ =1.58; and fluctuation in prices due to glut in the market $\bar{x}$=1.55. Significant difference existed in the GHTs management practices based on type of greenhouse structure used: high-cost GHTs (5.17±1.17) had better management practices than medium-cost GHTs (4.39±1.19) and low-cost GHTs (4.36±1.22). Farmers differed significantly in their adoption of GHTs across the states: adoption was significantly higher in Lagos (63.65±7.31) and Ogun (61.70±9.79) than Plateau (52.49±8.52). Farmers yield were similar across the different types of greenhouse structure used for tomato production. The GHTs management practices` (β=0.33), attitude (β=0.28) and constraints to use of GHTs (β=-0.13) significantly influenced adoption of GHTs.

Adoption of greenhouse technologies was higher in Lagos and Ogun than in Plateau state. Its adoption was determined by good management practices, favourable attitude and constraints to use of greenhouse technologies.

Keywords: Greenhouse technologies, Tomato farmers, Farm management practices, Postharvest loss

Word count: 499

TABLE OF CONTENTS

CHAPTER FIVE: SUMMARY, CONCLUSION AND RECOMMENDATIONS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

ARMD	Age-related Muscular Diseases
ASTC	Agricultural Service Training Center
ATA	Agricultural Transformation Agenda
ANOVA	Analysis of Variance
CBN	Central Bank of Nigeria
DFK	Dizengoff Farmers’ Kit
DPIRD	Department of Primary Industries and Regional Development
DOI	Diffusion of Innovation Theory
FAO	Food and Agricultural Organization
FMARD	Federal Ministry of Agriculture and Rural Development
GHT	Greenhouse Technology
KII	Key In-depth Interview
Ksh.	Kenyan Shillings
₦	Naira (Nigerian currency)
NALEP	National Agriculture and Livestock Extension Program
NBS	National Bureau of Statistics
NGOs	Non-Governmental Organizations
NIRSAL	Nigeria Incentive Based Risk Management System for Agricultural Lending
NPC	National Population Council
NPK	Nitrogen (N), Phosphorus (P) and Potassium (K) Fertilizer
OECD	Organization for Economic Co-operation and Development
ORAC	Oxygen Radical Absorbance Capacity
PPMC	Pearson Product Moment Correlation

CHAPTER ONE

INTRODUCTION

1.1 Background to the study

Tomato (*Solanum lycopersicon*) is amongst the most cultivated and consumed vegetable food crops worldwide and Nigeria in particular (Gebremariam, 2015; Foraminifera Market Research, 2016). Tomato can be cultivated in all the states in Nigeria but some northern states such as Kaduna, Bauchi, Kano, Katsina, Benue, Jigawa and Plateau as well as some southern states such as Kwara, Oyo and Delta states produce tomato on commercial scale (Ugonna *et al.,* 2015). Sahel research (2017) estimated world's tomato production to be 145 million tonnes which was cultivated on about 4.3 million hectares of land. An estimated tomato production of 1.86 million metric tons was produced in Nigeria from approximately 541,800Ha, giving an average of 4.0MT/Ha. This is the lowest yield generated for tomatoes in Africa, when compared to 38.7MT/Ha of tomatoes generated from 214,016Ha in Egypt (Sahel research, 2017).

Tomato production, yield, prices and consumption in Nigeria are largely affected by the seasonality of tomatoes. The price of fresh tomato fluctuates based on its availability in the market (Aminu and Shehu, 2004). Hence, seasonality affects tomato production, yield and market price. The trend of tomato production is such that the supply of fresh tomatoes is usually abundant in the open market between January and April, which often leads to gluts; and as a result, consumers' seldomly use other types of tomato products such as tomato pastes or dried tomatoes. However, between the months of April and September, fresh tomato supply rapidly declines, signaling the beginning of the crop's off-season (Aminu and Shehu, 2004; Ugonna *et al.,* 2015). Other factors affecting tomato production include biotic and abiotic factors. According to Asante *et al.* (2013), the biotic factors affecting the production of tomato include diseases (such as the yellow leaf curl virus, bacterial spot, early blight, mosaic viruses and bacterial wilt) and insect pests (such as whitefly, leaf moth, scale insects, aphids, mites and ball worms); while the abiotic factors include climatic changes (such as abnormal rainfalls and elevated temperatures), soils infertility, among others.

In Nigeria, tomatoes are usually cultivated in the open field and this predisposes its production to the hazardous effect of climate variation, pest and disease infestation. Due to the high sensitivity of tomatoes to high humidity, tomato farmers tend to minimize the adverse effect of climate change on their tomatoes by harvesting it early and selling it off cheaply to prevent rotting and also to be able to meet up with some of the production costs. This is corroborated by Momoh (2018) that tomato limited shelf life results in high glut during its short production season thereby increasing scarcity and cost during the off-season. In addition, farmers' lose a lot of revenue due to the limited lifespan of tomatoes coupled with poor processing and preservation. Since agricultural production activities depend on climate for its growth and climatic changes have made the rainfall patterns unpredictable, thus determining when, where and what crops to cultivate as well as the overall yield. There is need for an effective agricultural technology that can be used to mitigate the effect of rapid climatic variation, pest and disease infestation in order to enhance production, profitability and sustainability of tomato production. To this end, greenhouse technology can adequately cover for the deficiency in the open field production of high value horticultural crops (Omoro *et al.*, 2014).

Greenhouse technology (GHT) is a controlled method that offers beneficial environmental conditions to the plants by mitigating adverse climatic changes and variability such as temperature, wind, precipitation, excessive radiation; insects, pest and diseases (Mburu, 2012). These favourable environmental parameters are achieved using a greenhouse or glasshouse and this enables the cultivation of crops independent of time and location (Chauhan, *et al.*, 2017). In addition, GHT offers the additional advantages of altering the micro- environment in order to optimize plant performance, elongate production duration, induce earliness of flowering, as well as improving the yield and quality of the product (Gruda and Tanny, 2015). According to Gichuki (2012), under optimal conditions, growing vegetables and fruits in a greenhouse can give the farmers up to ten times what they would get if they did the same in an open rain-fed field. This is because greenhouse technology provides opportunity for soil treatment, the use of drip irrigation system (which supplies the adequate and regulated amount of water required by each plant), pot bagging and nets (used to prevent pests and insects invasion). It also includes the use of ultraviolet tarpaulin cover (used for covering the greenhouses; protecting the plants from excessive rainfall and temperature). High-yielding varieties of seeds are usually used and the plants enjoy regulated nutrient feeding regime which aids in increasing the quantity and quality of tomato fruits. Thus, GHT encourages better yield and consequently better income. Though most crops (Green Vegetables, Cucumber, Onions, Capsicums, Water melon, Strawberry, Cabbages, Cowpeas, Flowers, Brinjals, Black nightshade, Butternut, Herbs/Spices amongst others) can be cultivated using GHTs, tomato remains the most widely cultivated crop in the greenhouse because it has competitive and comparative advantages over the other crops (Omoro *et al*., 2014; National Agriculture and Livestock Extension Programme, 2011).

Greenhouse use in crop production is becoming a reality worldwide with approximately 405,000ha of greenhouses spread over all the continents with the degree of sophistication and technology depending on local climatic conditions and the socio-economic environment (FAO, 2013). Green House Technology (GHT) was introduced to Nigeria by Dizengoff in 2005, with the massive use of the Dizengoff farmers' kit (DFK) which is the greenhouse technology for crop cultivation. It is a technology specifically developed to enable farmers produce high quality fresh tomatoes regardless of the season throughout Nigeria. Farmers have with time tried adapting the greenhouse structure to suit their local climatic conditions and socio-economic environment, thus, leading to a decrease in the cost of the technology. This has led to the fabrication of medium and low cost types of greenhouses by farmers in the cultivation of horticultural crops especially vegetables. Greenhouse technologies has been widely adopted in other developing countries like Kenya, Algeria and Ghana as a reliable method of protecting crops against the adverse effects of climate variability, pests, diseases and soil infertility. In Kenya for instance, there is an aggressive promotion for greenhouses as farmers are intentional on making more profit from their farms. (Kamau and Baumgartner, 2011). Greenhouse tomato has become an important commercial vegetable crop for export in Kenya, contributing to increasing incomes in rural areas, improving living standards and creating employment for the local population (Ssejjemba, 2008).

In Nigeria, few individuals, private entrepreneurs, some research institutes as well as some state governments (for example, Ogun State established 1000 units of greenhouse kit in its three senatorial districts in order to provide job opportunities for its teeming youths) have promoted greenhouse technologies with most still being used and the rest discontinued. Hence, meeting up with the increasing demand for tomatoes in Nigeria implies that tomato production should not be left to open-field peasant farmers alone. Other stakeholders such as the federal, state, local governments, as well as entrepreneurs would have to engage in large scale production of tomato using GHTs and ensure optimal utilization of the technologies. This is because GHTs when widely adopted could serve as an alternative to the over-dependency on rain-fed agriculture and thereby help in mitigating the issue of food security in Nigeria.

Greenhouse technology is advantageous over the subsistence system of agricultural production as it gives a better return on investment. If farmers can adopt, utilize and comply with the required management practices, the initial investment cost on GHTs can be recouped within a year.

1.2 Statement of research problem

The tomato industry is one of the sub-sectors where Nigeria has comparative advantage and capacity in terms of production and exports as it ranks as the 14th largest producer of tomato in the world and the second in Africa (Taofiq, 2017). Unfortunately, Nigeria simultaneously ranks as the eighth largest importer of tomato paste in the world because the domestic demand for tomatoes of 2.3 million metric tons outweighs the supply of 1.8 million metric tons produced. This according to Nigerian Stored Products Research Institute (2021) creates an immediate gap of 105,000 metric tonnes to be filled by importation Nigeria. Thus, Nigeria spent about ₦16 billion between year 2018 and 2020 on tomato product importation from China and other parts of the world (Federal Internal Revenue Service, 2021). This implies that if Tsado (2014) assertion that the production of tomatoes remains low compared to the growth in population of most nations' is correct, it suffices therefore, that as Nigeria's population continues to increase, the demand for tomato will also increase.

In an attempt to bridge the gap between the demand and supply of tomato in Nigeria, the Nigerian government has made some efforts such as; establishment of irrigation facilities in the north and tomato processing plants by entrepreneurs in the major tomato producing states to ensure its availability during the dry seasons; ensuring seed improvements; Nigeria Incentive Based Risk Management System for Agricultural Lending (NIRSAL); making tomato one of the focus crops under the agricultural transformation agenda (ATA) to boost and encourage tomato production in Nigeria (Ayoola, 2014; This Day Newspaper, 2019; ATA_NIG, 2012); and currently, the introduction of the Green Alternative (Agricultural promotion policy) which aims at diversifying Nigeria's economy into agricultural production at all levels of government. However, the efforts at improving the tomato subsector are being inhibited by some factors.

The factors inhibiting the supply, productivity and economic value of tomato production in Nigeria hitherto are climatic changes, seasonal nature of tomato crop, soil infertility, inadequate technology on tomato production, deficiency of critical inputs and low yield. Also, of great importance are the lack of access to improved and certified seeds, high post-harvest losses, poor farmers-extension services, non-functional state of most of Nigeria's processing facilities and lack of marketing infrastructure. Inadequate information on how to access funds, inadequate improved tomato production techniques and incidences of pests and diseases also affect tomato production in Nigeria (Ugonna *et al.,* 2015; Central Bank of Nigeria (CBN), 2011). For instance, there were reports of *Tuta absoluta* (Tomato Ebola) infestation in 2016 which damaged most of the tomato farms in the major tomato-producing states in the North and some Southern States (Borisade *et al.*, 2016). To curb the aforementioned challenges, some technologies such as irrigation, the use of plastic mulch, the use of improved seeds, amongst others were introduced to increase tomato production in Nigeria as well as curtail the effect of some of the factors affecting its production.

Despite these interventions, tomato production in Nigeria is still prone to the hazardous effect of climate variation, pest and diseases since it is predominantly carried out in the open field. Recently, greenhouse technology which is a combination of all the above listed technologies as well as some other technologies was introduced and promoted by various greenhouse providers in Nigeria to provide the favorable environment needed for plant growth. According to Sahel research (2017), greenhouse technology has embedded in it technologies such as; plant nutrients management; mulching; use of high-yielding hybrids and cultivars; plant training and pruning techniques; integrated pest management; use of pollinator insects, climate control; soil solarization and other technologies. Though some state governments and private individuals in Nigeria have started promoting and using GHTs due to its comparative advantages over open-field for improved tomato production, especially for year round production of high quality tomatoes that are disease and pesticides-free which could be used regardless of place and time. However, the extent of adoption of all the components of the technology to achieve desired result has not been ascertained. Also, adequate attention has not been given to its use by the government and research institutes as a means of improving tomato production in Nigeria.

The limited use of GHT for tomatoes production by farmers as witnessed at the moment could be as a result of the characteristics of technology adoption. This includes: inadequate knowledge of its relative advantages over the open field farming, adaptability to the tropical environment, its complexity, observability and triability on a small scale. Also, socio-cultural beliefs about crops produced without the conventional method, sources of information, knowledge, management practices and attitude of the farmer adopting GHTs. Valera *et al.* (1987) in Kinyangi (2014) observed that farmers' behaviour (knowledge, attitude and practice) sometimes affects their extent of adoption, their adjustment or rejection as well as how they put the recommendation about a technology into practice. The fact that greenhouse technology requires total commitment and maximum care for it to be effective and efficient to achieve maximum yield could also pose a challenge (Thompson, 2010).

Studies previously conducted on greenhouse technologies include Chauhan *et al.* (2017), who researched on the knowledge of the farmers on the low-cost of Greenhouse Technology and concluded that farmers have medium level of knowledge of low cost greenhouse technology. Mijinyawa and Osiade (2011) reported on the status of greenhouses utilization in Oyo State, Nigeria. It was concluded that most of the greenhouses in Oyo State were mainly owned and located within the teaching and research institutions and are primarily used for research purposes. They also concluded that entrepreneurs have not been utilizing the technology due to the prohibitive cost of construction and maintenance and the lack of awareness of its potentials. Aznar-Sánchez *et al.* (2020) also observed that the research in GHT is dominated by technical disciplines and only 3.6% of the articles on GHT fall within the Social Sciences category which revealed the lack of research studies on GHT from the social science field. Itigi Prabhakar *et al.* (2017) also carried out a multi-stakeholder and multi-dimensional study on the constraints in the adoption and strategies to promote Polyhouse technology among farmers. But there is still a dearth of information regarding the extent of utilization and the factors affecting the adoption of GHTs in relation to tomato production in Nigeria. Hence, this study wanted to investigate the determinants of adoption of greenhouse technologies (GHTs) amongst tomato farmers in three selected states of Nigeria.

The research work sought to provide answers to the following research questions:

1. What are the personal characteristics of the respondents in the study area?
2. What are the farm enterprise characteristics of the respondents in the study area?
3. What are the respondents' sources of information on GHTs?
4. What are the respondents' levels of knowledge on the activities involved in operating GHTs?
5. What are the respondents' attitudes towards the activities involved in GHTs?
6. What are the management practices of GHTs carried out by respondents in the study area?
7. What are the constraints faced by respondents in the use of GHTs in the study area?
8. What is the level of adoption of GHTs by respondents in the study area?

1.3 Objectives of the study

The general objective of the study was to assess the determinants of adoption of greenhouse technologies among tomato farmers in three selected states of Nigeria. The specific objectives of the study include:

1. To identify the personal characteristics of the respondents in the study area,
2. ascertain the farm enterprise characteristics of the respondents in the study area,
3. identify the respondents' sources of information on GHTs
4. determine the respondents' levels of knowledge of the activities involved in operating GHTs,
5. ascertain the respondents' attitude towards the use of GHTs,
6. identify the management practices of GHTs carried out by respondents
7. ascertain the constraints faced by respondents' in the use of GHTs, and
8. determine the level of adoption GHTs by respondents in the study area.

1.4 Research hypotheses

The following hypotheses which were stated in the null form were tested in the study:

H_o1: There is no significant relationship between selected personal characteristics of the respondents’ and the level of GHTs adoption.

H_o2: There is no significant relationship between selected farm enterprise characteristics of the respondents and the level of GHTs adoption.

H_o3: There is no significant relationship between respondents’ level of knowledge of the activities involved in operating greenhouse technology and the level of GHTs adoption.

H_o4: There is no significant difference in the management practices involved with GHTs based on the type of greenhouse structure used for tomato cultivation.

H_o5: There is no significant difference in the yield of farmers based on the type of greenhouse structure used for tomato cultivation.

H_o6: There is no significant difference in the adoption level of GHTs among the respondents across the states.

H_o7: There is no significant contribution of the independent variables to the adoption of GHTs in the study area.

1.5. Significance of the study

In order to boost food production, farmers have always been in search of crop cultivation technologies that would help them control the climate for their plants. However, GHTs seems to be a way out as it is a controlled system of farming developed to combat the effect of climate change on crop production especially seasonal crops like tomato and ensure its availability all year round. However, it is very important to know the various factors encouraging or discouraging the adoption of GHTs among tomato farmers as production through GHTs would help in boosting and ensuring food security. It would also reduce importation of tomato paste and the wasting of our scarce resources on tomato import by encouraging its production by our local farmers. This study aimed to explain this.

This study would also help in ascertaining the yield per hectare of crops cultivated in the greenhouse farms in Nigeria. It would also provide information on greenhouse tomato production which could be used as a basis for comparison with crops cultivated in the open-field tomato system of farming. Results from the study would also serve as a guide to prospective farmers with information on the management practices available based on the type of structure used and constraint to the adoption of greenhouse technology in Nigeria. This would help guide their choice of the type of greenhouse structure to purchase in accordance to their capabilities. This study would also serve as a source of reference on greenhouse technology in Nigeria, due to the dearth of information on research on greenhouse technology in Nigeria. As many state governments are venturing into greenhouse technology, this study would serve as a guide in understanding the underlying factors that can affect the utilization of GHTs in order to prevent them. It would also help to confirm the capability of the tomato subsector in Nigeria to produce tomatoes enough to satisfy domestic demand; so that importation of tomato paste would be highly reduced as well as boost the potential of Nigeria to be an exporter of tomato.

1.6 Limitations of the study

The following were the challenges encountered during the study that posed a limitation to the scope of the study. The locations of the respondents were widely dispersed across the different states sampled and thus the respondents could not be sampled according to the Agricultural Development Programme (ADP) structure. Focus group discussion could not be conducted due to the distances between the different farms and also due to the secrecy of the business and marketing competition among the greenhouse farms. This resulted in increased cost of data collection as the researcher had to travel across the states to locate each of the greenhouse farms and farmers. Also, the number of registered greenhouse farmers collected from the President of Greenhouse Farmers Association (for Plateau State) as well as for other states as provided by greenhouse service providers like Dizengoff, Nigeria and Saro, Nigeria was not enough for the study. The researcher had to resort to snowballing to generate the list of unregistered greenhouse farmers to get more respondents for the study from which the samples were picked.

Some of the greenhouse farmers and owners in Ogun State (Iperu and Ewekoro) were harsh and refused to grant the researcher audience despite pleas and the presentations of the authorization letter from the department in the university. Some also refused to send back their questionnaires (this was particular to Ogun State) which limited the total number of response analyzed and reported for the study. Two of the abandoned greenhouse farms located during the study could not be reported because the owners refused to respond and return the questionnaires given to them.

Also, most of the greenhouse farms were located deep in the bush and required a guide for accessibility and security.

1.7 Operational Definition of terms

Greenhouse: A framed house which is covered with transparent material and in which crops can be grown with the climatic environment well modified and fully controlled to ensure great yield and productivity.

Greenhouse Technology (GHT): A technology which provides favorable environmental conditions for plant growth by protecting the plants from adverse climatic condition, insects, pest and disease.

Greenhouse farming: A controlled farming system that allows farmers to cultivate different types of crops even in seasons that are not favorable using greenhouse structures.

Technology adoption: It refers to the uptake of a technology. It involves the decision of an individual to utilize an innovation, an idea or a technology.

Determinants of adoption: These are the factors that determine whether an individual will adopt an innovation in its entirety or not.

Greenhouse crops: These are crops which can be cultivated in a greenhouse.

Climate variability: This refers to yearly or seasonal changes in climatic conditions.

Greenhouse farmers: All farmers directly involved in the use of greenhouse technology for crop cultivation.

Open-field farmer: A farmer who cultivates crops using the conventional open field system of farming.

Medium-cost Greenhouse: A greenhouse structure that is made with both imported and local materials.

High-cost Greenhouse: A greenhouse structure that is strictly made with imported materials.

Low-cost Greenhouse: A greenhouse structure that is strictly made with local materials.

CHAPTER TWO

LITERATURE REVIEW

2.1 Agriculture and climate change

The agricultural sector is an important sector of any country's economy. In Nigeria, prior to independence and thereafter, agriculture was the mainstay of the economy and a major source of revenue for funding development programmes of government (Onwualu, 2013). The sector provides most processing industries with raw materials as well as foreign exchange earnings for the country (Ajetomobi *et al.,* 2010). In the second-quarter of 2016, agriculture constituted 19.71% of nominal GDP and the contribution of agriculture to overall GDP in real terms was 22.55% in the second quarter of 2016 (National Bureau of Statistics (NBS), 2016). According to Alexander *et al.* (2015), the impact of agricultural production on national development cannot be overemphasized as it is the main source of livelihood for most rural communities in developing countries in sub-Saharan African. Agricultural production in most Sub-Saharan African countries including Nigeria is dependent on climate change. The climatic elements that affect agricultural production are rainfall, temperature, relative humidity, pressure, hours of sunshine, solar radiation and wind. However, the most important of the elements that have effect on tomato production are temperature and rainfall (Alexander *et al.*, 2015).

Climate change on the other hand poses a threat to food security owing to its impacts on the agricultural system. Food insecurity is almost synonymous with most African countries. According to Gichuki (2012), factors such as frequent droughts and agricultural productivity's reliance on climate and environment (rain-fed agriculture), overall decline in farm input investment including fertilizer, seeds and technology adoption and poor policies among others can lead to food insecurity. Orindi (2009) also posited that rain-fed agriculture yields in some countries could be reduced to 50% by 2020, resulting in increased food insecurity and hunger. Changes in temperature and rainfall will have a direct impact on crop productivity while changes in soil quality, pests and diseases will have an indirect impact (Ayoade, 2005). Climate variability has a significant impact on the productivity of physical production determinants like soil moisture and fertility, which often have a detrimental impact on the amount and quality of agricultural produce and farming outputs, putting food security at risk (Okoli and Ifeakor, 2014; Sowunmi and Akintola, 2010). Crop yield increased when there was ample rainfall and declined when the mean temperature increased according to (Awotoye and Matthew, 2010). High temperature causes evaporation and a decrease in soil moisture content reducing plant growth. High temperature may also affect crop yield and growth rate by accelerating its physiological development leading to hastened maturation and reduced yield (Sangotegbe, 2015). Therefore, if all factors of production are all in place but the climatic conditions are not favourable, it may eventually affect overall crop production and hence food insecurity.

Temperature and rainfall according to Guodaar (2015) are essential variables that have direct and indirect effects on most agricultural crops. Furthermore, Ekpoh (2010) claimed that crop yields are highly sensitive to rainfall and that the amount and distribution of rainfall can have a significant impact on crops. Since Ayanlade and Orimoogunje (2010) established that agricultural production in Nigeria is predominantly rain-fed, the decision on when, where and what crops to cultivate is based on the timing and amount of annual rainfall. Unfortunately, the changing climatic conditions have brought about very unpredictable rainfall patterns and have frustrated many farmers who depend on rain-fed crop production (Kemausuor *et al.,* 2011). Hence, the magnitude of the impact of climate change on agriculture cannot be underestimated because of its propensity to affect agricultural crops, especially vegetables (Lee *et al.,* 2012; Kemausuor *et al.,* 2011; Kotir, 2011).

2.2 Vegetable production

For many decades, vegetable production has been a main agricultural activity in Nigeria with rural farmers producing crops on both a subsistence and commercial scale. Tomatoes, okra, pepper, amaranthus, celosia, cochorus and other common vegetables are grown in Nigeria (Giroh *et al.,* 2008). According to Alemu *et al.* (2004), vegetable production can take place in backyards for personal consumption or on a large scale for both local and international markets. The demand for vegetables is high due to its high nutritional content and health potential, as well as being a staple diet of the growing population, but unfortunately the country is yet to meet its local needs.

During the dry season, there is also a constant problem of supply shortages (Oyediran *et al.,* 2020). Despite the high rate of consumption and demand for vegetables, open-field cultivation remains the most common agricultural technique. The crop is exposed to various constraints in this situation - such as pests, diseases and harsh weather which reduces the yield and quality of the produce. For vegetable production, the use of agricultural technology that provides protective cultivation such as greenhouse technology has been recommended as a solution (Dinham 2003).

Greenhouse technology (GHT) is a type of protective cultivation in which plants are grown in a controlled or partially controlled environment in order to maximize crop yields. GHT ensures that yield losses from insects, diseases and climatic factors are kept to a minimum and that crops are available throughout the year. In comparison to the traditional outdoor farming system, GHT farmers have a high production yield (94.3%) and income generation (75.7%) according to a study on the socio-economic significance of greenhouse technology for vegetable production in Nigeria (Oyediran *et al.,* 2020). GHT has helped in increasing vegetable yield and quality in developed countries, particularly in tomato production (Max *et al.,* 2009).

2.2.1 Tomato production

The tomato species *Lycopersicon esculentum* (formerly *Solanum lycopersicon* is an herbaceous plant cultivated for its edible fruit (Tomato Production Guideline, 2014). Tomato was domesticated and first cultivated by early Mexican civilizations in Central America. Then, it was introduced to Spain by Spanish explorers and it was later taken to Morocco (Tomato Production Guideline, 2014). Tomatoes are herbaceous plants with trailing stems that are hairy and weak. The leaves are hairy, come in variety of sizes and have clusters of yellow flowers. When ripe, the fruits are round to lobed and range in size and colour from red to pink to yellow (ProdGuideTomato.pdf). Tomatoes are one of the world's most popular vegetables grown both in home gardens and professionally (Tsado, 2014). It is the most common homegrown vegetable in the United States with at least 90% of households growing the crop (Peralta and Spooner, 2007; Gao *et. al.,* 2010). Tomatoes have an important role in agricultural and human nutrition all over the world.

2.2.2 Nutritional and Health Benefits of Tomato

Tomato is a good source of beta-carotene and antioxidants which are essential to a well-balanced human diet (Naika *et al.,* 2005). They are also high in minerals, vitamins, essential amino acids, sugars, dietary fibers, vitamin B and C, iron and phosphorus, all of which are requisite for a well-balanced human diet (Srinivasan, 2010). The taste, colour and food value makes it very important and widely acceptable as a major ingredient in food preparation, as almost all food prepared in Nigeria are not complete without tomato. It can be used in the preparation of stews, soups, salads, jollof rice, pottages and virtually every food prepared within the country. It can be processed into different products including; Ketchup, puree or paste, powder and juice and can also be consumed raw in its fresh state (Ugonna *et al*, 2015). Tomato can be produced under open fields and greenhouse condition (Gebremariam, 2015). The health and nutritional benefits include:

i. Tomatoes are low calorie vegetables as they contains 18 calories 100g; are also very low in fat contents and have zero cholesterol levels. They are excellent sources of antioxidants, dietary fiber, minerals and vitamins, which makes them easily recommended by nutritionists and dieticians in cholesterol controlling and weight reduction diet programs

ii. Antioxidants in tomato have been shown in studies to protect against malignancies such as colon, prostate, breast, endometrial, lung and pancreatic tumors. This vegetable has a total -ORAC (Oxygen Radical Absorbance Capacity) of 367mol TE/100g (Marowa-Wilkerson *et al.,* 2007).

iii. Lycopene, a dietary antioxidant found in tomatoes and most red fruits, shields the skin from UV radiation and offers protection against skin cancer. Lycopene also protects cells and other specific structures in the human body from damages caused by oxygen-free radicals. A substantial consumption of lycopene was reported to lower the incidences of digestive tract cancers, prostate and lung cancers in humans (Marowa-Wilkerson *et al.,* 2007). Besides its high lycopene content, tomato is ranked third and fourth highest source of vitamin C and vitamin A respectively and possess high levels of folate and tocopherols (Sánchez-Moreno *et al.,* 2006).

iv. Zeaxanthin, another carotenoids present in tomatoes functions to protect the human eyes from diseases including "age-related macular disease" (ARMD), predominant in the elderly by filtering harmful ultra-violet rays.

v. Tomatoes contain a good amount of flavonoid antioxidants such naringenin chalcone and rutin, which are chemo-preventive compounds. Natural vegetables and fruits high in these flavonoids have been shown to protect against lung and oral cavity tumors (Martí *et al.*, 2016).

vi. The Vitamin C content of tomatoes constitutes 21% of recommended daily intake in humans and its ingestion aids in the body's development of resistance to infections as well as the scavenging of damaging free radicals (Raiola *et al.*, 2014).

vii. Potassium is abundant in fresh tomatoes. 100 grams contain 237 milligrams of potassium. Potassium, a mineral found in cells and body fluids aids the regulation of the heart rate and blood pressure. (Sánchez-Moreno *et al.*, 2006).

viii. Tomatoes are high in B-complex vitamins including folates, thiamin, niacin, riboflavin and minerals like iron, calcium, manganese and other trace elements (Raiola *et al.*, 2014).

ix. Fresh juice and water extract of tomato fruit have been used to treat wounds, ulcers, hemorrhoids, kidney and liver problems and can be used as oriental medicine to relieve indigestion (Bhowmik *et al.*, 2012).

2.3 Greenhouse Technology

Greenhouse technology (GHT) is an agricultural technology which provides a climate-controlled environment for optimal growth and productivity of plants or crops. GHT in conjunction with automation creates ideal environmental conditions for plants or crops. Greenhouse structure protects cultivated plants from harsh climatic conditions and against damages from insects, pests and diseases. Moreover, it enables all-year cultivation and production of crops under controlled environment (Boodley and Newman, 2009). Greenhouse facilitates the production of high-quality produce and ensures the efficient use of water, seeds, plants’ protection chemicals and fertilizers (Aznar-Sánchez *et al.*, 2020).

Greenhouse farming has been in existence for centuries; however, technological advancements and climate change are altering how and why we grow in greenhouses. The benefits of greenhouse farming includes; early maturity of plants due to high temperatures, high yields, effective pest and disease control at reduced costs, minimized risks of production and maximized profits, reduced usage of chemicals to control pests and diseases and limited risks of chemical residues. Furthermore, there is an advantage of reduced weed control, limited water requirements and the production of high quality produce throughout the year (Wachira *et al.*, 2014).

Globally, there is a high rise in the demand for food, which is even expected to increase rapidly in the future, due to factors such as population growth, increased occurrence of natural disaster and climatic change which are important factors for agricultural farming. Therefore, the application of greenhouse farming ensures maximum yield and productivity and is considered effective in solving several challenges encountered in agricultural farming (Oyediran *et al*., 2020). However, GHT is yet to be fully adopted in several areas in the world, especially in Nigeria owing to some factors, which would be discussed in subsequent sections.

2.3.1 Types of greenhouses

Greenhouse structures are designed for optimal production of crops. They are often designed for a particular application and no single type of greenhouse can be considered the best for general applications. A greenhouse may be of high or low technology depending on materials used for construction, level and number of equipment used to grow the crops. Large-sized and advanced greenhouses use sophisticated and computerized climate control systems for the continuous monitoring and regulation of nutrient levels, temperatures, humidity, irrigation and light to optimize plant growth (Bhat, 2002**).**

Greenhouses are designed to meet the specific needs of crops. Categorically, greenhouses may be grouped based on their

i. Shapes and designs: lean-to, even and uneven span, ridge and furrow, quonset, saw tooth type.
ii. Utilities: greenhouses for active heating or cooling;
iii. Construction materials: wooden-, truss and pipe metal-framed structures;
iv. Covering materials: glass or fibre glass reinforced plastic, plain sheet, plastic film, UV stabilized LDPE film, corrugated sheet; and
v. Cost or technology: high, medium and low cost/technology of the greenhouse. This can be seen as shown in the appendices.

2.3.2 Cultural and management practices involved in greenhouse technology

Most of the management practices involved in the open-field tomato production is also used in the greenhouse tomato production. The differences in the two systems of farming are that the greenhouse is a controlled system of farming and the tomato plants are strictly managed and well looked after than in the open system of farming. Also, based on the assertation by (Agrifarming, 2015), reliability of crop increases under greenhouse cultivation because the environmental condition for plant growth is controlled and well monitored. Also, due to the use of drip irrigation, chemicals, fertilizers and pesticides used to boost growth of crops as well as control pests and diseases are efficiently utilized and crop water requirements are very minimal and easily controlled. Hence, the following cultural and management practices according to the Current DFK manual (2015) are carried out in the greenhouse:

A. Land preparation: Under land preparation, there are some compulsory procedures to follow. These includes:

i. Double digging: This entails digging the soil to a depth of 60cm. The process should be repeated two times to ensure that the soil is well turned. The advantages of double digging is to help in breaking the hard pan so as to allow good root establishment and networking, ensure proper drainage, as well as water and nutrients uptake.

ii. Manure application and incorporation: Dry manure should be applied in the greenhouse at a rate of 3 tons per greenhouse (8x24m). The spread will be followed by a thorough mixing with the soil. The source of manure should be preferably from compost or well composted livestock waste free from possible pathogens.

iii. Shaping of the bed

The bed should be raised to 80- 90cm width and 15cm above the ground level. The soil that is between the rows should be lifted on top of the bed using a digger or shovel. Bed forming has many advantages which include effective management of the crop and sustaining the soil structure established when double digging was done.

iv. Soil analysis: Slightly moist soil should be collected at various points within the greenhouse. The sample is then taken to the accredited laboratories for the pathological and nutritional analysis.

B. Pot/Bag Farming (Planting in Bags)

Pot farming is compulsory when the soil analysis shows the presence of bacterial wilt and soil borne diseases. The planting media is prepared by collecting the top soil and mixing it thoroughly with decomposed manure in a pan (soil to manure ratio, 3:1), then heating for 25-30 minutes, cooling and potting/bagging to at least $^{3}/_{4}$ bag full. Most soil pathogens are killed by this method of media preparation, especially *Ralstonia solanacerium*, which causes Bacterial Wilt. The dimensions of the pan to be used should be 10cmx100cmx200cm.

C. Preparation of bed

The bed can be raised slightly (about 10cm high). To avoid contamination from the treated content in the bags, plastic mulch should be used to cover the ground. The bags should be placed beneath the drip lines on the plastic mulch, with two drip emitters in each bag.

D. Irrigation water treatment

Irrigation and spraying water must be treated with calcium hypochlorite and the pots must be arranged in the green house in a pattern with two drip emitters per bag. The water is treated using 5-10gms of calcium hypochlorite per 600–1000lts of water (i.e. 2 tea spoonful or 1 table spoonful) and it should be allowed to stay for at least 12 hours before using it for irrigation or spraying.

E. The other growing operations adhere to the recommended agronomic measures.

i. Nursery procedure

- The nursery media is first soaked with water in a bucket.
- Mix thoroughly using your hand until wet
- Pour the nursery media into the tray grooves so that it fills ¾ of each tray groove
- Precisely place one seed in the center of each groove of the tray.
- Fill the remaining ¼ of the groove with media to cover the seed. (Before covering the seed, lightly squeeze this media to release water.)
- Arrange the trays on a raised surface, such as a wooden pallet or suspend between the beds. This is required to improve drainage and thus reduce water logging.
- Irrigation is carried out using a knapsack sprayer, ideally in the morning and evening (Current DFK manual, 2015).

ii. Nursery management

Regular irrigation is required daily for the next 5 days. Irrigate as often as possible, depending on the weather, as the media dries, but don't overdo it. Start using Polyfeed

19:19:19 or 20:20:20 with a knapsack on day 6 at a rate of 10gms per 16lts of water. For the duration of the crop, alternate 3 days with fertilizers and 1 day with plain water (3-1-3-1) until the seedlings are ready to be transplanted. Hardening off should take place one to two days before transplanting. This is accomplished by reducing the irrigation interval and feeding schedule to allow the seedlings to acclimate to their new surroundings and avoid transplant shock (Current DFK manual, 2015).

iii. Transplanting

The seedlings are ready for transplanting after 21 to 28 days in the nursery for tomatoes and 30-45 days for peppers and onions or when they are 7-10cm tall and pencil thick for peppers and onions. Transplanting should ideally be done in the evening but it can be done at any time during the day if the weather is cool. When transplanting tomatoes, the spacing should be 60cm x 60cm based on the crop canopy and if using planting bags, one seedling per bag should be used. Before transplanting, the soil must be well irrigated. This can be accomplished by irrigating the beds/planting bags for three days prior to transplanting for one to two hours daily and watering the beds/planting bags prior to transplanting. Make 5-10cm deep holes on top of beds or in the center of the planting bag, keeping the spacing in mind. If the bed is on the ground, the holes should be made in a zigzag pattern along the two rows of the bed (Current DFK manual, 2015).

iv. Fertilizer application

At a rate of 50gms per hole/bag, apply Smart fertilizer (SF), a slow-release base dressing fertilizer that aids in proper root development and apical growth. NPK 15:15:15 can also be applied in a split application of 30gms per plant in the first month, followed by 10-20gms in the fifth month. To avoid root scotch, thoroughly mix the fertilizer and soil within the hole/bag. To remove air bubbles, thoroughly irrigate the seedlings on the trays before transplanting. Slowly remove the seedlings from the tray, being careful not to damage the roots. Fill the hole with soil and ASF mixture, then, bury the transplant all the way to the collar (same height as the nursery media). To ensure there is no vacuum left at the base of the transplanted seedling, gently press on both sides of the media at the base of the seedling. After transplanting, give the plants plenty of water. For the first week after transplanting, daily irrigation with small amounts of water is recommended. Deep rooting is aided by deep irrigation followed by 1-3 days of water stress. Looking at the crop or using the handful method to check for moisture can help you decide when to irrigate (Current DFK Manual, 2015).

v. Nutrition

- Polyfeed/NPK

Polyfeed/ NPK should be applied with irrigation water at a rate of 0.5gms/1 liter of water for the first 4 weeks after transplanting. From the fourth week onwards, increase the dosage to 1gm/1Litre of water. This fertilizer is water soluble and applied via drip irrigation. When applying by drip, it's important to dissolve the fertilizer completely in a bucket before pouring it into the fertilizer tank. Apply at least once a week.

- Multi- K (Potassium Nitrate)

This should be applied at a rate of 1gm / 1lt of water with drips starting the 4th week of transplanting. Irrigate once a week after mixing in a bucket and pouring into the main irrigation tank. During the crop cycle, this rate should be maintained.

- Haifa cal. (Calcium Nitrate)

Three to four weeks after transplanting, top dress the crops with Haifa cal. at a rate of 5-10gms per plant, applied as a ring band around the plant and covered with soil after application. If a split application of 5gms/plant is used, the same rate will be applied again on the fifth month after transplanting (Current DFK manual, 2015).

vi. Trellising and Training/Staking

Trellising supports horizontal growth, whereas training/staking aids vertical growth. This allows for good aeration beneath the laid stems, easy fertilizer application and weeding and keeps the fruits off the ground (Current DFK manual, 2015).

The lower trellising lines and bags (if pot farming) are used as the base for laying the stems of the trellised plants. Support the plants with twine attached to the horizontal top and down running wires two weeks after transplanting. As the plant grows upward, it should be manually directed. Insect pests are attracted to yellow coloured plastic lines. When the stems reach the wires above, untie them and lower them as far as possible without the fruit touching the ground. Plants should be moved in a clockwise direction before being tied to the wires above. This should be done every two weeks at the very least. Wrap around onto the row on the opposite side of the bed for plants near the end of the rows. To avoid stem and branch breakage, trellising should be done at mid-day (Current DFK Manual, 2015).

vii. De-suckering

Excessive foliage causes overcrowding which reduces air circulation within the crop and overshadows the lower parts of the crop, thereby inhibiting photosynthesis and promotes fungus infection and flower abortion. Remove any upcoming lateral shoots to maintain a single stem (should be done timely before they overgrow). If you're using a pruning tool during the de-suckering process, sterilize it to prevent disease transmission from one plant to another.

viii. Pollination

This is usually done between 12 and 3 p.m. by lightly shaking the plant and tapping the upper trellising lines or training line with a stick. This is sufficient to allow pollen dust into the flower's stigma. This is due to the fact that insects that freely pollinate the flowers are unable to reach the plants inside the greenhouse. As a result, this must be done manually. Use fruit setting solution at a rate of 2mls/1lt. of water twice a week in hot and humid areas.

ix. Defoliation

Remove all leaves from below the ripening fruits as they mature. Because old leaves hide insect pests and disease pathogens, they must be removed. All defoliated leaves should be removed from the fields because they can attract and/or maintain diseases such as powdery mildew, and also serve as breeding grounds for crop enemies.

x. Harvesting

Harvesting should be done promptly (when the fruit colour changes to pink). Avoid fruits from over-ripening on the plant. After harvesting, all fruit cluster attachments should be removed. Fruit picked at this time is red on the inside and will turn red later. For such fruit to be a proper colour when placed on the grocery shelf, it must be packaged and moved to the market as soon as possible. To develop colour, mature green tomatoes can be harvested and treated with ethylene (ripening gas) under the right conditions. Green fruit is harvested infrequently compared to ripe fruit (Current DFK manual, 2015).

xi. Sorting and Packing

Tomato is sorted by colour and size to have a uniform pack suitable for various markets. In each box, only one size and colour should be used. Buyers will know exactly what they're getting and a grower's reputation for packing a high-quality product will improve (Current DFK Manual, 2015).

xii. Cleaning and Sanitation

A clean greenhouse environment must be maintained: rotten fruits, weeds, dead plants and leaves must be removed frequently. Foot bath and a hand wash should also be made available. Pruning tools should be disinfected with a solution of sodium hypochlorite (Bleach) or another disinfectant.

xiii. Crop Rotation

It's a crucial activity in any crop farming routine that must be followed at all times. Crops used in rotation should not be from the same family as this helps to break the breeding cycle for pests that are difficult to eradicate.

xiv. Record Keeping:

- Record keeping is an essential task in greenhouse farming because it aids in observing each stage of crop cultivation; act as a reference to the type and amount of water, fertilizers, manure, pesticides and other chemicals that were actually applied at each point in time and aids in keeping a consistent record of crop yield in order to determine how profitable the greenhouse investment has been for each cultivation season (Current DFK manual, 2015).

2.3.3 Advantages of greenhouse technology

1. Farmers can cultivate vegetables and crops when they can't be grown outside at any time of year.
2. It allows farmers to grow their crops in standardized and optimized conditions, protecting the plants from pests and bad weather because the ecological system is being monitored and controlled. Hence, less reliance on ecological system.
3. It allows farmers to grow out-of-season crops like tomatoes, basil, lettuce and other vegetables when the market price is high.
4. It can help to reduce the amount of foreign exchange spent on tomato imports each year.
5. It makes farming appealing to young people, particularly through the use of advanced technology used in greenhouse farming. As a result, it serves as a source of employment for the throng of unemployed youths.

6. When best agricultural practices are used in traditional open field tomato cultivation, the maximum yield that can be achieved is 7 tonnes per hectare (10,000m^2) whereas when GHTs are used in tomato cultivation on a hectare of land, the yield can be 19 times higher than what can be achieved using the traditional open field cultivation system, depending on the type of greenhouse, type of crop and other factors (NewsHerald, 2016).
7. Crop reliability improves in greenhouses because the environmental conditions for plant growth are carefully controlled and monitored.
8. It makes it easy to consistently produce disease-free and genetically superior transplants.
9. It ensures that chemicals and pesticides used to fertilize crops as well as control pest and diseases are efficiently utilized.
10. Crop water requirements are very low and easy to manage.
11. Stock plant maintenance, including grafted plantlets and micro propagated plantlets can easily be done within the greenhouse.
12. It provides an avenue whereby tomatoes free of blemishes are produced.

2.3.4 Challenges confronting the use of greenhouse farming in the world

Growing world population, changing consumption patterns, rising demand and food waste are putting unprecedented pressure on agriculture and natural resource systems. As a result, the availability of food is one of humanity's greatest challenges in the 21st century. Agriculture in greenhouses provides year-round crop production, improved yields, vegetable production on a small plot of land and high-quality products that can help reduce world food shortages (Wachira *et al.*, 2014; Nordey *et al*., 2017). Greenhouse farming has been successful for horticulturists and floriculturists for a long time, but there are a number of obstacles that have led to the closure of certain greenhouses. Inadequate buildings, lack of knowledge and skills in crop and greenhouse management, poor postharvest handling and marketing concerns are all cited as challenges of greenhouse farming. Wayua *et al.* (2020) reported that a large proportion of greenhouses were non-functional due to pests and diseases, high investment costs, insufficient water supply and insufficient knowledge on greenhouse farming in their study on the "challenges in greenhouse crop production by smallholder farmers in Kisii county, Kenya." In addition, Sanzua *et al*. (2018) reported that political involvement, technological expertise deficits, inadequate water sources and poor water quality usage for production were some of the issues facing greenhouse farming. Furthermore, Borse (2020) reported that the absence of technical know-how

, the low cost of agricultural produce relative to the production cost and the high cost of operation (investment) were all key obstacles to greenhouse farming.

2.3.5 Challenges confronting the use of greenhouse farming in Nigeria

To increase agricultural productivity, many crop production technologies have been initiated. The greenhouse is one of such technologies. In Nigeria, research institutes mostly use greenhouses while private greenhouse ownership is uncommon (Mijinyawa and Osiade, 2011). Due to low adoption rate of greenhouse technology and protected culture in tropical agriculture, benefits from this method of farming are not completely realized. Like in several countries across the world, weather variations and the impact of pest and disease infestation on farms have caused variations in the quantity of agricultural produce delivered to open markets, hence the necessity of the greenhouse. However, greenhouse production involves higher construction costs and adequate experience thus deterring farmers in Nigeria from getting involved. Oyediran (2016) also reported that the majority of farmers in Nigeria have not implemented greenhouse technology due to high investment costs, as Nigerian agriculture is still dominated by small-scale farming. In another study on “growing vegetables and ornamental plants in greenhouses in Nigeria to increase agricultural productivity”, Ibironke (2013) reported that lack of technology transfer, limited farmer empowerment in terms of access to financial and technological inputs necessary for sustained agricultural production and a poor public perception of modern technology were some of the factors preventing the successful introduction of greenhouse farming into the Nigerian agricultural sector.

2.4 Technology and its adoption in Agriculture

Agricultural technology is the application of technology to agriculture, horticulture and aquaculture with the goal of increasing yield, efficiency and profitability. Technology is employed in different aspects of agriculture and has been proven over years to be extremely useful. Farmers can use technology to revamp all of their processes for increased efficiency and output. Globally, agriculture technology has seen a massive increase in investment over the last ten years with $6.7 billion invested in the last five years and $1.9 billion invested in the year 2020 (Ku, 2021). In particular, modern greenhouse practices have seen significant technological advancements in the past decades (Ku, 2021). However, there has been a limitation on the adoption of technology in agriculture, especially among small-scale farmers. Some of the factors that account for the slow rate of adoption of agricultural technologies include: institutional, social and economic factors. To speed up this adoption process, the fundamental understanding and knowledge of these mentioned factors that impact farmer's decision on whether or not to adopt a particular technology in farming is essential (Arslan, *et al.*, 2020).

2.4.1 Adoption of agricultural technologies: GHT

The adoption of a new technology in agriculture at the farmer's level as defined by Feder and Umali (1993) is the degree of long-term use of the new technology when the farmer has complete information about the technology and its potentials. According to Challa, (2013), another important fact to consider in defining agricultural technology adoption by farmers is based on whether the farmer is a technology adopter or a non-adopter with values ranging from zero to one or the response is a continuous variable (Challa, 2013). The behavioral model behind the farmer's decision to adopt greenhouse technology is dynamic and complex and has been empirically categorized in literature (Obayelu *et al.,* 2017; Arslan, *et al.,* 2020). According to International Fund for Agricultural Development (IFAD), they range from socio-economic factors (e.g. age, education, and marital status), wealth indicators (e.g. income, land holding size, asset values) and agro-ecological variables (e.g. plot slope, soil quality, rainfall, temperature), location controls (e.g. farmer group membership, number of social connections) to market imperfections (e.g. access to credit, insurance and information). (Arslan *et al.*, 2020).

The adoption process consists of a series of sub-decisions about when to try out the new technology, when to adopt it, how intensely to adopt it and whether or not to completely replace the old method (Astebro, 2004; Yigezu *et al*., 2018). Loevinsohn *et al*. (2013) claim that farmer' decisions about whether and how to adopt new technology are influenced by the dynamic interaction between the technology's characteristics and a variety of conditions and circumstances. Farmers' willingness and speed to adopt new innovations are also influenced by the ease with which they can be tested to confirm their benefits which may be dependent on the extent to which they can be tested at low or no cost, with reduced risk (Pannell *et al*., 2006). The major factors that may influence adoption decisions have been thoroughly examined (Figure 2.1) and are summarized in the following sections.

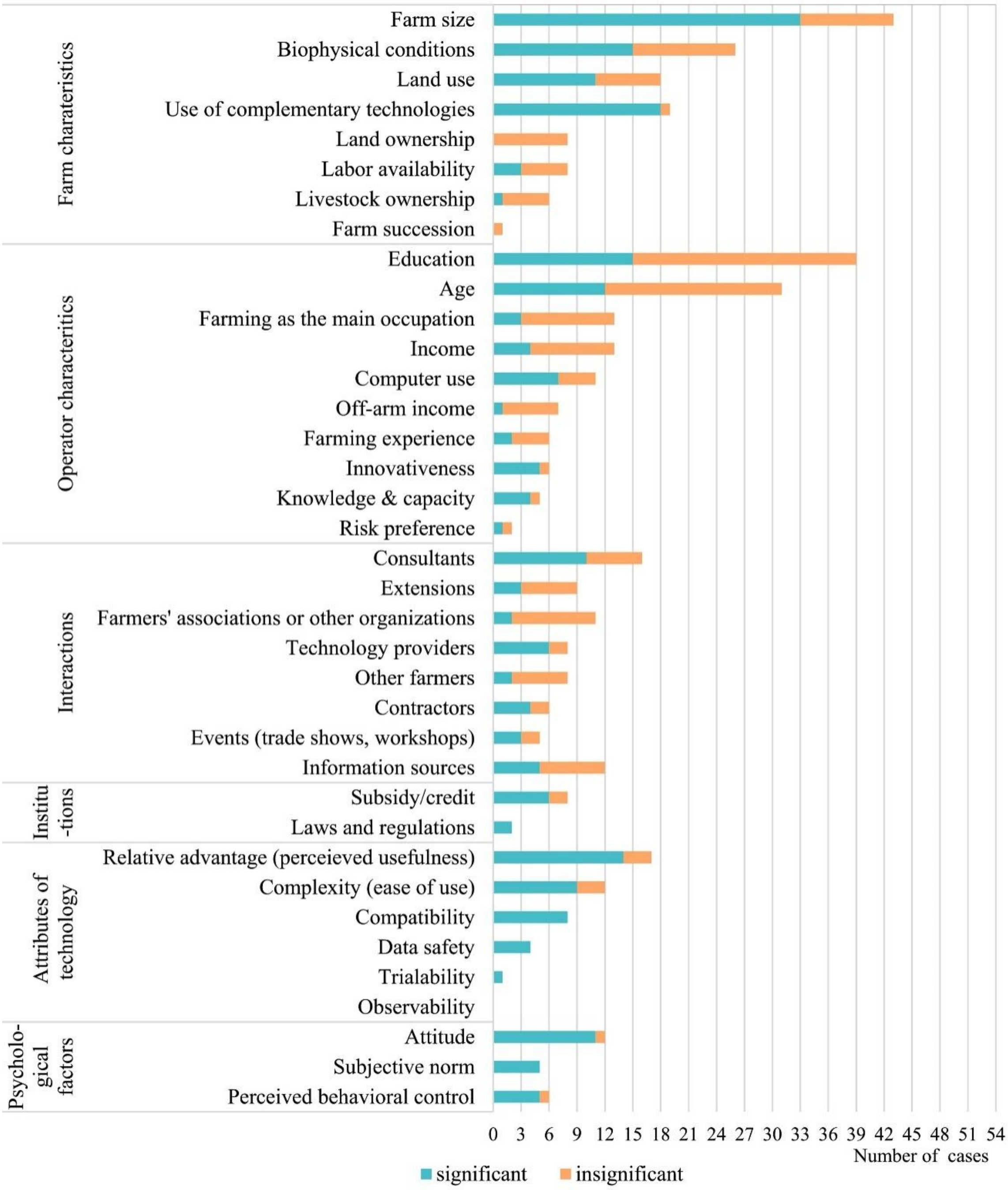

Figure 2.1: Factors influencing farmers' decision on technology adoption (Source: Shang et al., 2021).

2.4.2 Determinants of agricultural technology adoption

There are many categories for grouping determinants of technology adoption and there is no clear distinguishing feature between variables in each category. Categorizations are done to suit the current technology being investigated, the location, the researcher's preference, or even client needs (Bonabana-Wabbi, 2002). For instance, the level of education of a farmer has been classified as a human capital by some researchers while others classified it as a household specific factor. According to Shang *et al.* (2021) and Arslan, *et al.*, (2020), the determining factors of adopting agricultural technology were grouped as economic and farm characteristics, technology attributes, institutions and interactions and farmer/operator characteristics.

2.4.2.1 Economic and farm characteristics

Farm characteristics discussed under this section include: farm assets, farm size, land use, biophysical conditions, land ownership, labour availability, farm succession and economic factors which include various indicators of income, assets and wealth. Farm size plays a critical role in adoption process of a new technology. Farm size has been analyzed to get a great deal of attention in several technology adoption studies. Farm size can affect and in turn be affected by the other factors influencing adoption (Lavison, 2013). Some technologies are termed as scale-dependent because of the great importance of farm size in their adoption (Bonabana-Wabbi, 2002). Shang *et al*., (2021) identified an adoption rate of 33 out of 43 cases and more frequently, other studies have confirmed a positive relation between farm size and adoption of agricultural technology (Ahmed, 2004; Mignouna *et al.,* 2011).

Farmers with large farm size can take advantage of economies of scale and are more likely to devote part of their land to try new technology that requires high initial investment unlike those with less farm size (Tamirat *et al.*, 2018). Small-scale farmers also can also adopt a new technology, particularly when it comes to an input-intensive innovation like labor-intensive or land-saving technology (Obayelu *et al.*, 2017). With regards to farm size, technology adoption may best be explained by measuring the proportion of total land area used for the new technology.

Off-farm income has been shown to have a significant impact on technology adoption (Schimmelpfennig and Ebel, 2016). This is because off-farm income is an important strategy for rural households in many developing countries to overcome credit constraints (Reardon et al., 2007). In rural economies where credit markets are either absent or dysfunctional, off-farm income is said to act as a substitute for borrowed capital (Ellis and Freeman, 2004; Diiro, 2013). However, not all technologies have demonstrated a positive link between off-farm income and adoption. Labor-intensive technologies have shown a negative relationship between off-farm income and adoption (Goodwin and Mishra, 2004). According to their research, farmers' pursuit of off-farm income may actually hinder their adoption of modern technology by reducing the amount of household labor dedicated to farming enterprises.

2.4.2.2 Technology Attributes

Characteristic of a technology is a precondition of adopting it. Qualitative descriptive studies pay more attention to attributes of technology and frequently apply Rogers' (1995) Diffusion of Innovation (DOI) theory and Davis's (1989) Technology Acceptance Model (TAM) to explain technology attributes. According to the DOI theory, relative advantage, complexity, compatibility, triability and observability can explain the perceived characteristics of adopting an innovation (Rogers, 1995). Relative advantage like increasing productivity promotes adoption, while high cost and time required for handling data are barriers (Adrian *et al.,* 2005).

The complexity of new farming technologies and their compatibility with existing machinery are frequently perceived as barriers to adoption (Aubert *et al.,* 2012; Pivoto *et al.,* 2019). Furthermore, triability is a major determinant of technology adoption because it is the willingness of a potential adopter to try something out on a small scale before fully adopting it (Doss, 2003). Adoption can be aided by triability manifested in a positive exploratory experience. However, the only study that takes this factor into account finds a negative correlation between triability and adoption (Aubert *et al.,* 2012). Farmers' perceptions of the technologies' performance have a significant impact on their decision to adopt them. As a result, before any new technology is introduced to farmers, they must be involved in its evaluation to determine its suitability for their needs (Sinja *et al.,* 2004). On the other hand, study on the implications of observability of the technology by peers has not been examined in literature (Shang *et al.,* 2021).

2.4.2.3 Institutions, interactions and information

Institutions are formal and informal societies such as social groups or networks that enhance social capital through access to loan, credit or subsidy and the exchange of information and ideas make up institutions (Mignouna *et al.*, 2011). According to Shang *et al.* (2021), farmers' access to social institution subsidies/credit is thought to have a positive impact on adoption, as financial support is required for technology diffusion (Reichardt and Jürgens, 2009). Furthermore, farmers who participate in social groups learn about and benefit from new technology which influences their decisions about whether or not to adopt it (Mwangi and Kariuki, 2015). Katungi and Akankwasa (2010), in their study on the adoption of corm-paired banana technology in Uganda, discovered that farmers who participated more in community-based organizations engaged in social learning about the technology which positively influenced their decision to adopt the technology. Although many researchers have found that social groups have a positive impact on technology adoption, social groups can also have a negative impact on technology adoption, particularly when free-riding behavior is present (Hogset, 2005). Furthermore, while social factors have been found to influence agricultural innovation adoption, they have not been a focus of adoption studies of greenhouse farming technologies.

Technology adoption is influenced by interactions with consultants, extension workers, technology providers, other farmers as well as information sources such as participation in events, trade shows and workshops. Farmers' adoption decisions are negatively influenced by a lack of advisory services (Shang *et al.*, 2021). Extensions bring researchers and farmers together by introducing farmers to new technologies. Direct interaction with extension services has also been identified as a critical factor in technology adoption (Genius *et al.,* 2010). The extension agent serves as a link between the technology's innovators i.e. researchers and its users. Extension agents usually target specific farmers who are regarded as peers by other farmers, or they have a direct or indirect influence on the entire farming population in their respective areas (Genius *et al.,* 2010). In the overall decision to adopt some technologies, the influence of extension agents can counterbalance the negative effect of a lack of years of formal education (Bonabana-Wabbi, 2002).

The source and availability of information about a technology's existence have an impact on its adoption. Farmers who have access to information about a technology, according to Larson *et al.* (2008), are more likely to adopt the technology. Another important factor that influences adoption decisions is the source of information about a new technology. Farmers will only use technology that they are familiar with or have heard about from a reliable source. Access to information does reduce the uncertainty about a technology's performance. However, having access to information about a technology does not guarantee that all farmers will adopt it (Caswell *et al.,* 2001). Access to information may also lead to a decrease in technology adoption. For example, where the general population's experience with a particular technology is limited, more information leads to negative attitudes toward its adoption, owing to the fact that more information exposes an even larger information vacuum, thus increasing the risk associated with it (Caswell *et al.,* 2001). As a result, it's critical to make sure the data is accurate, consistent and reliable. Farmers' associations and other organizations are frequently thought to be a source of information for farmers (Arslan, *et al.,* 2020).

2.4.2.4 Farmer/operator characteristics

Farmers' characteristics are frequently mentioned in adoption studies. Education level, age, gender and household size can all be considered "human capital" (Keelan *et al.*, 2014). Farmers with a high level of education may be better capable of grasping the application of new technologies, so education is expected to have a positive impact on technology adoption (Huffman, 2020). A farmer's educational level improves his ability to obtain, process and apply information relevant to the adoption of a new technology (Mignouna *et al.,* 2011).

Age is another significant factor that influences adoption. Adoption is usually thought to be negatively correlated with age. Younger farmers are thought to be less risk-averse, more innovative and more willing to try new technologies; however, if the technology is labor-saving and the household is labor-constrained or if it is a modified version of a traditional practice they have prior experience with, older farmers may adopt some technologies faster (Arslan, *et al.,* 2020). Furthermore, it is assumed that older farmers have accumulated more knowledge and experience over time and are better able to evaluate technology information than younger farmers (Mignouna *et al.*, 2011).

Gender issues in agricultural technology adoption have been studied for a long time and the majority of studies have found conflicting evidence regarding the different roles men and women play in technology adoption (Bonabana-Wabbi, 2002). Because the head of the household is the primary decision maker and men have more access to and control over vital production resources than women due to socio-cultural values and norms, gender has an impact on technology adoption (Mignouna *et al.,* 2011; Omonona *et al.,* 2006). For instance, Obisesan (2014) reported gender to have a significant and positive influence on the adoption of improved cassava production in Nigeria.

The size of a household is simply a measure of labor availability. As a result, the size of a household is commonly expected to encourage adoption by allowing a larger household to relax the labor constraints imposed during the introduction of new technology (Mignouna *et al.,* 2011; Bonabana-Wabbi, 2002). However, the exact impact is determined by whether the technology reduces or increases labor demand (Arslan *et al.*, 2020).

2.5 THEORETICAL AND CONCEPTUAL FRAME WORK

2.5.1 Theoretical framework

The theoretical approach that will be used to guide this study will be drawn from the following theories:

1. The unified theory of acceptance and use of technology (UTAUT)
2. Diffusion of innovation theory
3. The theory of technology acceptance model.

2.5.1.1 The Unified Theory of Acceptance and Use of Technology (UTAUT)

This is an acceptance technology model developed by VenKatesh, *et al.* (2003) in their paper "User acceptance of information technology: Towards a unified view". The goal of UTAUT is to explain why people want to use an information system and how they eventually use it. Performance expectancy, effort expectancy, social influence and facilitating conditions are the four key constructs that make up the theory.

Expectancy of performance, effort and social influence are all direct determinants of usage intention and behavior, whereas facilitating conditions are a direct determinant of user behavior (Venkatesh *et al*., 2003). Therefore, farmers who are willing to increase their yield and income will gladly accept and make the best use of GHTs as long as it improves their social status. It also implies that if farmers have high expectations (in terms of yield and income) from their adoption and use of GHTs, they want great results from the efforts they put into GHTs, they understand the social influence the proceeds from their use will earn them, they will gladly embrace the technology.

2.5.1.2 Diffusion of Innovations Theory

Rogers (1995) defines diffusion as the "process by which an innovation is communicated over a period of time through certain channels among the members of a social system." An innovation is a practice, an idea or object that is perceived as new by an individual or other unit of adoption. The conditions that increase or decrease the likelihood of a new idea, product or practice being adopted by members of a given culture are the focus of diffusion research.

The five elements of diffusion are as follows:

(1) An innovation's characteristics that may influence its adoption, such as relative advantage, complexity, compatibility/adaptability, observability and triability.

(2) The process by which people decide whether or not to adopt a new idea, product, or practice.

(3) Personal characteristics that make an individual more likely to adopt a new idea.

(4) The implications of adopting an innovation for individuals and society.

(5) Communication channels used in the adoption process.

Innovation decision-making is neither authoritative nor collective; therefore, each member of the social system must make his or her own innovation decision, which follows a five-step process:

1. Knowledge – a person becomes aware of an innovation and has some understanding of how it works.

2. Persuasion – a person's attitude toward an innovation is formed, either positively or negatively.

3. Decision – a person engages in activities that lead to a decision about whether or not to adopt or reject an innovation.

4. Implementation – a person puts an innovation into practice.

5. Confirmation – a person evaluates the outcomes of a previously made innovation decision.

Hence, the characteristics of the innovation (GHTs) i.e. the complexity of GHTs, the relative advantages it has over open field system of farming, its compatibility and ease of adapting it to our local environment, the ability to observe its effectiveness and the ability to try greenhouse technology out on a small scale will determine the extent of its adoption and utilization by farmers in each study area. The rate at which farmers adopt greenhouse technologies will be determined by their individual characteristics, such as whether they are innovators, early adopters, early majority, late majority or laggards. The communication channel (which is the source through which the farmers gets information on GHTs e.g. radio, social media, greenhouse service providers, extension agents, farmer groups and associations, friends, etc.) will also determine the speed at which information that can guide farmers' choice and decision to adopt and utilize GHTs for tomato farming will be diffused to farmers.

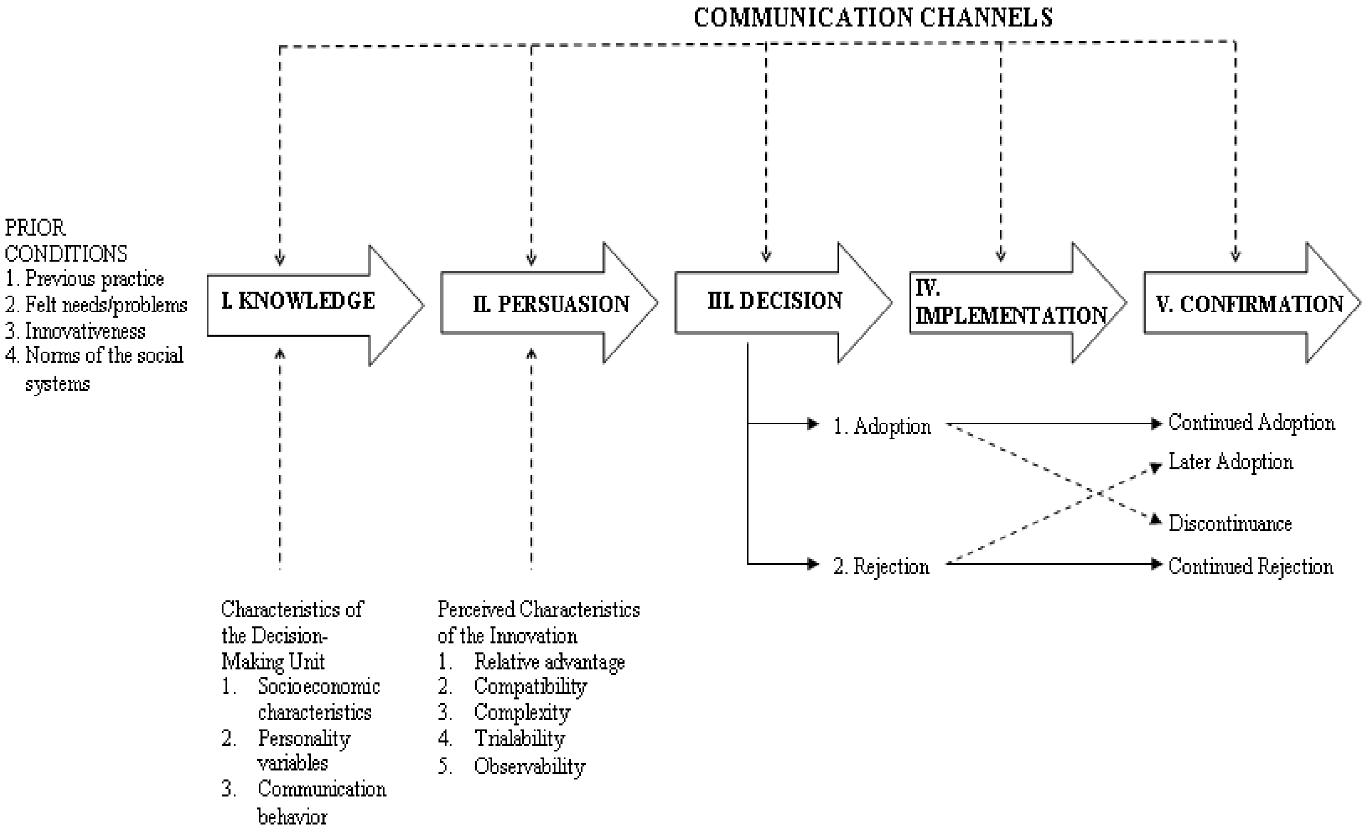

Figure 2.2: Diffusion of Innovation Model (Source: Rogers (2003)).

2.5.1.3 The Technology Acceptance Model (TAM):

Technology Acceptance model (TAM) is among the most influential extensions of Ajzen and Fishbein's (1980) theory of reasoned action (TRA). This is a theory of information systems that explains how users accept and use technology. When users are presented with new technology, this model suggests that a variety of factors influence their decision on how and when to use it. The following are some of the factors:

a. Perceived usefulness (PU): Davis (1989) defined perceived usefulness (PU) as "the degree to which an individual believes that using a technology or system will improve his or her job." Hence, if farmers believe that using GHTs will enhance their yield and invariably their income, they will accept and use it.

b. Perceived ease of use (PEOU): According to Davis (1989), this is the degree to which a person believes that using a particular technology or system will be free from efforts. Hence, if farmers believe that the use of GHTs will reduce the effort they need to put into mitigating the effect of disease, pest and climatic change, it will go a long way in influencing their decision about its adoption and use.

"Technology Acceptance Model (TAM) theory" has been criticized by (Chuttur, 2009) due to its questionable heuristic value, limited explanatory and predictive power, triviality and lack of practical value. According to Benbasat and Barki (2007), TAM "has diverted researchers' attention away from other important research issues and created an illusion of progress in knowledge accumulation."Lunceford (2009) also argued that the framework of perceived usefulness and ease of use ignores other factors like cost and structural imperatives that force users to adopt technology.

As a result, farmers' attitudes toward GHT use will be influenced by their perceptions of its usefulness and ease of use. Their behavioral intention to use GHTs will be influenced by their attitude to use and perceived usefulness which will eventually improve their actual use of GHTs.

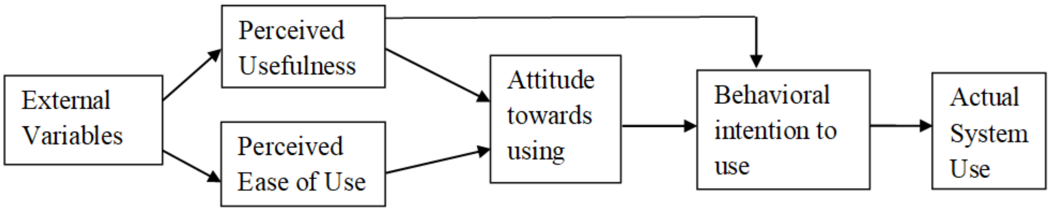

Figure 2.3:The Technology Acceptance Model, Version 1 (Davis, Bagozzi and Warshaw, 1989)

2.5.2 Conceptual Framework

The conceptual framework of this study consists of the independent, intervening and dependent variables and how they interrelate with each other. The independent variables are: personal characteristics (such as age, sex, religion, educational attainment), farm enterprise characteristics, sources of information on GHT, knowledge on GHT, attitude towards the use of GHT, management practices of GHT, benefits derived from the use of GHT and the constraints experienced by the respondents in the use of GHTs.

For instance, respondents' personal characteristics such as age, sex and educational attainment may influence some of the farm characteristics like access to credit which will aid in increasing their farm size, yield and eventually their income.

The personal characteristics like age and educational attainment may affect their zeal to source for information; which will also affect their farm enterprise. The sources of information will affect the respondents' knowledge, attitude and management practices of GHTs, which will invariably affect the benefits derived as well as the constraints faced by the respondents in the use of GHTs and this will eventually affect the adoption of GHTs.

The management practices will also affect the farm enterprise characteristics in terms of yield and income and this will therefore affect the adoption of GHTs. The knowledge of GHTs will affect the attitude of the respondents to the use of GHTs and will invariably affect how often they carry out the management practices. The constraints faced in the use of the technology will also affect how they adhere to the laid-down management practices and the extent to which the respondents will adopt GHTs.

The intervening variables operationalized as government policies on the importation of tomatoes, natural disaster (e.g. flood) and credit institutions will affect farmers' level of adoption. Importation of tomato paste will affect adoption as long as it remains a cheap alternative to tomato seasonality; natural disaster like flood may affect the farmers involved in GHTs while access to credit facilities may facilitate adoption.

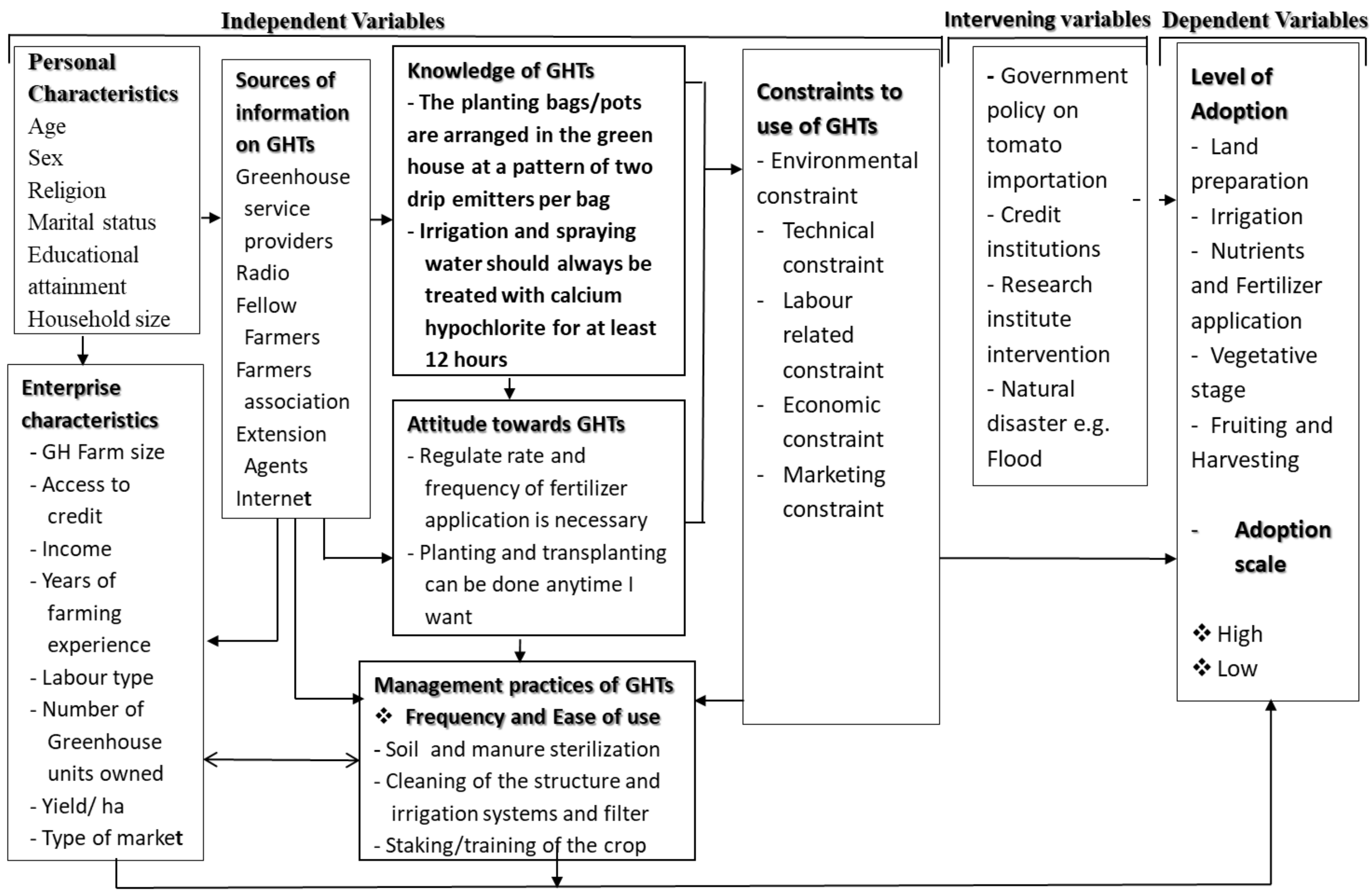

Figure 2.4 Conceptual Framework on Determinants of Adoption of Greenhouse Technologies

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Research design

The approach adopted for the study was mixed methods which included the use of survey method to generate qualitative and quantitative data. The qualitative data used was Key-in-depth interviews (KII), while the quantitative data were derived using structured questionnaires (through interview schedule and sending of electronic copies to some of the greenhouse farmers)

3.2 Area of study

The area of study is selected states in Nigeria. Nigeria is a West African country, which consists of 36 states including the Federal capital territory. Nigeria is endowed with an area of 923,769 Km^2 and a population of 182 million people (National Population Council, NPC, 2017). Nigeria lies between Latitudes 4^o to 14^o North and Longitudes $2^o2'$ and $14^o 30'$ East; shares boundaries with Niger Republic and Chad (at the north); Benin Republic (at the west), Cameroon Republic (at the East) and by the Atlantic Ocean (at the southern part) (FAO, 2009). Nigeria has a tropical climate with relatively high temperatures all year and two seasons: the rainy or wet season, which lasts from mid-March to November in the south and from May to October in the north and the dry season, which lasts the rest of the year (FAO, 2009).

The study was carried out in Plateau, Lagos and Ogun states because of the concentration of individual farmers and farmers' groups undertaking greenhouse tomato farming and their spread in the area. This is according to the report gathered from greenhouse service providers such as Dizengoff Nigeria, Agricultural Services and Training Centre (ASTC) and other greenhouse construction companies across Nigeria.

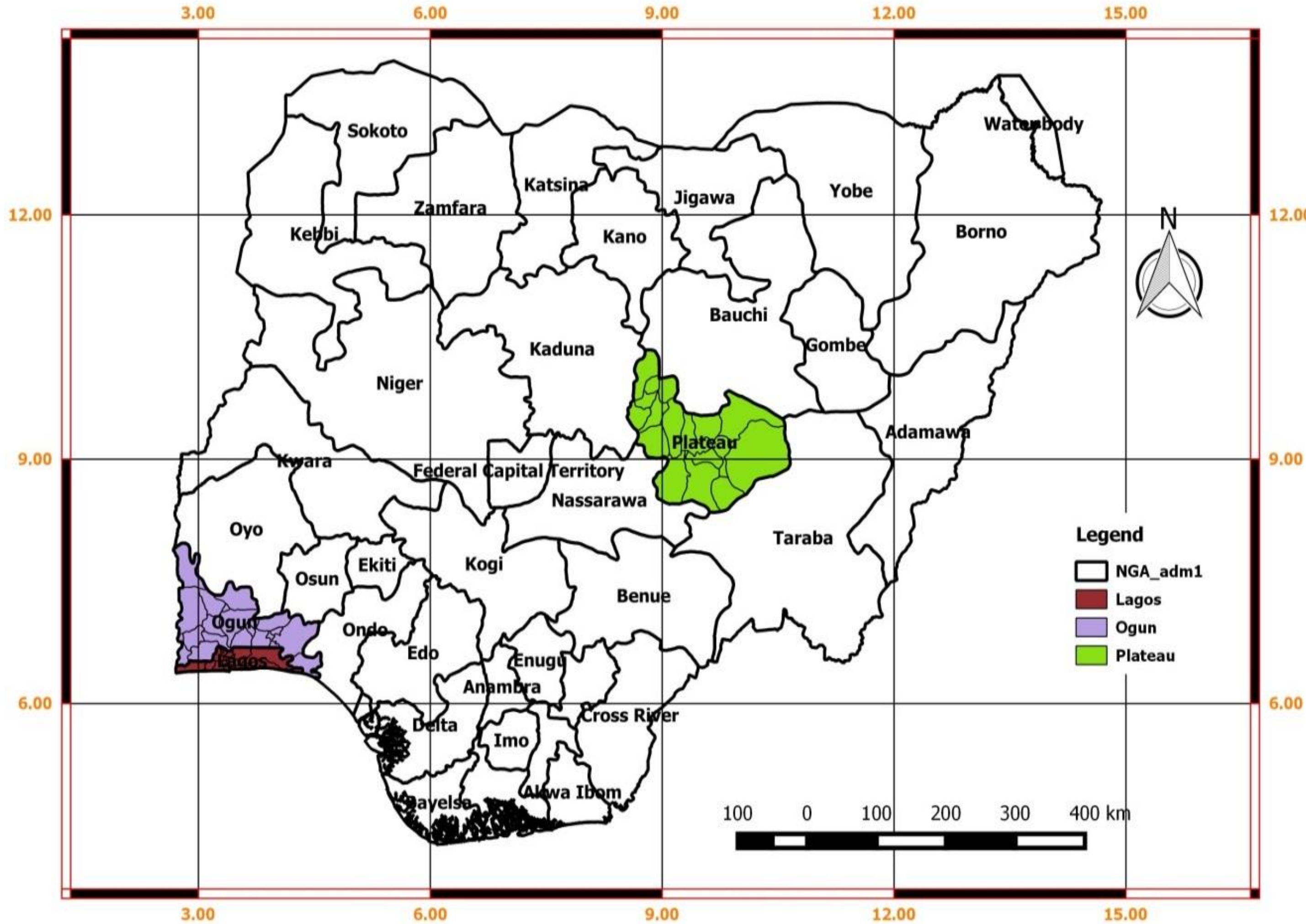

Figure 3.1: Map of Nigeria showing Lagos, Ogun and Plateau states

3.3 Population of the study

This study population comprises of greenhouse tomato farmers in the three (3) selected states of Nigeria.

3.4 Sampling procedure and sample size

Respondents for the study were selected using a multi-stage sampling procedure.

The first stage involved the purposive selection of Plateau, Lagos and Ogun states. This was hinged on the fact that the three states were the states where greenhouse technology has been widely accepted by both the state governments and private individuals. According to the National Greenhouse Farmers Association, the three states also had the highest number of greenhouse service providers.

The second stage involved generation of sampling frame consisting of registered greenhouse farmers from the greenhouse farmers' association and the service providers; as well as the generation of the list of unregistered farmers using snowball technique to give a total of 343 respondents. The respondents that constituted the sampling frame (both registered and unregistered farmers) were not concentrated in specific locations in each of the three selected states but scattered across them.

The third stage involved the sampling of 70% of the respondents from the sampling frame from each of the states to give a total of 240 respondents sampled for the study, out of which 216 questionnaires were retrieved back.

Table 3.1: Sampling procedure for selecting the respondents

Selected States	Number of registered GH Farmers	Number of unregistered GH Farmers	Total number of Farmers	Selection of 70% of the total number of GH Farmers	Total number of questionnaires returned
Plateau	84	46	130	91	83
Lagos	93	53	146	102	93
Ogun	49	18	67	47	40
Total	226	117	343	240	216

3.5 Instrument for data collection

Structured and systematically drawn questionnaires and Key In-depth interview (KII) were used as instruments for data collection. The questionnaires were given to some of the respondents that were literate to fill by themselves while the illiterates were interviewed and assisted to complete the questionnaire based on their responses to the questions. Electronic copies of questionnaires were also sent to some greenhouse farmers.

3.6 Validation of Research Instrument

The instrument for data collection was validated using face validity by discussing the contents and objectives of the study with experts in the Department of Agricultural Extension and Rural Development as well as experts from Agronomy Department, University of Ibadan

3.7 Pre-testing

Instrument pre-testing was carried out in Oyo State. Item analysis was conducted on the retrieved instruments.

3.8 Test of reliability of instrument

The reliability of the instrument was done using Cronbach's Alpha method. A reliability co-efficient of 0.92 was obtained and considered good to establish the reliability of the instrument.

3.9 Measurement of variables

3.9.1 Independent variables

The following were considered as independent variables for this study.

A. Personal Characteristics of the Respondents

1. Age: The respondents were requested to supply their actual age (in years).
2. Sex: Male (1), Female (2)
3. Marital status: (i) Single (ii) Married (iii) Divorced (iv)Widowed
4. Religion: (i) Christianity (1) (ii) Islam (2) (iii) Traditional (3); (iv) Others (specify)
5. Household size: actual number of people living together with them in their house.
6. Educational attainment: actual years of formal education (in years).
7. Years of farming experience (in years)

8. Years of involvement in the use of greenhouse technology? (Actual number of years)

9. Membership of social organization: (i)Yes (ii) No

10. What is your primary occupation? ___________

11. What is the average income that you generate from your primary occupation per month?

12. ` What other income-generating activities do you engage in? List them all.

B. **Farm Enterprise Characteristics**

13. Size of greenhouse farm (in acres).

14. The number of Greenhouse units owned.

15. Ownership status of greenhouse structure used (i) Personally acquired (ii) Hired workers (iii) Government leased/rent (iv)Individually leased (v) Research institutes

16. Type of greenhouse structure used in cultivating vegetable crops: (i) High-cost greenhouses (ii) Medium-cost greenhouses (i.e. a mixture of both local and imported materials) (iii) Low-cost greenhouses

17. Year of first use of greenhouse technology? (State the actual number of years).

18. Discontinued use of greenhouse technology (i) Yes (1) (ii) No (0)

19. Period of discontinued use: (Actual number of years).

20. Method of planting greenhouse tomatoes (i) Directly in the greenhouse unit (ii) In the nursery and later into pot/bags (iii) In the nursery and later on the greenhouse floor
(iv) Others (specify)

21. Frequency of cultivation of greenhouse tomatoes in a greenhouse unit within a year:
(i) Once (ii) Twice (iii) Thrice (iv) More than thrice

22. How much do you sell your tomatoes per kg during the off-season period? (Actual price/kg)

23. How much do you sell your tomatoes per kg during the on-season period? (Actual price/kg)

24. How many kilograms per stand of tomato do you derive in the greenhouse?

25. Source of planting materials/inputs: (i) Previous harvest (ii) Research institutes
(iii) Agro-dealers (iv) Greenhouse kit providers (v) Government agencies

(vi) Direct importation (vii) others (specify)

26. Which type of labour do you make use of for your greenhouse farming?
(i) Family labour (ii) Cooperative labour (iii) self labour (iv) Hired labour

27. What types of crops do you cultivate in the greenhouses?

28. Where do you sell off your produce?: (i) Local markets (ii) Private individuals (iii) Supermarkets (iv) Hotels (v) International market (vi) Processing industry (vii) On the farm (viii) Others

C. Sources of information on Greenhouse technologies

The respondents were asked to indicate sources of information and the frequency of getting information on Greenhouse technologies among the listed options. The frequency of obtaining information was measured as (i) Always (2), (ii) occasionally (1), (iii) Never (0). Based on the mean, the sources of information will be ranked in order of the most accessed source of information.

D. Knowledge of respondents on greenhouse technologies and the activities involved

Respondents' knowledge on greenhouse technologies and the activities involved was obtained by presenting a list of 19 items consisting of positive and negative statements to the respondents. This was measured using a 2 point scale of true and false with a score of one (1) assigned to the correct response and 0 to wrong response. The maximum possible score was 19 and the minimum score was zero (0). Respondents score on knowledge was added and the mean score was computed. The mean score of 10.43 was used to categorize respondents as either having high knowledge of the activities involved in greenhouse technologies for those with scores equal to and above the mean or having low knowledge of the activities involved in greenhouse technologies for those with scores below the mean.

E. Attitude of respondents towards the activities involved in greenhouse technologies

Respondents' attitude towards the activities involved in greenhouse technologies was obtained by presenting a list of 24 attitudinal items consisting of positive and negative statements to the respondents. This was measured on a 5-point Likert scale of SA- Strongly Agree, A- Agree, UD- Undecided, D- Disagree and SD- Strongly Disagree. This was scored as 5,4,3,2 and 1, respectively for positively worded statements and as 1, 2, 3, 4 and 5 for negatively worded statements. The highest possible score was 120 and the lowest possible score was 24. The respondents' score was summed up and the mean computed. The mean value of 89.46 was used to categorize respondents as either having favourable attitude towards the activities involved in greenhouse technologies for those with scores above the mean or unfavourable attitude towards the activities involved in greenhouse technologies for those with scores equal to and below the mean.

F. Management practices of greenhouse technologies by respondents

Management practices of greenhouse technologies carried out by respondents was obtained by standardizing the frequency of use and the ease of use. This was achieved by providing a list of 28 items on management practices and asking them to indicate the frequency with which the management practices were carried out and the ease of using each of the management practices listed. Mean was used to rank the available response.

(a) Frequency of use: This was measured using a 3 point scale of always, sometimes and never and scores of 2, 1 and 0 was assigned to it, respectively. The maximum score was 56 and the minimum score was 0. Mean was used to rank the available response.

(b) Ease of Use: This was measured using a 3 point scale of Easy-2, Difficult-1 and Unaffected-0. Those who never used a particular greenhouse management practices and those indifferent or unaffected by the ease or difficulty of use of greenhouse management practices were assigned zero. The maximum possible score for ease of use was 56 and the minimum possible score was 0. Mean was used to rank the available response.

Respondents score on management practices was generated by adding the standardized Z-scores of the frequency of use and ease of use. The mean of 4.51 was then obtained and used as a benchmark to categorize the respondents as either having good management practices for those with scores equal to and above the mean or poor management practices for those with scores below the mean.

G. Constraints to the use of Greenhouse technologies

The respondents were asked to respond to a number of items on the constraints experienced in adopting GHTs which were categorized into five viz: Environmental constraint, Technical constraint, Labour related constraints, Economic constraints and Marketing constraints as adapted from Itigi-Prabhakar *et al.* (2017). This was measured on a scale of: Not a constraint (0), Mild constraint (1) and Severe constraint (2). The mean was computed and used to rank the constraint based on the severity.

3.9.2 Dependent variable

The level of adoption is the dependent variable. Farmers' level of adoption of GHT was measured using the adoption scale of: Always using=3, Sometimes using=2, Used but discontinued=1 and Never used=0. The list on the recommended GHTs was presented to the farmers and the adoption score was generated.

The respondents were categorized as having high and low levels of adoption based on the mean (59.0). Respondents with scores above the mean were categorized as having high level of adoption, while those with scores below the mean were categorized as having low level of adoption.

3.10 Data analysis

Descriptive statistics such as frequency count (F), percentages (%) and mean ($\bar{x}$) were used to analyze the data. The following inferential statistics were used to analyze the hypotheses:

$H_0$1 and 2 were tested using Chi-square (χ^2) and Pearson Product Moment Correlation (PPMC)

$H_0$3 was tested using Pearson Product Moment Correlation (PPMC)

$H_0$4 - 6 were tested using ANOVA

$H_0$7 was tested using multiple linear regression analysis

CHAPTER FOUR

RESULTS AND DISCUSSION

This chapter presents the study's findings, interpretation and discussed the results in relation to the different specific objectives and hypotheses.

4.1 Socioeconomic characteristics of respondents

4.1.1 Age

Age distribution as presented in Table 4.1a showed that 39.8% of the respondents across the states were within the age ranges of 29-39 years with a mean age of 35.73±10.85 years. The majority of the respondents in Plateau (33.7%), Lagos (40.9%) and Ogun (50.0%) were within the age range of 29-39 years with mean ages of 41.83±12.14, 31.65±7.32 and 32.55±9.12, respectively. This implies that the greenhouse farmers in the study area were young, productive and economically active. This could be because of the high technology involved in greenhouse farming which older farmers might not be willing to adopt. This result is in consonance with Udimal *et al.*, 2017 that as farmers advanced in age, their tendencies to adopt new technology decrease as compared to the young farmers. This is related to an increase in risk aversion and a decline in interest in long-term agricultural investment as farmers get older.

4.1.2 Sex

The majority (72.7%) of the respondents across the three states were male compared to just a few (27.3%) of the respondents who were females. The disaggregated data on Table 4.1a revealed that most of the respondents in each state were males with Plateau State having the highest percentage (31.3%) of females involved in farming compared to Lagos (26.9%) and Ogun (20.0%) states. This might be due to the labor-intensive aspect of greenhouse farming which male peers tend to be better at. This corroborates the assertion of Mwangi and Kariuki (2015) that compared to females; males often have better access to technologies and information. The low involvement of women in greenhouse technology may also be due to time spent on housework and child care, as well as inadequate access to input and production resources required for greenhouse technology adoption.

4.1.3 Marital status

Overall, about an average (50.5%) of the respondents were married, while 46.3% were single as present in Table 4.1a. The result revealed that Plateau State recorded the lowest percentage (26.5%) of single population compared to Lagos that recorded the highest percentage (61.3%) and Ogun State with 52.5% of a single population. This revealed that greenhouse farming is profitable since married people who are assumed to be people with higher responsibilities than singles make up the majority of the greenhouse farmers. According to Jain (2017), the majority of the respondents considered for the research study were married, as they were responsible for family welfare and needed to earn a significant amount of money from agriculture to support their families. Tijani *et al.* (2010) also observed that because married individuals have more mouths to feed, they participate in more activities that generate extra money to augment their household income than singles and divorcees.

4.1.4 Religion

The result on religious affiliation across the three states (Table 4.1a) reflected that most (85.2 %) of the greenhouse tomato farmers were Christians and only (14.8%) were Muslims. The disaggregated data also revealed that the majority of the respondents were from each of the three states, namely Plateau (96.4%), Lagos (79.6%) and Ogun states (75.0%). The remaining few respondents in Plateau (3.6%), Lagos (20.4%) and Ogun states (25.0%) were Muslims. This implies that greenhouse farming is an innovation acceptable by both religions. Religion is an important factor that considerably influences people's behaviour, acceptance and norms (Baazeem 2019).

4.1.5 Household size

Results presented in Table 4.1a further revealed that the overall average household size of the respondents was 4.07±2.68 members. The average household size of Plateau, Lagos and Ogun states were 5.25±2.97, 3.45±2.22 and 3.05±2.14, respectively. This result showed that the family size among respondents was not large. The finding is consistent with those of Alabi and Haruna (2015) who found that the projected household size on a national scale is small. The result resonated Bryan *et al*. (2013) conclusion that the effect of household size on the adoption of agricultural technology used is not significant; thus, most of the greenhouse farmers do not have large household sizes.

4.1.6 Education

Overall, the study revealed that the average years of education was 11.43±6.77 across the states, while the years of education for Plateau, Lagos and Ogun states were 12.20±7.09, 10.01±6.38 and 13.10±6.51, respectively as shown in Table 4.1a. This suggests that many of the farmers participating in greenhouse farming have a fairly high level of education (secondary). This could be associated with the nature of greenhouse farming which requires a farmer to be educated in order to read and understand the guidelines for operating GHTs due to its technicality to successfully manage it. The fairly high level of education among the respondents could have positively influenced the adoption of greenhouse technology. The findings corroborate Moges and Taye (2017) that a high degree of education has a favorable impact on the adoption of new technologies.

4.1.7 Years of farming experience

The study revealed the average years of farming experience of respondents across the states to be 9.32±9.86 (Table 4.1a). The years of farming experience of respondents in Plateau, Lagos and Ogun states were revealed to be 13.63±11.65, 6.27±5.97 and 7.48±10.01, respectively. The result also revealed that farmers in Plateau State have more years of farming experience than those in Lagos and Ogun states. The difference in the years of farming experience between farmers in Plateau State and the other two states could be attributed to the fact that most of the farmers in Plateau personally owned the greenhouse structure used. Also, they might have previously been involved in other types of farming activities, while most of the farmers in the other states were farm hired workers. This indicates that the farmers involved in GHTs would have at least gathered ample farming experience over the years from the conventional farming system which could assist them in coping with the use of greenhouse technology. This farming experience, especially vegetable crop production is needed to run a successful greenhouse farm and also make them familiar with the climatic condition and soil requirements necessary in the greenhouse for successful tomato production. This is consistent with Ntshangase *et al.* (2018), who said that experienced farmers are more likely to accept innovations than those with less agricultural experience.

Table 4.1a: Socioeconomic characteristics of respondents in the study area

Personal characteristics	Plateau (F=83)	%	Lagos (F=93)	%	Ogun (F=40)	%	Total (F=216)	%
Age								
18-28	11	13.3	36	38.7	13	32.5	60	27.8
29-39	28	33.7	38	40.9	20	50.0	86	39.8
40-50	24	28.9	19	20.4	6	15.0	49	22.7
51-61	15	18.1	0	0	0	0	15	6.9
62-72	5	6.0	0	0	1	2.5	6	2.8
Mean($\bar{x}$)±SD	41.83±12.14		31.65±7.32		32.55±9.12		35.73±10.85	
Sex								
Male	57	68.7	68	73.1	32	80.0	157	72.7
Female	26	31.3	25	26.9	8	20.0	59	27.3
Marital status								
Single	22	26.5	57	61.3	21	52.5	100	46.3
Married	55	66.3	35	37.6	19	47.5	109	50.5
Widowed	4	4.8	1	1.1	0	0	5	2.3
Divorced	2	2.4	0	0	0	0	2	0.9
Religion								
Christianity	80	96.4	74	79.6	30	75.0	184	85.2
Islam	3	3.6	19	20.4	10	25.0	32	14.8
Household size								
1-3	22	26.5	44	47.3	21	52.5	87	40.3
4-6	38	45.8	44	47.3	18	45.0	100	46.3
7-9	16	19.3	3	3.2	1	2.5	20	9.3
10-12	5	6.0	2	2.2	0	0	7	3.2
13-15	2	2.4	0	0	0	0	2	0.9
Mean($\bar{x}$)±SD	5.25±2.97		3.45±2.22		3.05±2.14		4.07±2.68	
Education								
0-7	23	27.7	38	40.9	9	22.5	70	32.4
8-14	17	20.5	28	30.1	11	27.5	56	25.9
15-21	40	48.2	24	25.8	19	47.5	83	38.4
22-29	3	3.6	3	3.2	1	2.5	7	3.2
Mean($\bar{x}$)±SD	12.20±7.09		10.01±6.38		13.10±6.51		11.43±6.77	
Year of farming experience								
1-10	44	53.0	81	87.1	33	82.5	158	73.1
11-20	20	24.1	9	9.7	4	10.0	33	15.3
21-30	12	14.5	2	2.2	2	5.0	16	7.4
31-40	4	4.8	1	1.1	0	0	5	2.3
> 40	3	3.6	0	0	1	2.5	4	1.9
Mean($\bar{x}$)±SD	13.63±11.65		6.27±5.97		7.48±10.01		9.32±9.86	
Years of greenhouse involvement								
1-3	46	55.4	71	76.3	32	80.0	149	69.0
4-6	23	27.71	18	19.4	7	17.5	48	22.2
7-9	9	0.8	2	2.2	1	2.5	12	5.6
10-13	5	6.0	2	2.2	0	0	7	3.2
Mean ($\bar{x}$)±SD	4.06±2.65		2.42±2.12		2.45±1.54		3.06±2.38	

4.1.8 Years of involvement in greenhouse technology

Overall, the average years of greenhouse involvement is 3.06±2.38 with an average of 4.06±2.65, 2.42±2.12 and 2.45±1.54 for Plateau, Lagos and Ogun states, respectively (Table 4.1a). The relatively small number of years of involvement in greenhouse farming among the respondents indicates that greenhouse technology is a technology that is novel to the farming community in Nigeria. This is because it was previously regarded as a technology for the rich people due to the high cost of the technology. However, presently more farmers are now involved in the use of the technology either as the direct owners of the greenhouse structure, hired workers or by leasing and renting of greenhouse structures for vegetable crop production.

4.1.9 Membership of social organizations

Most (65.7%) of the respondents across the states were not members of any social group as only 34.3% belonged to a social group as presented in Table 4.1b. In Plateau State, close to half (47.0%) of the respondents belonged to social groups while majority of the respondents in Lagos (74.2%) and Ogun (72.5%) were not members of any social group. This trend could affect the quality of information and social networks that would be available to greenhouse farmers on greenhouse technology from fellow group members/associations due to their non-participation in social groups. This finding is in tandem with Mwaura (2014). He opined that belonging to a group as a farmer was very low (16%) in Uganda which implies that group membership does not have a strong influence on technology adoption.

4.1.10 Primary occupation

A majority (75.5%) of respondents across the states had farming as their primary occupation (Table 4.1b). The disaggregated data in each of the states also revealed a similar pattern. The respondents in Lagos (82.8%) and Ogun (75.0%) were mostly involved in farming as their major occupation. This is in line with Akinwalere and Okunlola (2019) that most of the farmers engage in farming as their primary occupation. Though majorities (67.5%) of respondents in Plateau State were involved in farming, it still had the lowest number of farmers among the three states. This is because most of the farmers there are elite farmers, involved in one business or the other but still have a passion for farming. According to a (Key-In-Depth) KII with one of the respondents in Plateau state:

'I am a nurse (a matron), but my passion for farming generally encouraged me to delve into greenhouse farming and I make use of the medium cost greenhouse'. 07-04-2018

4.1.11 Average monthly income from primary occupation

Across the states, almost half (48.2%) of the greenhouse farmers earned an average monthly income ≤ ₦50, 000 from their primary occupation (farming-greenhouse farming) with a mean score of ₦90625.00±87622.20 as presented in Table 4.1b. The disaggregated data revealed that the average monthly income generated by a majority (51.8%) of the respondents in Plateau State was between ₦51,000-150,000 with a mean score of ₦137385.54±115640.62. In Lagos and Ogun states, a majority (65.6 and 62.5%) earned an average monthly income ≤ ₦50, 000 from their primary occupation with a mean score of ₦57,150.54±38865.98 and ₦71425.00±54235.43, respectively. This implies that the average monthly income earned by the majority of the greenhouse farmers whose primary income-generating activity is farming is low compared to the profit generated from the use of GHTs. The difference in the income earned by the greenhouse farmers in Plateau State could be as a result of the personal ownership status of the greenhouse farm used for greenhouse farming and thus, they can benefit more from GHTs in terms of profitability. While the low average monthly income earned by a majority of the greenhouse farmers in Lagos and Ogun states may stem from the fact that they are hired workers and they make do with whatever they can earn from their involvement in the use of GHTs in order to make a living from the technology.

4.1.12. Other income-generating activities

Overall, 48.1% of the respondents had no other income-generating activities apart from farming and 23.1% still have farming as their secondary income-generating activity (Table 4.1b). In Plateau, Lagos and Ogun states, 44.6, 52.7 and 45.0% had no other income-generating activities, respectively. This implies that most of the greenhouse farmers have farming as their source of income. This may be because GHT is time-consuming and distraction as a result of engaging in too many activities might lead to farmers' inability to devote enough time to the management of the greenhouse farm which can negatively affect the yield, productivity as well as income generated from the technology.

Table 4.1b: Socioeconomic characteristics of respondents in the study area

Personal characteristics	Plateau (F=83)	%	Lagos (F=93)	%	Ogun (F=40)	%	Total (F=216)	%
Membership of social organization								
No	44	53.0	69	74.2	29	72.5	142	65.7
Yes	39	47.0	24	25.8	11	27.5	74	34.3
Primary occupation								
Farming	56	67.5	77	82.8	30	75.0	163	75.5
Agro-consultancy	0	0.0	3	3.2	1	2.5	4	1.9
Public servant	21	25.3	4	4.3	8	20.0	33	15.3
Artisans	1	1.2	3	3.2	0	0.0	4	1.9
Trading	3	3.6	2	2.2	1	2.5	6	2.8
Students	2	2.4	4	4.3	0	0.0	6	2.8
Average income from primary occupation (N)								
≤50,000	18	21.7	61	65.6	25	62.5	104	48.2
51,000-150,000	43	51.8	31	33.3	12	30.0	86	39.8
151.000-250,000	14	16.9	1	1.1	3	7.5	18	8.3
251,000-350,000	3	3.6	0	0.0	0	0.0	3	1.4
>350,000	5	6.0	0	0.0	0	0.0	5	2.3
Mean ($\bar{x}$)±SD	137385.54± 115640.62		57150.54± 38865.98		71425.00± 54235.43		90625.00± 87622.20	
Other income-generating activities								
None	37	44.6	49	52.7	18	4	104	48.1
Farming	16	19.3	24	25.8	9	5.0	50	23.1
Trading/Business	16	19.3	6	6.5	5	22.5	26	12
Artisans	5	6.0	6	6.5	2	12.5	13	6.0
Greenhouse consultancy	5	6.0	4	4.3	6	5.0 15	15	6.9
Civil servant	4	4.8	4	4.3	0	0.0	8	3.7

Source: Field survey (2018)

4.2 Farm Enterprise characteristics

4.2.1 Greenhouse farm size

Overall, about half (45.8%) of the farmers have a greenhouse farm size of between 1 and 3 acres and some (40.7%) have a greenhouse farm size of less than 1 acre (Table 4.2a). The disaggregated data revealed similar results in Lagos and Ogun states with most of the farmers in Lagos (61.3%) and Ogun (50.0%) having greenhouse farm sizes of between 1 and 3 acres and some having less than 1 acre (Lagos 26.9 and Ogun 27.5%), while most (62.7%) of the farmers in Plateau State have greenhouse farm size of less than 1 acre and only 26.5% has greenhouse farm sizes of between 1 and 3 acres. This result confirms the assertion of one of the benefits of GH technology that it affords a farmer to continually make use of a small area of land for greenhouse farming as it helps in land conservation and still yields much more than on the open field. This is in accordance with Baudoin *et al.* (2017) that GHTs ensures more yield from the same area of land, conserves resources as well as aid in the enhancement of natural capital and the flow of ecosystem services.

4.2.2 Number of greenhouse structures used for tomato production

Overall, about 33.3% of the greenhouse farmers have only one greenhouse structure being used for cultivating vegetable crops (tomato especially) as presented in Table 4.2a. The disaggregated data revealed that most (42.2%) of the farmers in Plateau State made use of only one greenhouse structure, while most (24.7 and 35.0%) of the farmers in Lagos and Ogun states made use of more than six greenhouse structures, respectively. This may be because most of the farmers in Plateau State cultivate at the subsistence level using different types of greenhouse structures with most of them using low and medium cost greenhouses. Conversely, most of the farms in Lagos and Ogun states were operating on a relatively larger scale with the aim of meeting market target as most of them are wholesalers.

4.2.3 Type of greenhouse structure used

Overall, almost half (48.1%) of the greenhouse structure farmers made use are of the imported type; while 38.9 and 13.0% made use of the medium and low cost greenhouses, respectively. This implied that the imported type of greenhouse structure is most popularly in use among the greenhouse farmers across the three states. The disaggregated data across the states revealed that most (53.0%) of the farmers in Plateau State use the medium cost type of greenhouse structure while most (60.2 and 72.5%) of the greenhouse farmers in Lagos and Ogun states, respectively uses the imported type of greenhouse structure for their tomato cultivation. This indicated that most of the farmers in Plateau states prefer the medium-cost greenhouse structure to the High-cost greenhouses as against the other two states. This may be because of the high initial cost of the imported greenhouse structure. This is consistent with the findings of Gruda and Tanny (2015), which discovered that while high-tech greenhouses produce high yields but have high initial costs. Locally fabricated greenhouse structures are a low-cost suitable alternative for high-tech greenhouses for greenhouse farmers with limited capital or who live in regions with fluctuating vegetable crop demand.

4.2.4 Greenhouse ownership status

Results presented in Table 4.2a revealed that in the three states, most (52.8%) of the greenhouse farmers' work as 'hired workers' in greenhouses owned by private individuals who are either 'not involved' or 'partially involved' with the use of the greenhouse technology. Also, 27.8% of the respondents 'personally owned' the greenhouse structures they were using. About 18.9% of the greenhouses used for carrying out tomato cultivation in the study area were owned by the government of the selected states and 0.5% were leased by a private individual.

The disaggregated data revealed that most (57.8%) of the greenhouse farmers in Plateau State 'personally owned' the greenhouse structure used, while 25.3% are hired workers. Almost 16.0% of the respondents use government leased greenhouses. The high proportion of 'personally owned' greenhouse ownership status among Plateau State respondents is due to the use of various low-cost and medium-cost greenhouse structures ranging from bamboo greenhouses to net houses. Majority of greenhouse farmers produce at the subsistence level for both personal consumption and sales.

In Lagos and Ogun states, 73.1 and 62.5%, respectively were greenhouse farmers who were hired workers. Also, 21.5 and 20.0% of the respondents from Lagos and Ogun states, respectively, made use of state government leased greenhouses, while only 5.4 and 17.5%, respectively personally owned the greenhouses used for tomato cultivation. This is because most of the greenhouses in Lagos and Ogun states were strictly for commercial purposes to get more profits; hence they made use of farm-hired workers to boost the yield and profit from the use of the greenhouse structures. This is similar to the findings of DeFacio *et al.* (2002) that having higher yield and profitability are the key concern of greenhouse owners.

4.2.5 Year of first use of GHT

According to Table 4.2a, almost half (46.3%) of the respondents in the three states got involved with the use of GHT for the first time between the years 2016 and 2018. This confirms that most greenhouse farmers have been recently engaged in the use of greenhouse technology. About 38.0% started using GHT between the years 2013 and 2015; 12.0% between the years 2010 and 2012; 2.8% between years 2007 and 2009, while only 0.9% of the respondents started using GHT before the year 2006. Disaggregating the result across the three states, the trend seems similar as about 38.6% of the respondents in Plateau State, 49.5% in Lagos State and 55.0% in Ogun State used GHT for the first time between the year 2016 and 2018. About 37.3%, 37.6 and 40.0% of the respondents in Plateau, Lagos and Ogun states used GHT for the first time within the years 2013 and 2015; whereas respondents in Plateau State (16.9%), Lagos State (11.8%) and 2.5% in Ogun State used GHT for the first time within year 2010 and 2012. Within years 2007 and 2009, about 4.8% in Plateau State, 1.1% in Lagos State and 2.5% in Ogun State used GHT for the first time, while only 2.4% in Plateau State used GHT for the first time before the year 2006. The result further implies that as the year progresses, more farmers are inclined to go into greenhouse technology. This is in agreement with the findings of Justus and Yu (2014), which discovered a recent and general trend toward more and larger horticultural greenhouse producers.

4.2.6 Discontinuity and Period of discontinuity of GHT (in years)

Presentation in Table 4.2a also revealed that few (13.9%) of the respondents' discontinued the use of greenhouse technology across the three states. About 8.3, 4.2 and 1.4% of the respondents in Plateau, Lagos and Ogun states skipped the use of GHT for only 1, 2 and more than 3 years, respectively. Most (86.1%) of the greenhouse farmers never discontinued the use of the technology despite the numerous constraints they might have faced in the use of the technology. Disaggregating the result across each state, few (8.5, 7.2 and 3.6%) of the respondents in Plateau State discontinued the use of GHT for 1, 2 and more than 3 years, respectively. Very few (9.7, 1.1 and 0.0%) of the respondents discontinued the use of GHT for 1, 2 and more than 3 years, respectively in Lagos State; while only 5.0, 5.0 and 0.0% of the respondents discontinued the use of GHT for 1, 2 and more than 3 years, respectively in Ogun State. This suggests that only a small number of respondents have stopped using GHTs since greenhouse technology is a viable source of income. This is evident from the findings of this study since the majority of greenhouse farmers are still actively involved in the usage of the technology, either because of its profitability or as a means of subsistence.

4.2.7 Planting methods

The study revealed on Table 4.2b that about half (49.1%) of the respondents in the three states raise tomato seedlings in the nursery and later transplant it on greenhouse floor beds/ridges. About 40.7% of the respondents raised tomato seedlings in the nursery and later transplant it into pots/bags, while 10.2% of them plant their tomatoes directly on the greenhouse beds. This implied that across the three states, the greenhouse farmers prefer transplanting tomato seedlings into the greenhouse floor as well as into pots/bags than planting it directly into the greenhouse soil without undergoing the nursery phase.

Disaggregating the results across the three states, most of the respondents in Plateau and Ogun states, respectively prefer to transplant tomato seedlings into pots/bags (47.0 and 55.0%); (43.4 and 42.5%) prefer to transplant tomato seedlings into beds constructed on the greenhouse floor; while only (9.6 and 2.5%) of the respondents prefer planting tomatoes directly on the greenhouse beds without it going through the nursery phase.

In Lagos State, most (57.0%) of the respondents transplant tomato seedlings on beds constructed on the greenhouse floor; 29.0% transplant tomato seedlings into pots/bags; while only 14.0% of the respondents plant their tomatoes directly on the greenhouse beds without it going through the nursery phase. Results showed that the majority of greenhouse farmers in Plateau and Ogun states prefer to raise tomato seedlings in the nursery before transplanting them into pots/bags rather than transplanting them into the greenhouse floor, but the opposite is true in Lagos State.

Table 4.2a: Farm Enterprise characteristics

Farm enterprise	Plateau (F=83)	%	Lagos (F=93)	%	Ogun (F=40)	%	Total (F=216)	%
Greenhouse farm size (acres)								
< 1.0	52	62.7	25	26.9	11	27.5	88	40.7
1.0 - 3.0	22	26.5	57	61.3	20	50.0	99	45.8
3.1 –5.0	2	2.4	6	6.5	3	7.5	11	5.1
5.1 – 7.0	5	6.0	2	2.2	1	2.5	8	3.8
> 7	2	2.4	3	3.3	5	12.5	10	4.6
Mean±SD	1.37±2.40		2.36±5.32		2.57±3.26		2.02±4.06	
Number of greenhouses used on the farm								
1	35	42.2	24	25.8	13	32.5	72	33.3
2	22	26.5	13	14.0	6	15.0	41	19.0
3	15	18.1	12	12.9	3	7.5	30	13.9
4	5	6.0	6	6.5	2	5.0	13	6.0
5	4	4.8	13	14.0	1	2.5	18	8.3
6	1	1.2	2	2.2	1	2.5	4	1.9
> 6	1	1.2	23	24.7	14	35.0	38	17.6
Type of greenhouse structure used								
Low cost greenhouses	19	22.9	6	6.5	3	7.5	28	13.0
Medium cost greenhouses	45	54.2	31	33.3	9	22.5	85	39.3
High cost greenhouses	19	22.9	56	60.2	28	70.0	103	47.7
Greenhouse ownership status								
Personally acquired	48	57.8	5	5.4	7	17.5	60	27.8
Hired workers	21	25.3	68	73.1	25	62.5	114	52.8
Government leased/rent	13	15.7	20	21.5	8	20.0	41	18.9
Individual leased	1	1.2	0	0.0	0	0.0	1	0.5
Research institute	0	0.0	0	0.0	0	0.0	0	0.0
Year of first use of GHT								
<2006	2	2.4	0	0.0	0.0	0.0	2	0.9
2007- 2009	4	4.8	1	1.1	1	2.5	6	2.8
2010- 2012	14	16.9	11	11.8	1	2.5	26	12.0
2013- 2015	31	37.3	35	37.6	16	40.0	82	38.0
2016- 2018	32	38.6	46	49.5	22	55.0	100	46.3
Discontinuity of GHT	16	19.3	10	10.8	4	10.0	30	13.9
Yes	67	80.7	83	89.2	36	90.0	186	86.1
No								
Period of discontinuity (years)								
None	67	80.7	83	89.2	36	90.0	186	86.1
1	7	8.5	9	9.7	2	5.0	18	8.3
2	6	7.2	1	1.1	2	5.0	9	4.2
≥3	3	3.6	0	0.0	0	0.0	3	1.4

Source: Field survey (2018)

4.2.8 Frequency of planting

Results in Table 4.2b showed that across the three selected states, most (75.4%) of the respondents cultivated tomatoes in the greenhouses twice a year, while 20.4% of the respondents cultivated tomatoes in the greenhouses thrice in a year. Only a few (3.7 and 0.5%) of the respondents cultivated tomatoes in the greenhouses once and more than thrice in a year, respectively. This agrees with Mani *et al.* (2018) that tomato harvesting is carried out twice a year in Kaduna State.

Disaggregating the data across the three states, the results seemed similar as most (63.9%, 80.6 and 87.5%) of the respondents cultivated tomatoes in the greenhouses twice in a year; (27.7, 19.4, and 7.5%) cultivated tomatoes three times a year; while (7.2, 0.0 and 5.0%) cultivated the crop once a year in Plateau, Lagos and Ogun states, respectively. Only 1.2% cultivated tomatoes more than thrice a year in Plateau State. This implies that most of the respondents cultivate tomatoes twice in a year and can harvest for almost six months before transplanting the second cycle into a freshly prepared bed or pots/bags. This result is supported by the key-informant-interview (KII) with a Dizengoff Agronomist attached to a greenhouse in Lagos State:

'The moment the yield derived from the tomato starts dropping, we start planting new sets of tomatoes. Also, when the size of the tomato harvested is no longer suitable for the market size, we either uproot the stems if planted on the greenhouse floor or add fresh soil mixed with substrates on the beds. We could also bring in new bags/pots for transplanting new crops while the old soil is used to cultivate other crops or allowed to rest and then re-fried again for another cycle of production'. 03-05-2018

This result contradicts the findings of van Os *et al.* (2012) that cultivating tomatoes in one long cycle is better than cultivating it twice in a year. This lowers the total yield that would have been obtainable due to break in the production process as well as lead to increased cost of production on planting materials and labour.

4.2.9 Tomato Price during the off-season in the greenhouse

The result in Table 4.2b revealed that overall, about (39.4%) of the respondents sold their tomato between ₦ 601 and 800/kg; 27.3% sold at between ₦401 and 600/kg; 19.4% sold at between ₦801 and 1000. About 7.4, 5.1 and 1.4% of the respondents sold tomatoes at about ₦400/kg, greater than ₦1200/kg and between ₦1001 and 1200/kg, respectively during the off-season. This implies that cultivating tomatoes in the greenhouse pays off during its off-season than in the open field. This is due to the additional price attached as a result of the scarcity and inflation in the cost of tomatoes in the market. According to Walker and Joukhadar (2017), tomatoes are grown in the greenhouses during the off-season to benefit from the additional price to be derived from it during this period. Liu and Nyalala (2017) reported that the price of greenhouse tomato in the market could be as much as Kenyan Shillings (Ksh.) 150 to Ksh. 250 per kilogram (Kg) which is an equivalent of (1.50 to 2.47 USD and ₦540.00 to ₦890.00) per Kg. Yadav *et al.* (2015) also concluded that the cultivation of high-value off-season vegetable crops like tomatoes under greenhouse structure was economical and profitable to the farmers. This is because it aids in enhancing productivity and ensuring their profitability by fetching a better price in the market.

The results of the across the three states further showed that almost half (49.4%) of the respondents in Plateau State sold their tomatoes from ₦401-600/kg and 25.3% sold at ₦ 601-800/kg. About 18.1% of the respondents sold at about ₦400/kg; while only 7.2% sold at ₦801-1000/kg. In Lagos states, 40.9% of the respondents sold at ₦601-800/kg; 33.3% sold at ₦801-1000/kg and 12.9% sold their tomatoes at ₦401-600/kg. Only 10.7% sold their tomatoes greater than ₦1200/kg, while 1.1% sold their tomatoes at 1001-1200/kg and about ₦400/kg, respectively. In Ogun State, most (65.0%) of the respondents sold their tomatoes ₦601 and 800/kg; 15.0% sold at ₦401-600/kg and 12.5% sold at ₦801-1000/kg. Only 5.0 and 2.5% sold their tomatoes at ₦1001-1200/kg and greater than ₦1200/kg, respectively. This implies that most of the respondents in Lagos and Ogun states took advantage of the off-season production to make more money from tomato production than those from Plateau State. This is consistent with Cook (2005) findings that, because tomato availability fluctuates with time and place, most marketers choose to extend their growing seasons to periods of lower output and higher pricing.

4.2.10 Tomato Price during on season in the greenhouse

The result in Table 4.2b revealed that overall, about half (48.6%) of the respondents sold their tomato between ₦201 and 400/kg and 30.6% sold between ₦401 and 600/kg. A few

(9.7%) sold at about ₦200/kg; 8.3% sold at ₦601-800/kg; while 2.8% sold at ₦801-1000/kg during the on-season. Comparing the price generated during the off-season to what is obtainable during the on-season, it was observed that producing tomato during the on-season is not so economical; therefore, most greenhouse farmers diversify to other high-value crops like cucumber, green pepper and habanero pepper. This is further affirmed by a KII with one of the greenhouse farm managers in Lagos State:

'During the time of tomato glut in the market, most customers purchase tomatoes from the open market, therefore, we diversify to other crops that are in the off-season in the market such as green pepper, habanero pepper and cucumber. We cultivate only a little quantity of tomatoes during this period in order not to disappoint and to keep our other customers with a preference for greenhouse tomatoes. During this period, the bulk of our production is on other high-value vegetable crops that are in their off-season.' 03-05-2018

Disaggregating the data across the different states, most (65.1%) respondents in Plateau State sold tomatoes between ₦201 and 400/kg; 18.1% sold at about ₦200/kg; while 16.8% sold at about ₦401-600/kg. In Lagos State, 38.7% of the respondents sold tomatoes at ₦201-400/kg; 34.4% sold at₦401-600/kg and 18.3% sold ₦800/kg. Only 5.4 and 3.2% of the Lagos State respondents sold their tomatoes at ₦801-1000/kg and about ₦200/kg, respectively. In Ogun State, half (50.0%) of the respondents sold their tomatoes between ₦401 and 600/kg and 37.5% sold at ₦201-400/kg. Only a few (7.5%) of the respondents sold tomatoes at about ₦200/kg; while 2.5% sold their tomatoes at ₦601-800/kg and ₦801-1000/kg, respectively. This implies that producing tomatoes during the on-season of tomatoes in the open market is not economical if a farmer wants to break even. This is due to the fact that most of the respondents from Ogun State alone could only make a little more money from the sales of tomatoes cultivated during the on-season of tomatoes in the open market than the respondents from Lagos and Plateau states. According to Cook (2005), while greenhouse tomatoes may be produced anywhere at any time of year, concerns of economics still force seasonality and as a result, most greenhouse farmers cultivate and sold tomatoes when it will bring them the greatest profit.

4.2.11 Average Yield of tomatoes cultivated in the greenhouse/plant stand (kg)

The yield derived from the cultivation of tomatoes depended on many factors such as the variety of tomatoes planted, management practices, soil fertility, weather, disease infestation, irrigation amongst others. According to Table 4.2b, about 61.1% of the respondents recorded an average yield of 4 and 8kg per plant stand and 20.8% had an average yield of between 8.1 and 12 kg per plant stand. About 9.7% had an average yield of less than 4 kg and 5.6% had an average yield of 12.1-16 kg. Only a few (1.9 and 0.9%) of the respondents had an average yield of 16.1-20 kg and greater than 20 kg, respectively. This is in line with the findings of Liu and Nyalala (2017) that the yield from one tomato plant stand can be up to 16-20 kilograms. van Os *et al.* (2012) confirmed that the tomato yield obtained in the greenhouse is higher because of the extended season for its cultivation and the controlled climatic environment.

Yadav *et al.* (2015) also reported that the yield of tomatoes grown inside the greenhouse is more than 4 to 5 times the yield realized in the open field. According to the NewsHerald (2016), the Dizengoff farmers' kit (DFK) produces a yield of up to 4 tonnes of tomatoes in a 6-month season from a single (8m x 24m or 192m^2) greenhouse, whereas traditional open-field tomato cultivation, using the best agricultural practices can only give yields of a maximum of 7 tonnes per hectare (10,000m^2). This implies that when DFK is replicated over one hectare, it gives a yield which is 19 times more than is expected from the open field. Greenhouse farming, according to Plethora Farms (2016), helps to extend the tomato growing season by allowing harvests to last up to eight months as opposed to one month in open fields.

Disaggregating the data across the different states, the result looks similar as most (68.7%, 57.0 and 55.0%) of the respondents in Plateau, Lagos and Ogun states respectively recorded an average yield of 4-8 kg per plant stand. About (22.9, 18.3 and 22.5%) of the respondents had an average yield of 8.1-12 kg per plant stand and (3.6, 16.1 and 7.5%) recorded an average yield of less than 4 kg per plant stand in Plateau, Lagos and Ogun states, respectively. Only (3.6, 8.6 and 2.5%) had an average yield of 12.1-16 kg per plant stand, while very few (1.2, 0.0 and 7.5%) %) of the respondents recorded an average yield of 16.1-20 kg per plant stand in Plateau, Lagos and Ogun states, respectively. About 5.0% of the respondents in Ogun State had an average yield of more than 20 kg per plant stand. This implies that producing tomatoes using greenhouses is economical due to the abundant yield generated from its use.

Table 4.2b: Farm Enterprise characteristics contd.

Farm enterprise	Plateau(F=83)	%	Lagos (F=93)	%	Ogun (F=40)	%	Total (F=216)	%
Planting methods								
Directly in the greenhouse unit	8	9.6	13	14.0	1	2.5	22	10.2
In the nursery and later into pot/bags	39	47.0	27	29.0	22	55.0	88	40.7
In the nursery and later on the greenhouse floor	36	43.4	53	57.0	17	42.5	106	49.1
Frequency of planting								
Once	6	7.2	0	0.0	2	5.0	8	3.7
Twice	53	63.9	75	80.6	35	87.5	163	75.4
Thrice	23	27.7	18	19.4	3	7.5	44	20.4
> Thrice	1	1.2	0	0.0	0	0.0	1	0.5
Price off-season (N)								
≤400	15	18.1	1	1.1	0	0.0	16	7.4
401-600	41	49.4	12	12.9	6	15.0	59	27.3
601-800	21	25.3	38	40.9	26	65.0	85	39.4
801-1000	6	7.2	31	33.3	5	12.5	42	19.4
1001-1200	0	0.0	1	1.1	2	5.0	3	1.4
>1200	0	0.0	10	10.7	1	2.5	11	5.1
Mean±SD	608.43±152.38		894.62±332.93		791.25±164.04		765.51±279.33	
Price on season (N)								
≤200	15	18.1	3	3.2	3	7.5	21	9.7
201-400	54	65.1	36	38.7	15	37.5	105	48.6
401-600	14	16.8	32	34.4	20	50.0	66	30.6
601-800	0	0.0	17	18.3	1	2.5	18	8.3
801-1000	0	0.0	5	5.4	1	2.5	6	2.8
Mean±SD	360.84±109.06		500.00±196.99		446.25±137.46		436.57±168.94	
Average Yield/plant stand (kg)								
<4								
4-8	3	3.6	15	16.1	3	7.5	21	9.7
8.1-12	57	68.7	53	57.0	22	55.0	132	61.1
12.1-16	19	22.9	17	18.3	9	22.5	45	20.8
16.1-20	3	3.6	8	8.6	1	2.5	12	5.6
>20	1	1.2	0	0.0	3	7.5	4	1.9
Mean±SD	0	0.0	0	0.0	2	5.0	2	0.9
	7.29±3.12		6.35±3.69		9.75±6.16		7.34±4.23	

Source: Field survey (2018)

Based on the following analysis of the yield that can be generated per hectare if all good agronomic practices (GAP) are complied with as given by the President of the Greenhouse Farmers Association of Nigeria:

If planting bags are used for planting tomatoes in the greenhouse, there could be up to six (6) planting bags per square meter, while if planting on the ground/greenhouse beds, there could be up to four (4) plants per square meter.

1 hectare= 10,000m^2

If using bags, 6*10,000m^2=60,000 plants

If planting directly, 4*10,000m^2=40,000 plants

If assuming 10% plant mortality rate and each plant gives an average of 4 kg and the selling price is ₦400 per kg

Then,

For bags, 54,000 plant stands*4*400= ₦86, 400,000 per cycle

For direct planting, 36,000 plant stands*4*400= ₦57, 600,000 per cycle

According to him, the cost of production should not be more than 35% per cycle.

Hence if using bags, ₦86, 400,000* 0.35=N30, 240,000

If planting directly, ₦57, 600,000* 0.35=N20, 160,000

Therefore, a farmer can earn a profit that is up to ₦56, 160,000/cycle when cultivating tomatoes using bags and ₦37, 440,000/cycle when planting tomatoes directly on the greenhouse floor.

This result is in consonance with the findings of Liu and Nyalala (2017) that the income from the tomato yield derived per square meter within the greenhouse in 2017 may be as much as Kenyan shillings (Ksh.) 3,000 which is equivalent to (30 USD and ₦10,800.00). Also, an average income of about Ksh. 400,000 (3950 USD and ₦1,422,000.00) can be earned per harvest. Therefore, the high profit derived from greenhouse tomato production could enable the greenhouse owners to be able to pay on time the initial capital invested in purchasing the greenhouse structure

4.2.12 Source of planting materials/inputs for greenhouse tomato production

According to Table 4.2c, more than half (55.1%) of the total respondents purchased planting materials from agro-dealers, while 22.7% made use of planting materials from direct importation, greenhouse kit provider (20.4%), research institutes (7.4%), previous harvest (6.0%) and government agencies (3.2%). This implies that the agro-dealers were the major suppliers of planting materials across the three states.

The result of the disaggregated data showed that most (57.8%) of the respondents in Plateau State, as well as in Lagos (51.6%) and Ogun (57.5%) states purchased their planting materials from agro-dealers. Also, about 30.1% of the respondents in Plateau State purchased their planting materials from direct importation, 13.3% from greenhouse kit providers and previous harvest, respectively. Few (4.8 and 2.4%) of the respondents purchased their planting materials from government agencies and research institutes, respectively in Plateau State.

In Lagos and Ogun states, 21.5 and 32.5% of the respondents, respectively purchased their planting materials from greenhouse kit providers, while only 19.4% in Lagos State and 15.0% in Ogun State purchased theirs from direct importation. Also, about 11.8% of the respondent in Lagos State and 7.5% in Ogun State purchased their planting materials from research institutes; while only 2.2% from Lagos State and 2.5% in Ogun State purchased planting materials from research institutes. Very few (3.2%) of the respondents in Lagos State purchased planting materials from government agencies. This agrees with Nonga *et al.* (2011) that agro-dealers/agrochemical shop owners are the primary supplier of planting materials in the farming areas, as they provide information on the type of chemicals to use; application method and the precautions of chemical usage.

Table 4.2c: Sources of planting materials/inputs for greenhouse tomato production

Sources of planting materials/inputs (Yes Answer only)	Plateau (Freq)	%	Lagos (Freq)	%	Ogun (Freq)	%	Total (Freq)	%
Previous harvest	10	12.0	2	2.2	1	2.5	13	6.0
Research institutes	2	2.4	11	11.8	3	7.5	16	7.4
Agro-dealers	48	57.8	48	51.6	23	57.5	119	55.1
Greenhouse kit provider	11	13.3	20	21.5	13	32.5	44	20.4
Government agencies	4	4.8	3	3.2	0	0.0	7	3.2
Direct importation	25	30.1	18	19.4	6	15.0	49	22.7

Source: Field survey (2018)

4.2.13 Type of labour used for greenhouse tomato farming

Labour is an important factor of production in all agricultural enterprises of which greenhouse farming is not exempted due to the high level of management practices carried out to ensure the profitability of greenhouse tomato production. The overall result in Table 4.2d showed that most (79.6%) of greenhouse tomato farmers made use of hired labour for their farm work. The result further revealed that 21.3, 7.4 and 5.1% engage in self labour, family labour and cooperative labour, respectively.

The disaggregated data revealed a similar result as most (72.3%) of the respondents in Plateau State, 82.8% in Lagos State and 87.5% in Ogun State made use of hired labour for their farm work. Some (31.3%) of the respondents in Plateau State, in Lagos State (14.0%) and Ogun State (17.5%) made use of self labour in combination with other sources of labour. A few (16.9%) of the greenhouse farmers in Plateau State engaged in the use of family labour, while very little (1.1 and 2.5%) of the respondents in Lagos and Ogun states, respectively used family labour due to the scale of greenhouse tomato production in the states, in order to meet market demand and target. Also, very few of the respondents in Plateau State (4.8%), Lagos State (5.4%) and Ogun State (5.0%) depended on cooperative labour for greenhouse tomato production. This indicates that the vast majority of greenhouse farmers employ hired labor to carry out the tasks associated with the greenhouse farm.

The implication of the use of hired labour in the greenhouse tomato production is that more care, time, energy and attention are required than other greenhouse vegetable crops. According to Laate (2013), cucumbers and peppers need 19 and 32% less labor, respectively, than tomatoes, because tomatoes require greater attention from hired employees throughout the season.

Table 4.2d: Type of labour used for greenhouse tomato farming

Type of labour (Yes Answer only)	Plateau (Freq)	%	Lagos (Freq)	%	Ogun (Freq)	%	Total (Freq)	%
Family labour	14	16.9	1	1.1	1	2.5	**16**	**7.4**
Cooperative labour	4	4.8	5	5.4	2	5.0	**11**	**5.1**
Self labour	26	31.3	13	14.0	7	17.5	**46**	**21.3**
Hired labour	60	72.3	77	82.8	35	87.5	**172**	**79.6**

Source: Field survey (2018) Multiple responses

4.2.14 Types of Crops Cultivated in the Greenhouse

Overall, the most commonly cultivated crop in the greenhouse is tomato (100%). This is because tomato is the most widely grown greenhouse crop due to its competitive and comparative advantages (Omoro *et al*., 2014). According to van Os *et al.* (2012), tomato is the most important greenhouse crop, while FAO (2017) indicated that the area used for tomato cultivation is twice more than that used for any other protected vegetable crops. This is because tomatoes are the most common vegetables grown in greenhouses followed by cucumbers (Walker and Joukhadar, 2017). Some other important and high-value horticultural crops were also cultivated by the respondents in the greenhouse alongside tomatoes or during the peak period of open-field tomato production. They include: green pepper (47.7%), cucumber (43.1%), red pepper/Habanero (41.2%), yellow pepper (29.2%) and different leafy vegetables (24.5%). Crops such as carrots (11.6%), cabbage (11.1%) as well as some other high-value horticultural crops were also cultivated in minute quantities by the greenhouse farmers.

The Disaggregated result revealed that tomatoes (100%), green pepper (44.6, 48.6 and 52.5%) and cucumber (50.6, 32.3 and 52.5%) were being cultivated by all the greenhouse farmers in Plateau, Lagos and Ogun states, respectively. Crops such as yellow pepper (32.5, 22.6 and 37.5%), red pepper (43.4, 38.7 and 42.5%) and leafy vegetable (26.5, 21.5 and 27.5%) were also cultivated by all the greenhouse farmers in Plateau, Lagos and Ogun states, respectively. The cultivation of tomatoes by all the greenhouse farmers across the three states proved that tomato is an economically viable crop to be cultivated in the greenhouse. This result contradicts the findings of Murthy *et al.,* (2009) that production of tomatoes in a polyhouse was not economically feasible as it takes the farmers up to eleven years of continuous tomato cultivation to breakeven. Although in Plateau State, different types of vegetable crops such as Kale, Broccoli, Iceberg-lettuce and roses which cannot be cultivated elsewhere abound.

Table 4.2e: Types of Crops Cultivated in Greenhouse

Types of crops cultivated	Plateau		Lagos		Ogun		Total	
	(Freq)	**%**	**(Freq)**	**%**	**(Freq)**	**%**	**(Freq)**	**%**
Tomato	83	100	93	100	40	100	216	100
Green pepper	37	44.6	45	48.6	21	52.5	103	47.7
Leafy vegetables	22	26.5	20	21.5	11	27.5	53	24.5
Cucumber	42	50.6	30	32.3	21	52.5	93	43.1
Yellow pepper	27	32.5	21	22.6	15	37.5	63	29.2
Red pepper	36	43.4	36	38.7	17	42.5	89	41.2
Carrots	8	9.6	15	16.1	2	5.0	25	11.6
Watermelon	4	4.8	13	14.0	2	5.0	19	8.8
Cabbage	14	16.9	6	5.5	4	10.0	24	11.1
Onions	2	2.4	3	3.2	2	5.0	7	3.2
Strawberry	3	3.6	2	2.2	1	2.5	6	2.8
Flowers	8	9.6	3	3.2	0	0.0	11	5.1
Spices	7	8.4	3	3.2	1	2.5	11	5.1
Broccoli	4	4.8	3	3.2	0	0.0	7	3.2
Eggplant	2	2.4	5	5.4	2	5.0	10	4.6
Iceberg lettuce	1	1.2	0	0.0	0	0.0	1	0.5
Kale	4	4.8	3	3.2	0	0.0	7	3.2

Source: Field survey (2018)

4.2.15 Sales point for greenhouse tomatoes

Results on Table 4.2f showed that most (50.9%) of the greenhouse farmers sold their tomatoes to supermarkets. According to one of the greenhouse farm managers at the Garden of Eden farm (Epe, Lagos):

"*We cultivate tomatoes to meet the market demands and sometimes cannot even satisfy the high demands for the greenhouse tomatoes and as such, have to source for more tomatoes to supply our customers from other reputable greenhouse farms in order not to disappoint our customers (especially supermarkets)." 05-05-2018*

Other places the greenhouse tomatoes are being sold include private individuals (41.7%); farm gate (24.5%); local markets (19.4%) and hotels (14.4%). Other places where greenhouse tomatoes are seldom sold are: to the international market (2.8%), through the middlemen (2.3%) and to processing industries (0.9%).

Disaggregating the result into states revealed that most (53.0%) of the farmers in Plateau State sold greenhouse tomatoes to private individuals; at the farm gate (39.8%), supermarket (20.5%), hotels (14.5%), local markets (10.8%) and to middlemen (6.0%), respectively. The majority of the farmers in Lagos and Ogun states supplied greenhouse tomatoes to supermarkets (71.0 and 67.5%), private individuals (25.8 and 55.0%) and local markets (22.6 and 30.0%). Also, about (11.8 and 22.5%) of the respondents supplied greenhouse tomatoes to the farm gate, (16.4 and 10.0%) to hotels and (2.2 and 10.0%) to international markets in Lagos and Ogun states, respectively. Only a few (2.2%) of the respondents in Lagos State sell to the processing industries. The result affirms the fact that respondents in Lagos and Ogun states produce on a commercial scale with the aim of profiting by selling to wholesalers such as supermarkets who in turn sell to others (DeFacio *et al*., 2002).

Table 4.2f: Sales point for greenhouse tomatoes

Sales point	Plateau	%	Lagos	%	Ogun	%	Total	%
Local market	9	10.8	21	22.6	12	30.0	42	19.4
Private individuals	44	53.0	24	25.8	22	55.0	90	41.7
Supermarkets	17	20.5	66	71.0	27	67.5	110	50.9
Hotels	12	14.5	15	16.1	4	10.0	31	14.4
International markets	0	0.0	2	2.2	4	10.0	6	2.8
Processing industries	0	0.0	2	2.2	0	0.0	2	0.9
Farm gate	33	39.8	11	11.8	9	22.5	53	24.5
Middlemen	5	6.0	0	0.0	0	0.0	5	2.3

Source: Field survey (2018) Multiple responses

4.3 Respondents Sources of Information on GHTs

The source of information about new technology is critical when determining technology adoption. It provides farmers with awareness as well as relevant information needed in the effective and efficient use of the technology. Hence, the result in Table 4.3 revealed that overall; fellow farmers ranked first ($\bar{x}$ =1.27) as the main source of information on GHTs, followed by greenhouse service providers ($\bar{x}$ =1.26) and the Internet ($\bar{x}$ =1.10). This implies that the greenhouse farmers have access to information from various sources. This is in consonance with Mittal and Mehar (2016) that farmers access information from various sources that complement or substitute one another, as sourcing for information from just one source cannot satisfy the information needs of the farmer. This result is also in agreement with Dhola and Thumar (2012) that majority of greenhouse farmers' source information on greenhouse technology from other farmers. Adio *et al.* (2016) ranked fellow farmers as an important source of agricultural information. Komolafe *et al.* (2014) also found that fellow farmers serve as the second source of information on improved crop practices among women farmers after extension agents.

The disaggregated data across the states revealed that in Plateau and Lagos states, fellow farmers ($\bar{x}$ =1.24 and $\bar{x}$ =1.32), respectively were the major source of information, while in Ogun State; farmers mostly got their information from greenhouse service providers ($\bar{x}$ =1.38). The utilization of greenhouse service providers by most of the respondents in Ogun State can be justified by DeFacio *et al.* (2002), that 'greenhouse operators should have a regular contact with a greenhouse service provider in order to be updated with relevant information on greenhouse technology.'

This result justifies the use of the snowball technique to generate the list of the unregistered farmers in the states. This is because as the registered greenhouse farmers provided referrals to the other greenhouse farmers who though not registered, but have replicated the use of GHT based on the results seen from fellow farmers and what were derived from using the technology. Based on the interview schedule conducted with some of GHT farmers in Plateau State, this was the response:

'We derive r*elevant information on the sources of inputs, labour and disease control for the greenhouse from our fellow farmers.' 07-04-2018*

Generally in the three states, handbills ($\bar{x}$=0.37), newspaper ($\bar{x}$=0.41) and radio ($\bar{x}$=0.45) ranked as the least sources of information on GHT for the respondents in the study area. The disaggregated data however revealed that in Lagos State, radio ($\bar{x}$0.51) ranked the least source of information; while in Plateau ($\bar{x}$=0.27) and Ogun ($\bar{x}$ =0.17), handbills ranked the least source of information. This suggests that farmers may not have access to the 'full/all the contents of the GHT package' since a majority of the information is obtained from fellow greenhouse farmers and information loss or addition might be transferred at any point.

The result of this study also indicated that there is low assistance from government agencies, research institutes and extension services in promoting greenhouse farming. Although radio seems to be a common information channel, the result of this study proved it to be otherwise. This is contrary to the findings of Sanusi *et al*. (2018) who reported that farmers prefer to access information from their friends and relatives, extension agents and radio. This might be because GHT is still relatively new to Nigerian agricultural communities thereby resulting in lack of awareness and participation of government agencies and extension services in the technology.

Table 4.3 Respondents' sources of information in the study area

Sources of information	Frequency of use															
	Plateau				Lagos				Ogun				Total			
	Always F (%)	Occasionally F (%)	Never F (%)	Mean	Always F (%)	Occasionally F (%)	Never F (%)	Mean	Always F (%)	Occasionally F (%)	Never F (%)	Mean	Always F (%)	Occasionally F (%)	Never F (%)	Mean
Greenhouse service providers	24 (28.9)	28 (33.7)	31 (37.3)	0.9157	61 (65.6)	19 (20.4)	13 (14.0)	1.5161	25 (62.5)	5 (12.5)	10 (25.0)	1.3750	110 (50.9)	52 (24.1)	54 (25.0)	1.2593
Television	9 (10.8)	34 (41.0)	40 (48.2)	0.6265	11 (11.8)	29 (31.2)	53 (57.0)	0.5484	5 (12.5)	5 (12.5)	30 (75.0)	0.3750	25 (11.6)	68 (31.5)	123 (56.9)	0.5463
Radio	5 (6.0)	27 (32.5)	51 (61.4)	0.4458	7 (7.5)	34 (36.6)	52 (55.9)	0.5161	3 (7.5)	7 (17.5)	30 (75.0)	0.3250	15 (6.9)	68 (31.5)	133 (61.6)	0.4537
Newspapers	4 (4.8)	17 (20.5)	62 (74.7)	0.3012	9 (9.7)	33 (35.5)	51 (54.8)	0.5484	2 (5.0)	10 (25.0)	28 (70.0)	0.3500	15 (6.9)	60 (27.8)	141 (65.3)	0.4167
Farmers association	18 (21.7)	23 (27.7)	42 (50.6)	0.7108	28 (30.1)	28 (30.1)	37 (39.8)	0.9032	6 (15.0)	16 (40.0)	18 (45.0)	0.7000	52 (24.1)	67 (31.0)	97 (44.9)	0.7917
Extension agents	12 (14.5)	21 (25.3)	50 (60.2)	0.5422	18 (19.4)	25 (26.9)	50 (53.8)	0.6559	4 (10.0)	6 (15.0)	30 (75.0)	0.3500	34 (15.7)	52 (24.1)	130 (60.2)	0.5556
Internet	32 (38.6)	27 (32.5)	24 (28.9)	1.0964	48 (51.6)	15 (16.1)	30 (32.3)	1.1935	16 (40.0)	4 (10.0)	20 (50.0)	0.9231	96 (44.4)	46 (21.3)	74 (34.3)	1.1070
Fellow farmer	39 (47.0)	25 (30.1)	19 (22.9)	1.2410	52 (55.9)	19 (20.4)	22 (23.7)	1.3226	20 (50.0)	8 (20.0)	12 (30.0)	1.2000	111 (51.4)	52 (24.1)	53 (24.5)	1.2685
Handbills	2 (2.4)	18 (21.7)	63 (75.9)	0.2651	11 (11.8)	30 (32.3)	52 (55.9)	0.5591	1 (2.5)	5 (12.5)	34 (85.0)	0.1750	14 (6.5)	53 (24.5)	149 (69.0)	0.3750
Seminars	12 (14.5)	38 (45.8)	33 (39.8)	0.7470	17 (18.3)	37 (39.8)	39 (41.9)	0.7634	8 (20.0)	18 (45.0)	14 (35.0)	0.8500	37 (17.1)	93 (43.1)	86 (39.8)	0.7731
Conferences	7 (8.4)	34 (41.0)	42 (50.6)	0.5783	12 (12.9)	36 (38.7)	45 (48.4)	0.6452	3 (7.5)	18 (45.0)	19 (47.5)	0.6000	22 (10.2)	88 (40.7)	106 (49.1)	0.6111
Workshop	10 (12.0)	40 (48.2)	33 (39.8)	0.7229	23 (24.7)	30 (32.3)	40 (43.0)	0.8172	6 (15.0)	14 (35.0)	20 (50.0)	0.6500	39 (18.1)	84 (38.9)	93 (43.1)	0.7500
Friends and neighbors	18 (21.7)	30 (36.1)	35 (42.2)	0.7952	41 (44.1)	25 (26.9)	27 (29.0)	1.1505	8 (20.0)	11 (27.5)	21 (52.5)	0.6750	67 (31.0)	66 (30.6)	83 (38.4)	0.9259

Source: Field survey (2018)

4.4.1 Respondents' Knowledge of the activities involved in operating GHTs

The study revealed (Table 4.4a) that in the three states, almost all the respondents had knowledge of the following activities involved in operating GHTs: 'the use of drip irrigation supplies regulated amount of water directly to plant roots (98.6%); 'two seedlings should be put in one pot/bag when transplanting to ascertain germination' (83.8%) and that 'drip irrigation cannot be used to irrigate the nursery trays' (80.6%). Few of the respondents knew that they should 'put plastic mulch on the ground before arranging the pot/bag to prevent soil infection with the ground' (14.4%). Also, they have low knowledge of the following: 'soluble fertilizers (Polyfeed/ NPK) should not be applied directly to each plant' (43.1%) and that 'nursery feeding regime of plant nutrients to water before transplanting should be a ratio of three days of fertilizers and a day of plain water (48.1%). This implies that the respondents had more knowledge of the use of drip irrigation and planting methods. Thus, this influences the high use of drip irrigation systems among most greenhouse farmers. In contrast, the respondents had limited knowledge of crop fertigation and the use of plastic mulch for crop protection against diseases and infections.

A disaggregated result however revealed that respondents had more knowledge that 'the use of drip irrigation supplies regulated amount of water directly to plant roots' in Plateau (97.6%), Lagos (100.0%) and Ogun states (97.5%) as this ranks first across the three states. Respondents in Plateau (90.4%) and Ogun (92.5%) had adequate knowledge that two seedlings should be put in one pot/bag when transplanting to ascertain germination as they both ranked second. In Lagos State, 86.0% of the respondents' had knowledge on 'the use of nets as air filters to the crops from dust and environmental wastes' as it ranked second. In Ogun State, the knowledge on the 'use of nets as air filters to the crops from dust and environmental wastes' (80.0%); 'Removal of the upcoming lateral shoots from the tomato stem before they overgrow helps to prevent fungus infection and flower abortion' (80.0%) and 'Over-irrigation leads to tomato fruits cracking' (80.0%) ranked third. The respondents' knowledge on the 'non-suitability of the drip irrigation for irrigating nursery trays' (84.9%) ranked as third in Lagos State.

In Plateau State, the 'knowledge that the drip system prevents foliar wetting and bacterial wilt' (88.0%) ranked as third. Hence, the respondents have high knowledge of the use of drip systems, good crop planting methods and crop protection practices. This agrees with Oluwayemisi *et al.* (2017) that having good knowledge of technology is one of the major factors determining the adoption of the technology.

In Plateau, Lagos and Ogun states, the respondents have low knowledge in the aspect of ‘the use of plastic mulch for preventing soil infection (12.0%), (18.3%) and (10.0%), respectively. However, in Plateau State, the respondents also have low knowledge on ‘the direct application of soluble fertilizers (Polyfeed/NPK) on plants’ (25.3%) and on the degradability of the plastic cover used in constructing the greenhouse (42.2%). In Lagos and Ogun states, the respondents’ knowledge is low in terms of the immediate use of water treated with hypochlorite (45.2%) and (47.5%), respectively. Also, their knowledge of the ‘feeding regime of plants to water in the nursery’ in Lagos (45.2%) and Ogun (47.5%) states is low. In Ogun State, respondents also have low knowledge in the aspect of filling of the pot/bag with soil to the brim (25.0%).

Thus, the respondents across the states have low knowledge on some of the necessary agronomic practices that can prevent soil infection build-up such as the use of mulch, water treatment and soil fertigation. Thus having absolute knowledge of all aspects of a technology will encourage the utilization of such technology by farmers (Akudugu *et al*., 2012). As a result, as compared to conventional agriculture, the employment of greenhouse technology necessitates a greater degree of knowledge, skills, superior management techniques and decision-making ability. Hence, the use of greenhouse technology requires having a higher level of knowledge, skills, better management practices and decision making abilities when compared to conventional agriculture.

Table 4.4a: Respondents' Knowledge of the activities involved in operating GHTs

S/N	Knowledge statements	Correct responses only							
		Plateau (F=83)	**%**	**Lagos (F=93)**	**%**	**Ogun (F=40)**	**%**	**Total (F=216)**	**%**
1	Pollination is done manually in the greenhouse	43	51.8	62	66.7	30	**75.0**	135	62.5
2	The use of drip irrigation supplies regulated the amount of water directly to plant roots	81	**97.6**	93	**100.0**	39	**97.5**	213	**98.6**
3	Training of crops should be carried out at the mid of the day to avoid stem and branch breakage	43	51.8	68	73.1	26	65.0	137	63.4
4	The nets acts as an air filters to the crops from dust and environmental wastes	61	73.5	80	**86.0**	32	**80.0**	173	**80.1**
5	The drip lines cannot be easily filled and drained	59	71.1	51	54.8	23	57.5	133	61.6
6	The plastic cover used in the greenhouse is easily ultraviolet degradable	35	**42.2**	46	**49.5**	26	65.0	107	**49.5**
7	The spread of light in the greenhouse unit is not uniform	58	69.9	63	67.7	30	**75.0**	151	69.9
8	The drip system encourages foliar wetting and bacterial wilt	73	**88.0**	61	65.6	24	60.0	158	73.1
9	The soluble fertilizers (Polyfeed/ NPK) should be applied directly to each plant	21	**25.3**	51	54.8	21	52.5	93	**43.1**
10	The soil should be dug to a depth of 60cm to ensure proper drainage when planting directly on the ground	40	48.2	58	62.4	31	**77.5**	129	59.7
11	When putting the soil into the pot/bag, each bag should be filled to the brim	67	**80.7**	45	**48.4**	10	**25.0**	122	56.5
12	Putting plastic mulch on the ground before arranging the pot/bags prevents soil infection with the ground	10	**12.0**	17	**18.3**	4	**10.0**	31	**14.4**
13	Over-irrigation leads to tomato fruits cracking	65	78.3	75	**80.6**	32	**80.0**	172	**79.6**
14	Water treated with calcium hypochlorite can be used immediately after treatment	56	67.5	42	**45.2**	19	**47.5**	117	**54.2**
15	The nursery tray grooves should be filled with soil up to ¾ of each tray groove	67	**80.7**	65	69.9	30	**75.0**	162	75.0
16	Drip irrigation cannot be used to irrigate the nursery trays	66	**79.5**	79	**84.9**	29	72.5	174	**80.6**
17	The nursery feeding regime of plant nutrients to water before transplanting should be 1 day of fertilizers and 3days of plain water	43	**51.8**	42	**45.2**	19	47.5	104	**48.1**
18	Two seedlings should be put in one pot/bag when transplanting to ascertain germination	75	**90.4**	69	**74.2**	37	**92.5**	181	**83.8**
19	Removal of the upcoming lateral shoots from the tomato stem before they overgrow helps to prevent fungus infection and flower abortion	49	59.0	48	51.6	32	**80.0**	129	59.7

Source: Field survey (2018)

4.4.2 Respondents’ knowledge level of the activities involved in operating GHTs

Table 4.4b revealed a high knowledge level (62.5%) of the activities involved in operating GHTs among respondents in the study area. The level of awareness of the activities involved in operating GHTs among respondents across the three states was high in Plateau State (57.8%), but much higher in Lagos (65.6%) and Ogun (65.0%). It suffices to say that adequate knowledge of the activities involved in the use of GHT could determine the adoption of GHTs. Jabbar *et al*. (2003) concluded that the acquisition of knowledge and information precedes any decision to adopt a technology. The respondents' high degree of understanding of the activities involved in operating greenhouse technology might be ascribed to their relatively high level of education (secondary). According to Fry *et al.* (2018), knowledge is the first innovation decision-making process that precedes any decision to adopt innovation by an individual. Hence, the high knowledge of GHTs possessed by the respondents could have influenced their adoption of GHT and can equally go a long way in determining the sustainability of the technology.

Table 4.4b: Categorisation of Respondents' knowledge of the activities involved in operating GHTs

Knowledge level	Plateau (n=83)		Lagos (n=93)		Ogun (n= 40)		Total (n=216)		Minimum	Maximum	Mean	SD
	F	%	F	%	F	%	F	%				
Low (1-10.42)	35	42.2	32	34.4	14	35.0	81	37.5	1.00	19.00	10.43	3.03
High (10.43-19)	48	57.8	61	65.6	26	65.0	135	62.5				
Mean ± SD	9.63±2.62		10.82±2.90		11.25±3.73							

Source: Field survey (2018)

4.5 Respondents' attitude towards the use of GHTS

The attitude expressed by the greenhouse farmers across the states towards the use of GHTs in Tables 4.5 a, b, c and d revealed that majority (93.5%) of the respondents agreed that 'harvesting crops when they have matured, but not overripe will help them earn good money because crops will get to the market in good shape'. Respondents in Plateau State (89.2%), Lagos (98.9%) and Ogun (90.0%) states also agreed to the above-mentioned statement. Tables 4.5 a, b, c and d further revealed that 92.1% of the respondents across the three states believed that 'training and staking prevent the stem from breaking off and touching the ground due to weight of the tomato fruits and this will help to get better yield and income'.

Respondents in Plateau, Lagos and Ogun states (96.4, 87.1 and 95.0%), respectively were also of the same opinion that 'training and staking prevent the stem from breaking off and touching the ground due to weight of the tomato fruits and this will help to get better yield and income'. This implies that the greenhouse farmers are mindful of greenhouse tomato handling and harvesting in order to make adequate profit from it due to the perishability nature of tomatoes. This is in consonance with Boyette, Sanders and Estes (2006) that tomatoes are very sensitive to mishandling and improper storage conditions. As a result, timely harvesting as well as a high degree of care in post-harvest handling should be guaranteed in order to preserve standard quality and market value of tomatoes, while also extending shelf life.

The respondents also showed a favourable disposition towards 'sorting of harvested crops according to their size and colour, which improves their reputation before their customers for packing high-quality products. In Plateau State, 90.4% showed favourable disposition towards 'sorting of harvested crops according to their size and colour, which improves their reputation before their customers for packing high-quality products'. There was however, a slightly higher percentage (91.4 and 92.5%) in Lagos and Ogun states that had favourable disposition. This indicated that the respondents are careful in the presentation and packaging of their greenhouse tomatoes to the market due to the exclusive marketing nature of crops grown in the greenhouses. Boyette *et al.* (2006) further opined that high grading and packing standards are the basic requirements for marketing greenhouse tomatoes. This is because consumers purchase tomatoes basically due to their appearance and continue buying based on the flavor and quality. Zewdie (2017) also added that since consumers enjoy produce with good quality and elongated shelf-life; it is expedient to package fresh produces in accordance with market standards.

Furthermore, a majority (93.0%) of the respondents in the three states agreed that 'strictly following the recommended good agronomic practices (GAPs) could help to boost yield and income'. The study further revealed that in Plateau State, a majority (95.2%) of the respondents opined that 'strictly following the recommended management practices could help to boost yield and income'. About 91.4 and 92.5% of the respondents in Lagos and Ogun states, respectively also agreed. Therefore, this implies that most of the respondents have a favourable disposition towards every activity that can increase tomato yield, boost their income as well as improve their reputation before any customer. This is consistent with the Unified Theory of Acceptance and Use of Technology (UTAUT) that users' intention of using a technology will determine the subsequent utilization of the technology. Hence, since increased yield, income and customers' satisfaction were part of the greenhouse farmers' intention of using the greenhouse technology; farmers will therefore adhere strictly to the recommended management practices.

Results presented on Table 4.5d revealed that most (69.9%) of the respondents across the states indicated that 'complying with the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag'. This is an unfavourable disposition and contrary to one of the important GH management practices that indicates drip emitters to pot/bag ratio of 2:1 (DFK Manual, 2015). The result on Table 4.5a, b and c further revealed that 65.1% of Plateau respondents agreed with the statement that 'complying with the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag', while 72.0 and 75.0% in Lagos and Ogun states, respectively agreed. This result is in accordance with a KII with one of the farm managers in Lagos State who stated that:

'The number of drip emitters to pot/bag depends on the size/diameter of the drip installed on each farm. This is because when using small tube drip size, it limits the flow, thus two

emitters can be used, but while using the big size tube drip emitter, one drip emitter may be used.' 04-05-2018.

Therefore, the opinion of the number of drip emitters to use depends on the size/diameter of the drip system installed in each farm.

Furthermore, less than half (40.5%) of the respondents did not consider it important to allow water just treated with calcium hypochlorite to stay for 12 hours before applying it on their crops because it was believed that it will have no effect on their crops. The study further revealed that 26.5, 35.5 and 32.5% of the respondents in Plateau, Lagos and Ogun states, respectively shared the same opinion. This is contrary to the normal management practice of allowing chlorinated water to stay for sufficient time to allow the treated water to disinfect the water supply (Department of Primary Industries and Regional Development (DPIRD), 2019)

Of major concern again is that about half (47.7%) of the total respondents in the three states believed that 'cleaning the drip filter on a daily basis could be stressful and so not necessary'. More than half of the respondents in Ogun State (52.5%) and less than half of the respondents in Plateau (44.6%) and Lagos (48.4%) states opined that 'cleaning the drip filter on a daily basis could be stressful and so not necessary.' This attitude does not comply with the drip manufacturers' instruction on drip irrigation maintenance that 'drip irrigation filters should always be cleaned and flushed on daily basis before irrigation' (DFK Manual, 2015; Drip Irrigation Systems Irrigationglobal.com).

Results on Tables 4.5 a, b and c further revealed that slightly less than half (48.1%) of the respondents across the three states had an unfavorable disposition towards 'waiting for soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank do not affect its rate of absorption by the plant'. Disaggregating the results across the states revealed that 41.0% of the respondents in Plateau State had an unfavourable disposition towards 'waiting for soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank because it does not affect its rate of absorption by the plant'. In Lagos and Ogun states, 48.4 and 62.5% of the respondents agreed with the statement. This implies that respondents have an unfavorable attitude towards the use of irrigation processes within the greenhouse such as the cleaning of the drip system after use as well as the disinfection process of water for the irrigation process. This can be inferred from the respondents' attitudinal disposition towards the use of GHT across the states.

4.5.1 Level of respondents' attitude towards the use of GHTS

The results revealed that overall, more than half (56.5%) of the respondents had favourable attitude towards the use of GHTs. This implies that most of the farmers have the favourable disposition needed to determine their readiness to adopt and use GHTs. This agrees with Moghavvemi *et al.* (2012) that having a positive attitude toward innovation leads to a higher intention to accept and apply innovation. The study further showed that Lagos (72.0%) and Ogun (55.0%), respectively had respondents with favourable attitudes towards the use of GHTs, while respondents in Plateau (60.2%) had an unfavourable attitude towards the use of GHTs. This may be because most of the respondents in Plateau State made use of the medium cost and low-cost greenhouse structures, while respondents from the Agricultural Service Training Centre (ASTC -the main owners of the imported structures in Plateau State) do not have a favourable disposition towards the use of its structures. This could be seen in the way the structures were being put to use, with most of them abandoned or destroyed. This contrasts with the findings of van der Spijk (2019), who claimed that while small and medium-scale farmers have a good view about greenhouse technology, more attention to correct agricultural methods is required to enhance the technology's acceptance.

Table 4.5a: Distribution of Respondents' attitude towards the use of GHTS in Plateau State (N=83)

S/N	Items	SA		A		U		D		SD		MEAN
		F	%	F	%	F	%	F	%	F	%	$\bar{x}$
1	Cleaning the drip filter on a daily basis could be stressful and so not necessary	12	14.5	25	30.1	14	16.9	17	20.5	15	18.1	2.98
2	Leaves removed during defoliation process may be left on the greenhouse floor to rot and decay to add more nutrients to the soil	5	6.0	11	13.3	5	6.0	20	24.1	42	50.6	**2.00**
3	In order to ease transplanting, it is advisable to irrigate the soil-manure mixture put in the pot/bags for three day before transplanting.	32	38.6	13	15.7	11	13.3	12	14.5	15	18.1	3.42
4	Complying to the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag	20	24.1	34	41.0	9	10.8	16	19.3	4	4.8	**2.40**
5	The position of seeds when planting it in the nursery tray does not really matter	13	15.7	20	24.1	4	4.8	28	33.7	18	21.7	3.22
6	Irrigating the seedlings in the nursery trays can be done at any time of the day when it is convenient for me	17	20.5	11	13.3	5	6.0	29	34.9	21	25.3	3.31
7	Waiting for the soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank does not affect its rate of absorption by the plant	13	15.7	21	25.3	5	6.0	26	31.3	18	21.7	2.82
8	Reducing the recommended rate of fertilizer used for my crops should not significantly affect crop growth	12	14.5	17	20.5	8	9.6	27	32.5	19	22.9	3.29
9	De-suckering of each plant is necessary to ensure great yield	47	56.6	17	20.5	11	13.3	4	4.8	4	4.8	4.19
10	Sorting harvested crops according to their size and colour improves my reputation before my customers for packing high quality products	63	75.9	12	14.5	6	7.2	1	1.2	1	1.2	**4.65**
11	Harvesting crops when they have matured, but not overripe will help me earn good money, because my crops will get to the market in good shape	62	74.7	12	14.5	3	3.6	3	3.6	3	3.6	4.53
12	I can prevent disease transmission from one plant to another by sterilizing the pruning tools during the de-suckering process	37	44.6	19	22.9	6	7.2	5	6.0	16	19.3	3.67
13	Laying plastic mulch on the greenhouse floor before arranging pots/bags is not so necessary	4	4.8	22	26.5	12	14.5	30	36.1	15	18.1	3.36
14	It is very necessary to regulate rate and frequency of the irrigation calibration with the drip irrigation system	27	32.5	39	47.0	12	14.5	3	3.6	2	2.4	4.04
15	I can use the water I just treated with calcium hypochlorite without letting it stay for 12 hours and it will have no effect on my crops	6	7.2	16	19.3	22	26.5	23	27.7	16	19.3	**2.67**
16	When I keep the records of each activity carried out on the farm, I will be able to watch the progress or otherwise of my crops	60	72.3	16	19.3	2	2.4	3	3.6	2	2.4	**4.55**
17	Carrying out crop rotation will save me more money because I will be able to break the breeding cycle of some stubborn crops pests	57	68.7	17	20.5	6	7.2	2	2.4	1	1.2	4.53
18	Strictly following the recommended management practices could help to boost my yield and income	59	71.1	20	24.1	3	3.6	1	1.2	0	0.0	**4.65**
19	Sorting and packaging of crops immediately after harvest might help to prevent postharvest losses and reduction of my income	47	56.6	31	37.3	1	1.2	4	4.8	0	0.0	4.46
20	Removing all leaves below ripe and mature fruits may prevent hiding places for insect pests and diseases' pathogens	49	59.0	25	30.1	6	7.2	2	2.4	1	1.2	4.43
21	Gently tapping the trellis or training lines in the afternoon might induce pollination and increased yield	30	36.1	19	22.9	19	22.9	9	10.8	6	7.2	3.70
22	Frying of soil and manure mixture could be very laborious	40	48.2	31	37.3	11	13.3	1	1.2	0	0.0	**1.67**
23	Training and staking prevent the stem from breaking off and touching the ground due to the weight of the tomato fruits and thus I will be able to get better yield and income	66	79.5	14	16.9	2	2.4	1	1.2	0	0.0	**4.75**
24	GHT is a controlled system of farming where high quality crops devoid of chemicals are expected, therefore the use of pesticides even once awhile should be totally avoided	13	15.7	19	22.9	12	14.5	23	27.7	16	19.3	2.88

Source: Field survey (2018) SA- Strongly Agreed; A- Agreed; U- Undecided; D- Disagreed; SD- Strongly Disagreed

Table 4.5b: Distribution of Respondents' attitude towards the use of GHTS in Lagos State (N=93)

S/N	Items	SA		A		U		D		SD		MEAN
		F	%	F	%	F	%	F	%	F	%	$\bar{x}$
1	Cleaning the drip filter on a daily basis could be stressful and so not necessary	15	16.1	30	32.3	1	1.1	23	24.7	24	25.8	3.12
2	Leaves removed during defoliation process may be left on the greenhouse floor to rot and decay to add more nutrients to the soil	6	6.5	9	9.7	7	7.5	29	31.2	42	45.2	**2.01**
3	In order to ease transplanting, it is advisable to irrigate the soil-manure mixture put in the pot/bags for three day before transplanting.	34	36.6	42	45.2	4	4.3	6	6.5	7	7.5	3.97
4	Complying to the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag	33	35.5	34	36.5	6	6.5	13	14.0	7	7.5	**2.22**
5	The position of seeds when planting it in the nursery tray does not really matter	9	9.7	16	17.2	12	12.9	24	25.8	32	34.4	3.58
6	Irrigating the seedlings in the nursery trays can be done at any time of the day when it is convenient for me	9	9.7	14	15.1	5	5.4	28	30.1	37	39.8	3.75
7	Waiting for the soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank does not affect its rate of absorption by the plant	28	30.1	17	18.3	2	2.2	20	21.5	26	28.0	3.01
8	Reducing the recommended rate of fertilizer used for my crops should not significantly affect crop growth	10	10.8	12	12.9	8	8.6	41	44.1	22	23.7	3.57
9	De-suckering of each plant is necessary to ensure great yield	51	54.8	19	20.4	13	14.0	4	4.3	6	6.5	4.13
10	Sorting harvested crops according to their size and colour improves my reputation before my customers for packing high quality products	69	74.2	16	17.2	2	2.2	3	3.2	3	3.2	**4.58**
11	Harvesting crops when they have matured, but not overripe will help me earn good money, because my crops will get to the market in good shape	71		21		1	1.1	0	0.0	0	0.0	**4.75**
12	I can prevent disease transmission from one plant to another by sterilizing the pruning tools during the de-suckering process	60	**64.5**	18	**19.4**	6	6.5	3	3.2	6	6.5	4.32
13	Laying plastic mulch on the greenhouse floor before arranging pots/bags is not so necessary	25	**26.9**	7	**7.5**	11	**11.8**	23	**24.7**	27	**29.0**	3.22
14	It is very necessary to regulate rate and frequency of the irrigation calibration with the drip irrigation system	49	52.7	33	35.5	6	6.5	4	4.3	1	1.1	4.34
15	I can use the water I just treated with calcium hypochlorite without letting it stay for 12 hours and it will have no effect on my crops	19	20.4	14	15.1	14	15.1	19	20.4	27	29.0	**2.77**
16	When I keep the records of each activity carried out on the farm, I will be able to watch the progress or otherwise of my crops	67	72.0	14	15.1	4	4.3	6	6.5	2	2.2	4.48
17	Carrying out crop rotation will save me more money because I will be able to break the breeding cycle of some stubborn crops pests	61	65.6	23	24.7	3	3.2	5	5.4	1	**1.1**	4.48
18	Strictly following the recommended management practices could help to boost my yield and income	65	69.9	20	21.5	4	4.3	3	3.2	1	1.1	**4.56**
19	Sorting and packaging of crops immediately after harvest might help to prevent postharvest losses and reduction of my income	64	68.8	20	21.5	6	6.5	2	2.2	1	1.1	4.45
20	Removing all leaves below ripe and mature fruits may prevent hiding places for insect pests and diseases' pathogens	59	63.4	23	24.7	8	8.6	2	2.2	1	1.1	4.47
21	Gently tapping the trellis or training lines in the afternoon might induce pollination and increased yield	40	43.0	21	22.6	11	11.8	15	16.1	6	6.5	3.80
22	Frying of soil and manure mixture could be very laborious	52	55.9	27	29.0	6	6.5	5	5.4	3	3.2	4.29
23	Training and staking prevent the stem from breaking off and touching the ground due to the weight of the tomato fruits and thus I will be able to get better yield and income	70	75.3	11	11.8	4	4.3	6	6.5	2	2.2	**4.52**
24	GHT is a controlled system of farming where high quality crops devoid of chemicals are expected, therefore the use of pesticides even once awhile should be totally avoided	28	30.1	26	28.0	14	15.1	11	11.8	14	15.1	3.46

Source: Field survey (2018) SA- Strongly Agreed; A- Agreed; U- Undecided; D- Disagreed; SD- Strongly Disagreed

Table 4.5c: Distribution of Respondents' attitude towards the use of GHTS in Ogun State (N=40)

S/N	Items	SA		A		U		D		SD		MEAN
		F	%	F	%	F	%	F	%	F	%	$\bar{x}$
1	Cleaning the drip filter on a daily basis could be stressful and so not necessary	8	20.0	13	32.5	3	7.5	11	27.5	5	12.5	**2.80**
2	Leaves removed during defoliation process may be left on the greenhouse floor to rot and decay to add more nutrients to the soil	4	10.0	0	0.0	0	0.0	9	22.5	27	67.5	**1.63**
3	In order to ease transplanting, it is advisable to irrigate the soil-manure mixture put in the pot/bags for three day before transplanting.	14	35.0	22	55.0	0	0.0	3	7.5	1	2.5	4.13
4	Complying to the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag	11	**27.5**	19	47.5	3	7.5	5	12.5	2	5.0	**2.20**
5	The position of seeds when planting it in the nursery tray does not really matter	7	17.5	4	10.0	3	7.5	17	42.5	9	22.5	3.43
6	Irrigating the seedlings in the nursery trays can be done at any time of the day when it is convenient for me	5	12.5	6	15.0	2	5.0	12	30.0	15	37.5	3.65
7	Waiting for the soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank does not affect its rate of absorption by the plant	6	**15.0**	7	7	2	5.0	18	45.0	7	17.5	3.33
8	Reducing the recommended rate of fertilizer used for my crops should not significantly affect crop growth	3	7.5	7	17.5	2	5.0	15	37.5	13	32.5	3.70
9	De-suckering of each plant is necessary to ensure great yield	21	52.5	8	20.0	4	10.0	1	2.5	6	15.0	3.93
10	Sorting harvested crops according to their size and colour improves my reputation before my customers for packing high quality products	29	**72.5**	8	20.0	2	5.0	0	0.0	1	2.5	**4.60**
11	Harvesting crops when they have matured, but not overripe will help me earn good money, because my crops will get to the market in good shape	34	**85.0**	2	5.0	1	2.5	1	2.5	2	5.0	**4.63**
12	I can prevent disease transmission from one plant to another by sterilizing the pruning tools during the de-suckering process	24	**60.0**	12	30.0	2	5.0	1	2.5	1	2.5	4.43
13	Laying plastic mulch on the greenhouse floor before arranging pots/bags is not so necessary	7	**17.5**	5	12.5	4	10.0	11	27.5	13	32.5	3.45
14	It is very necessary to regulate rate and frequency of the irrigation calibration with the drip irrigation system	22	**55.0**	14	35.0	2	5.0	0	0.0	2	5.0	4.35
15	I can use the water I just treated with calcium hypochlorite without letting it stay for 12 hours and it will have no effect on my crops	5	**12.5**	8	20.0	9	22.5	12	30.0	6	15.0	2.85
16	When I keep the records of each activity carried out on the farm, I will be able to watch the progress or otherwise of my crops	28	70.0	7	17.5	4	10.0	1	2.5	0	0.0	**4.55**
17	Carrying out crop rotation will save me more money because I will be able to break the breeding cycle of some stubborn crops pests	22	55.0	13	32.5	1	2.5	4	10.0	0	0.0	4.33
18	Strictly following the recommended management practices could help to boost my yield and income	18	**45.0**	19	47.5	2	5.0	1	2.5	0	0.0	4.35
19	Sorting and packaging of crops immediately after harvest might help to prevent postharvest losses and reduction of my income	23	**57.5**	11	27.5	2	5.0	2	5.0	2	5.0	4.28
20	Removing all leaves below ripe and mature fruits may prevent hiding places for insect pests and diseases' pathogens	21	**52.5**	15	37.5	2	5.0	1	2.5	1	2.5	4.35
21	Gently tapping the trellis or training lines in the afternoon might induce pollination and increased yield	18	**45.0**	15	37.5	2.0	5.0	3	7.5	2	5	4.10
22	Frying of soil and manure mixture could be very laborious	15	**37.5**	17	42.5	2	5.0	5	12.5	1	2.5	4.00
23	Training and staking prevent the stem from breaking off and touching the ground due to the weight of the tomato fruits and thus I will be able to get better yield and income	29	**72.5**	9	22.5	1	2.5	0	0.0	1	2.5	**4.63**
24	GHT is a controlled system of farming where high quality crops devoid of chemicals are expected, therefore the use of pesticides even once awhile should be totally avoided	9	**22.5**	9	22.5	4	10.0	11	27.5	7	17.5	3.05

Source: Field survey (2018) SA- Strongly Agreed; A- Agreed; U- Undecided; D- Disagreed; SD- Strongly Disagreed

Table 4.5d: Distribution of Respondents' attitude towards the use of GHTS in the three states (N=216)

S/N	Items	SA		A		U		D		SD		Mean
		F	%	F	%	F	%	F	%	F	%	$\bar{x}$
1	Cleaning the drip filter on a daily basis could be stressful and so not necessary	35	16.2	68	31.5	18	8.3	51	23.6	44	20.4	**3.00**
2	Leaves removed during defoliation process may be left on the greenhouse floor to rot and decay to add more nutrients to the soil	15	6.9	20	9.3	12	5.6	58	26.9	111	**51.4**	4.06
3	In order to ease transplanting, it is advisable to irrigate the soil-manure mixture put in the pot/bags for three day before transplanting.	80	37.0	77	35.6	15	6.9	21	9.7	23	10.6	3.79
4	Complying to the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag	64	**29.6**	87	40.3	18	8.3	34	15.7	13	6.0	**2.28**
5	The position of seeds when planting it in the nursery tray does not really matter	29	13.4	40	18.5	19	8.8	69	31.9	59	27.3	3.41
6	Irrigating the seedlings in the nursery trays can be done at any time of the day when it is convenient for me	31	**14.4**	31	14.4	12	5.6	69	31.9	73	33.8	3.56
7	Waiting for the soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank does not affect its rate of absorption by the plant	48	22.2	56	25.9	9	4.2	53	24.5	50	23.1	**3.00**
8	Reducing the recommended rate of fertilizer used for my crops should not significantly affect crop growth	25	11.6	36	16.7	18	8.3	83	38.4	54	25.0	3.49
9	De-suckering of each plant is necessary to ensure great yield	119	**55.1**	44	20.4	28	13.0	9	4.2	16	7.4	4.12
10	Sorting harvested crops according to their size and colour improves my reputation before my customers for packing high quality products	161	74.5	36	16.7	8	3.7	4	1.9	5	2.3	**4.61**
11	Harvesting crops when they have matured, but not overripe will help me earn good money, because my crops will get to the market in good shape	167	77.3	35	16.2	5	2.3	4	1.9	5	2.3	**4.64**
12	I can prevent disease transmission from one plant to another by sterilizing the pruning tools during the de-suckering process	121	**56.0**	49	22.7	14	6.5	9	4.2	23	10.6	4.09
13	Laying plastic mulch on the greenhouse floor before arranging pots/bags is not so necessary	36	**16.7**	34	15.7	27	12.5	64	29.6	55	25.5	3.31
14	It is very necessary to regulate rate and frequency of the irrigation calibration with the drip irrigation system	98	**45.4**	86	39.8	20	9.3	7	3.2	5	2.3	4.23
15	I can use the water I just treated with calcium hypochlorite without letting it stay for 12 hours and it will have no effect on my crops	30	13.9	38	17.6	45	20.8	54	25.0	49	22.7	**3.25**
16	When I keep the records of each activity carried out on the farm, I will be able to watch the progress or otherwise of my crops	155	**71.8**	37	17.1	10	4.6	10	4.6	4	1.9	4.52
17	Carrying out crop rotation will save me more money because I will be able to break the breeding cycle of some stubborn crops pests	140	**64.8**	53	24.5	10	4.6	11	5.1	2	0.9	4.47
18	Strictly following the recommended management practices could help to boost my yield and income	142	**65.7**	59	27.3	9	4.2	5	2.3	1	0.5	**4.56**
19	Sorting and packaging of crops immediately after harvest might help to prevent postharvest losses and reduction of my income	134	62.0	62	28.7	9	4.2	8	3.7	3	1.4	4.46
20	Removing all leaves below ripe and mature fruits may prevent hiding places for insect pests and diseases' pathogens	129	59.7	63	29.2	16	7.4	5	2.3	3	1.4	4.44
21	Gently tapping the trellis or training lines in the afternoon might induce pollination and increased yield	88	40.7	55	25.5	32	14.8	27	12.5	14	6.5	3.81
22	Frying of soil and manure mixture could be very laborious	107	49.5	75	34.7	19	8.8	11	5.1	4	1.9	3.23
23	Training and staking prevent the stem from breaking off and touching the ground due to the weight of the tomato fruits and thus I will be able to get better yield and income	165	76.4	34	15.7	7	3.2	7	3.2	3	1.4	**4.63**
24	GHT is a controlled system of farming where high quality crops devoid of chemicals are expected, therefore the use of pesticides even once awhile should be totally avoided	50	23.1	54	25.0	30	13.9	45	20.8	37	17.1	3.16

Source: Field survey (2018) SA- Strongly Agreed; A- Agreed; U- Undecided; D- Disagreed; SD- Strongly Disagreed

Also, the unfavourable attitude of greenhouse farmers in Plateau State may be consequent on the fact that most of them are not directly involved in raising the tomato plants at the nursery phase. The farmers purchased their tomato seedlings from greenhouse service providers around or pay people to set it up and manage the nursery phase of the GHTs for them. This is the most tedious aspect of greenhouse tomato production. According to the KII with the National Greenhouse Farmers' President:

"The process of raising tomato seedlings in the nursery is so delicate and requires careful monitoring and proper attention so as to quickly notice how many of the seeds have germinated and to quickly replant so as to be able to meet up with the number of seedlings to be transplanted into each greenhouse per time. It also requires timely watering as at when due and proper fertigation so as to grow well." 05-04-2018

The favourable attitude in Lagos and Ogun states can also be explained by the production scale of the greenhouse technology within the two states. This is because most of the greenhouse structures used was imported and most of the production processes from land clearing to tomato sorting were carried out by the greenhouse farmers employed on the farm. Careless attitude and disposition to the use of GHTs which can affect the production process, yield and eventually the profit gained are not condoned by the farm managers. Also, the aim of the owners of the greenhouse business for investing in the technology is to ensure maximum productivity, realize back on time the large money/capital invested into purchasing the kits and to maximize their profits.

Table 4.5e: Categorisation of respondents' attitude towards the use of GHTS

Attitude level	Plateau (n=83)		Lagos (n=93)		Ogun (n=40)		Total (n=216)		Minimum	Maximum	Mean	SD
	F	%	F	%	F	%	F	%				
Unfavourable (56-89.45)	50	60.2	25	26.9	18	45.0	93	43.1	56	108	89.50	8.56
Favourable (89.46-108)	33	39.8	68	73.1	22	55.0	123	56.9				
Mean ± SD	86.20±7.53		91.91±8.53		90.70±8.67							

Source: Field survey (2018)

4.6 Respondents' Management practices of the greenhouse

4.6.1 Respondents' frequency of use of Greenhouse management practices

Presentation on Table 4.6a revealed that in the three states, the most frequently utilized management practices of GHT include: 'application of appropriate fertilizers and nutrients to crops' ($\bar{x}$ =1.76) ranking first; 'proper sanitation and bio-safety in the greenhouse' ($\bar{x}$ =1.74) ranked second, while 'proper record keeping' ($\bar{x}$ =1.73) ranked third. The least practiced management activity is 'crop rotation' ($\bar{x}$ =0.50) which ranked last, followed by 'soil analysis' ($\bar{x}$ =1.10) ranking twenty-seventh and 'soil and manure sterilization' ($\bar{x}$ =1.11) ranking twenty-sixth. This revealed that the greenhouse farmers in the three states tend to follow strictly the practices related to crop nutrients, sanitation and record keeping. This is in accordance with Nguyen (2019) that record keeping of production as well as other expenses for each crop produced is an essential part of good management practices as it showed the overall picture of farms' health and performance annually. This implies that the management practices not frequently or never observed by most of the respondents were crop rotation, soil analysis and soil and manure sterilization. Though Strausbaugh (2014) reported that soil sterilization is one of the management practices used in greenhouse operations for the production of high-value crops and weed control, it was seldom or never used by most of the respondents

A disaggregated result however revealed that in Plateau State, the most frequently utilized management practices include: 'application of appropriate fertilizers and nutrients to crops' ($\bar{x}$ =1.84) ranking first, followed by 'pruning' ($\bar{x}$ =1.83) and 'Training, Staking and Trellising' ($\bar{x}$ =1.82). The least utilized management practices were 'the use of plastic mulch' ($\bar{x}$ =0.84) which ranked last and 'soil analysis' and 'soil and manure sterilization' ($\bar{x}$ =0.90), respectively.

In Lagos State, the most frequently utilized management practices carried out in the greenhouse include: 'Use of drip irrigation ($\bar{x}$ =1.77) ranking first, 'proper record keeping' ($\bar{x}$ =1.74) ranked second and 'Application of appropriate fertilizers and nutrients to crops' ($\bar{x}$ =1.73) ranked third. The management practices seldom used or never carried out include: 'application of fruit setting solution twice weekly' ($\bar{x}$ =1.19) which ranked last, 'soil and manure sterilization' and 'desuckering' ($\bar{x}$ =1.23), respectively.

In Ogun State, the most frequently utilized management practice is the 'Use of drip irrigation' ($\bar{x}$ =1.80) ranking first, followed by 'Proper record keeping' ($\bar{x}$ =1.78) ranking second and 'Proper sanitation and biosafety in the greenhouse' ($\bar{x}$ =1.75) which ranked as third. The least utilized include: ‘desuckering’ ($\bar{x}$ =1.05) which ranked last, followed by soil analysis ($\bar{x}$ =1.20) and 'weekly flushing of the irrigation system' ($\bar{x}$ =1.23).

Hence, 'application of appropriate fertilizers and nutrients to crops is one of the management practices most frequently used by the greenhouse farmers in Plateau and Lagos states. Soil and manure sterilization was one of the least management practices carried out by the respondents in the two states.

The 'Use of drip irrigation' and 'Proper record keeping' are the management practices commonly utilized by the respondents from Lagos and Ogun states, while 'desuckering' is not a management practice GH farmers in both states are used to. 'Soil analysis' is also not a management practice common to respondents from Plateau and Ogun states.

Table 4.6a: Respondents' Frequency of Use of Greenhouse Management Practices in the three states (N=216)

Frequency of Use of Greenhouse Management Practices	Plateau $\bar{x}$	Lagos $\bar{x}$	Ogun $\bar{x}$	Total $\bar{x}$
Land preparation/Integration of nutrients	1.75	1.60	1.53	1.64
Bed shaping	1.46	1.46	1.38	1.44
Soil analysis	0.90	1.24	1.20	1.10
Soil and manure sterilization	0.90	1.23	1.28	1.11
Bagging	1.17	1.24	1.45	1.25
Use of plastic mulch (Use of damp proof)	0.84	1.26	1.35	1.12
Use of drip irrigation	1.42	1.77	1.80	1.64
Setting up of the nurseries	1.60	1.47	1.53	1.53
Fertilization of the nurseries	1.40	1.27	1.40	1.34
Hardening of crops before transplanting	1.08	1.47	1.38	1.31
Application of appropriate fertilizers and nutrients to crops	1.84	1.73	1.68	1.76
Regular checking of the irrigation systems and filters	1.45	1.63	1.68	1.57
Disinfection of the water for irrigation	0.93	1.33	1.25	1.16
Regular and constant irrigation of crops in the greenhouse	1.71	1.70	1.70	1.70
Weekly flushing of the irrigation system	1.33	1.41	1.23	1.34
Proper record keeping	1.69	1.74	1.78	1.73
Application of recommended pesticides when necessary	1.60	1.67	1.50	1.61
Training, Staking and Trellising	1.82	1.69	1.43	1.69
Pruning	1.83	1.49	1.43	1.61
Hand weeding	1.67	1.48	1.35	1.53
De-suckering	1.49	1.23	1.05	1.30
Application of fruit setting solution twice weekly	0.98	1.19	1.25	1.12
Defoliation	1.42	1.25	1.28	1.32
Timely Harvesting	1.83	1.63	1.53	1.69
Sorting and Packing	1.71	1.61	1.70	1.67
Regular cleaning of the drip filters	1.36	1.54	1.48	1.46
Proper sanitation and biosafety in the greenhouse	1.77	1.70	1.75	1.74
Crop rotation	1.64	1.44	1.33	0.50

Source: Field survey (2018)

4.6.2 Respondents' Ease of Use of Greenhouse Management Practices

Table 4.6b showed that in the three states, half of the respondents (50.0%) said that the 'Use of drip irrigation' was a simple management technique to implement in greenhouse technology ($\bar{x} = 1.08$) which ranked as first. It further revealed that the respondents ($\bar{x} = 0.97$) ranked 'fertilization of the nurseries' (42.1%) as the second most easy greenhouse management practice. About 41.7% of the respondents ($\bar{x} = 0.96$) ranked 'Application of appropriate fertilizers and nutrients to crop' as the third management practice easy for them to undertake in the greenhouse. Results also showed that 42.1% of the respondents ($\bar{x} = 0.63$) ranked 'bagging of soil' as the most difficult task within the greenhouse (Table 4.6b). According to KII with a farm manager at a farm in Ikorodu, Lagos state:

'Bagging of soil for planting is such a difficult task as it requires a lot of bending which stresses the backbone.'15-05-2018

Respondents (40.7%) in the three states also ranked 'Soil and manure sterilization/frying' as the second most difficult task to undertake in greenhouse technology ($\bar{x} = 0.65$), while 43.5% of respondents ranked 'Bed shaping' as being the third most 'difficult' greenhouse management practice. This implies that the greenhouse farmers across the three states considered management practices of GHT that pertains to crop irrigation using drips and crop nutrients especially at the nursery phase as being easy to undertake. The management practices of GHT that relate to pre-planting such as bagging, soil sterilization and bed shaping were considered as being strenuous.

The disaggregated results however revealed that in Plateau State, management practices such as 'Use of drip irrigation' ranked as the first most easy management practices to use in the greenhouse ($\bar{x} = 0.89$); Timely Harvesting ($\bar{x} = 0.82$) ranked second and 'Application of appropriate fertilizers and nutrients to crop' as third ($\bar{x}$ =0.81). In Lagos, 'Setting up of the nurseries' ($\bar{x} = 1.20$) ranked as the first most easy management practices to use in the greenhouse, followed by 'Use of drip irrigation' ($\bar{x} = 1.16$) as second and 'Hardening of crops before transplanting, ranked as third management practices easy for them to undertake in the greenhouse ($\bar{x} = 1.10$). In Ogun State, 'Use of drip irrigation' was ranked as the first most easy management practice to use in the greenhouse ($\bar{x} = 1.28$); Fertilization of the nurseries ($\bar{x} = 1.25$) ranked second, while Proper record-keeping ($\bar{x} = 1.20$) ranked as the third easiest management practice to carry out in the greenhouse. The common management practice considered as very easy to do by the respondents in each of the states was the 'Use of drip irrigation'. According to Thomas *et al*. (2009), limited energy is required for operating a drip system and it also has the advantage of conserving water, fertilizer and preventing the plant leaves and stems from pathogen attack. It was also reported that 35% or more savings on labour costs is due to the use of drip irrigation.

The results further revealed that in Plateau State, 'Soil analysis' ($\bar{x}$ =0.41) ranked as the least management practices the respondents considered 'easy to use', followed by 'Use of plastic mulch ($\bar{x} = 0.43$) and 'Soil and manure sterilization' ($\bar{x}$ =0.45). In Lagos State, 'bagging of soil' ($\bar{x}$ =0.70) was considered as the most as the most difficult task within the greenhouse as it ranked as the least easy to do management practices. This was followed by 'Land preparation/Integration of nutrients' and 'Bed shaping' ($\bar{x}$ =0.72) ranked as second, respectively. In Ogun State, most ($\bar{x}$ =0.75) of the respondents ranked Bed shaping and Hand weeding, respectively as the most difficult management practices within the greenhouse followed by 'Bagging of soil'($\bar{x}$ =0.78) .

Hence, most of the respondents in the three states considered management practices related to land preparation and pre-planting as difficult tasks to undertake in the greenhouse. This is because the process of planting tomatoes requires more labour than other phases. According to a KII with a greenhouse farm manager in Epe, Lagos State:

'During the process of land preparation, most greenhouse farms hire labourers as ad-hoc workers to carry out the tedious tasks of land preparation in order to save time'.09-05-2018

Table 4.6b: Respondents' Ease of Use of Greenhouse Management Practices in the three states (N=83)

Ease of Use of Greenhouse Management Practices	**Plateau** $\bar{x}$	**Lagos** $\bar{x}$	**Ogun** $\bar{x}$	**Total** $\bar{x}$
Land preparation/Integration of nutrients	0.76	**0.72**	0.85	0.76
Bed shaping	0.64	**0.72**	**0.75**	**0.69**
Soil analysis	**0.41**	0.87	1.00	0.72
Soil and manure sterilization	**0.45**	0.76	**0.80**	**0.65**
Bagging	0.49	**0.70**	**0.78**	**0.63**
Use of plastic mulch (Use of damp proof)	**0.43**	1.05	**1.20**	0.84
Use of drip irrigation	**0.89**	**1.16**	**1.28**	**1.08**
Setting up of the nurseries	0.63	**1.20**	1.15	**0.97**
Fertilization of the nurseries	0.65	**1.08**	**1.25**	0.94
Hardening of crops before transplanting	0.58	**1.10**	1.08	0.89
Application of appropriate fertilizers and nutrients to crops	**0.81**	1.05	1.08	**0.96**
Regular checking of the irrigation systems and filters	0.60	0.99	1.10	0.86
Disinfection of the water for irrigation	0.63	1.05	1.10	0.90
Regular and constant irrigation of crops in the greenhouse	0.71	1.05	1.13	0.94
Weekly flushing of the irrigation system	0.61	0.92	0.95	0.81
Proper record keeping	0.73	1.00	**1.20**	0.94
Application of recommended pesticides when necessary	0.69	1.04	1.18	0.93
Training, Staking and Trellising	0.64	0.80	0.88	0.75
Pruning	0.67	0.75	0.93	0.75
Hand weeding	0.58	0.83	**0.75**	0.72
De-suckering	0.64	0.78	0.98	0.76
Application of fruit setting solution twice weekly	0.54	0.75	1.08	0.73
Defoliation	0.58	0.77	0.85	0.71
Timely Harvesting	**0.82**	0.89	0.95	0.88
Sorting and Packing	0.71	0.91	0.90	0.83
Regular cleaning of the drip filters	0.54	0.85	1.00	0.76
Proper sanitation and biosafety in the greenhouse	0.65	0.91	1.10	0.85
Crop rotation	0.72	1.02	1.15	0.93

Source: Field survey (2018)

4.6.3 Management level of greenhouse practices

The study revealed that the management level of GHTs among respondents across the states was high and good (51.9%). This implies that the respondents take into cognizance and comply with the laid down management practices needed to effectively run the greenhouse technology. This is in line with Thompson (2010) that greenhouse technology requires total commitment and maximum care for it to be effective, efficient and to achieve maximum yield. Knuth *et al*. (2018) also confirmed that the frequency of management checks on technology compliance drives technology adoption. Hence, when regular management checks are put in place to ensure proper compliance with the laid down GHTs management practices, then, it would help in increasing the rate of GHTs adoption in the study area.

Management level across all the three study locations showed that there was a good and high level of greenhouse management practices (62.5 and 58.1%) in Ogun and Lagos states, respectively while in Plateau State, the level of management was low and poor as 60.2% of the Greenhouse farmers had a mean score of less than 4.51. The poor greenhouse technologies management practices among Plateau State greenhouse farmers might explain for the limited variance in overall management level across respondents. The low management level among the farmers in Plateau State could be closely associated with the attitude of Plateau farmers and the type of greenhouse structure predominant in the state. As earlier observed in this study, majority of the respondents in Plateau had unfavourable attitudes toward GHT, which can invariably determine the management practices undertook when operating their greenhouses. This is coupled with the fact that most of the respondents in Plateau State made use of the medium cost and low-cost greenhouse structures, which may not elicit any serious routine management activities unlike the modern structures used by most of their counterparts in Lagos and Ogun.

Furthermore, among the three states, farmers in Plateau exhibited the lowest level of knowledge on greenhouse technology. This could have affected their management level since the farmers might not be aware of many management practices necessary for the maintenance of a successful greenhouse. This might be due to the fact that fellow farmers served as the primary source of information on greenhouse technology in the state, while their counterparts in Lagos and Ogun states derived their information mainly from greenhouse Service Providers.

Table 4.6c: Categorisation of respondents' level of Management of Greenhouse Practices

Management level	Plateau (n=83)		Lagos (n=93)		Ogun (n=40)		Total (n=216)		Minimum	Maximum	Mean	SD
	F	%	F	%	F	%	F	%				
Poor (0 - 4.50)	50	60.2	39	41.9	15	37.5	104	48.1	0.00	7.00	4.51	1.66
Good (4.51-7.0)	33	39.8	54	58.1	25	62.5	112	51.9				
Mean ± SD	4.20±1.19		4.68±1.79		4.74±2.06							

Source: Field survey (2018)

4.7 Constraints faced in the adoption OF GHTs

High initial investment in the construction of greenhouse ($\bar{x}$ =1.58), fluctuation in market prices due to glut in the market ($\bar{x}$ =1.55), high cost of planting materials/plant protection chemicals ($\bar{x}$ =1.53), lack of adequate and timely disbursement of loans from financial institutions ($\bar{x}$ =1.42) were the major constraints to the adoption of GHTS experienced by respondents in the study area (Table 4.7). The disaggregated result similarly revealed that in Plateau, fluctuation in market prices due to glut in the market ($\bar{x}$ =1.70), high initial investment in the construction of greenhouse ($\bar{x}$ =1.66) and glut of crops in the market ($\bar{x}$ =1.64) were the major constraints experienced by respondents in the state. In Lagos, the high cost of planting materials/plant protection chemicals ($\bar{x}$ =1.59), a high initial investment in the construction of greenhouse ($\bar{x}$ =1.51) and fluctuation in prices due to glut in the market ($\bar{x}$ =1.47) bedeviled the respondents most. In Ogun State, the greenhouse farmers considered a high initial investment in the construction of greenhouse ($\bar{x}$ =1.58), high cost of planting materials/plant protection chemicals ($\bar{x}$ =1.40) and fluctuation in prices due to glut in the market ($\bar{x}$ =1.40) as their major constraints.

The obtained results imply that the major constraints respondents experienced in the adoption of greenhouse farming relate to both financial and marketing constraints. This might be related to the high cost of production required for the maintenance of the greenhouse which is in agreement with Moges and Taye (2017) that having access to credits could positively influence the adoption of technology. Smitha *et al.* (2016) also reported high initial cost, the inadequate exclusive market for greenhouse tomatoes at reasonable prices and non-availability of inputs and timely credit as constraints faced in utilizing greenhouse technology.

The least constraints to adoption of GHTs experienced by respondent across the three states were erosion ($\bar{x}$ =0.61), blowing off of flower petals ($\bar{x}$ =0.75); scarcity of water for irrigation ($\bar{x}$ =0.82) and poor drainage of soil ($\bar{x}$ =0.85). Erosion was the constraint considered least according to the disaggregation across the three states i.e. Plateau ($\bar{x}$ =0.42), Lagos ($\bar{x}$ =0.77) and Ogun ($\bar{x}$ =0.63). Other constraints least experienced by the respondents across the states include: Plateau: Occurrence of physiological disorders e.g. disordered fruit shape ($\bar{x}$ =0.69) and scarcity of water for irrigation under greenhouse

($\bar{x}$ =0.77). In Lagos, low soil fertility status due to leaching ($\bar{x}$ =0.85); and in Ogun; Blowing off of flower petals and Difficulties in complying with the recommended management practices ($\bar{x}$ =0.63), respectively. The above-listed constraints considered least by the respondents were environmental constraints. This result is in consonance with Chauhan *et al.* (2017) that the environmental conditions in the greenhouse are well modified to make it suitable for the cultivation of any crop, at anytime and anywhere. Also, van der Spijk (2019) reported that only 7% of greenhouse farmers in Kenya encountered water shortages and its non-availability as part of the constraints faced in the greenhouse.

Table 4.7: Constraints faced by respondents in the Adoption of GHTs

Constraints	PLATEAU Severity of constraints NC F (%)	MC F (%)	SC F (%)	WM	LAGOS Severity of constraints NC F (%)	MC F (%)	SC F (%)	WM	OGUN Severity of constraints NC F (%)	MC F (%)	SC F (%)	WM	TOTAL Severity of constraints NC F (%)	MC F (%)	SC F (%)	WM
Environmental constraints																
Relatively higher perishability of fruits	32 (38.6)	32 (38.6)	19 (22.9)	0.84	23 (24.7)	39 (41.9)	31 (33.3)	1.09	12 (30.0)	16 (40.0)	12 (30.0)	1.00	67 (31.0)	87 (40.3)	62 (28.7)	0.98
Scarcity of water for irrigation under greenhouse	44 (53.0)	14 (16.9)	25 (30.1)	0.77	39 (41.9)	24 (25.8)	30 (32.3)	0.90	20 (50.0)	10 (25.0)	10 (25.0)	0.75	103 (47.7)	48 (22.2)	65 (30.1)	0.82
Strong winds	23 (27.7)	25 (30.1)	35 (42.2)	1.14	29 (31.2)	28 (30.1)	36 (38.7)	1.08	13 (32.5)	16 (40.0)	11 (27.5)	0.95	65 (30.1)	69 (31.9)	82 (38.0)	1.08
Poor drainage of soil	32 (38.6)	30 (36.1)	21 (25.3)	0.87	32 (34.4)	38 (40.9)	23 (24.7)	0.90	18 (45.0)	16 (40.0)	6 (15.0)	0.70	82 (38.0)	84 (38.9)	50 (23.1)	0.85
Low soil fertility status due to leaching	29 (34.9)	32 (38.6)	22 (26.5)	0.92	34 (36.6)	39 (41.9)	20 (21.5)	0.85	15 (37.5)	20 (50.0)	5 (12.5)	0.75	78 (36.1)	91 (42.1)	47 (21.8)	0.86
Occurrence of physiological disorders e.g. disordered fruit shape	41 (49.4)	27 (32.5)	15 (18.1)	0.69	21 (22.6)	47 (50.5)	25 (26.9)	1.04	15 (37.5)	19 (47.5)	6 (15.0)	0.78	77 (35.6)	93 (43.1)	46 (21.3)	0.86
Erosion	61 (73.5)	9 (10.8)	13 (15.7)	0.42	43 (46.2)	28 (30.1)	22 (23.7)	0.77	22 (55.0)	11 (27.5)	7 (17.5)	0.63	126 (58.3)	48 (22.2)	42 (19.4)	0.61
Blowing off of flower petals	51 (61.4)	21 (25.3)	11 (13.3)	0.52	33 (35.5)	27 (29.0)	33 (35.5)	1.00	20 (50.0)	15 (37.5)	5 (12.5)	0.63	104 (48.1)	63 (29.2)	49 (22.7)	0.75
Technical constraints																
Lack of scientific knowledge about crop production under	29 (34.9)	31 (37.3)	23 (27.7)	0.93	24 (25.8)	27 (29.0)	42 (45.2)	1.19	18 (45.0)	8 (20.0)	14 (35.0)	0.90	71 (32.9)	66 (30.6)	79 (36.6)	1.04

greenhouse																
Non-availability of required quantity and quality planting material/inputs on time	15 (18.1)	35 (42.2)	33 (39.8)	1.22	24 (25.8)	26 (28.0)	43 (46.2)	1.20	15 (37.5)	10 (25.0)	15 (37.5)	1.00	54 (25.0)	71 (32.9)	91 (42.1)	1.17
Limited and irregular power supply	31 (37.3)	31 (37.3)	21 (25.3)	0.88	25 (26.9)	26 (28.0)	42 (45.2)	1.18	18 (45.0)	9 (22.5)	13 (32.5)	0.88	74 (34.3)	66 (30.6)	76 (35.2)	1.01
Non-availability of quality greenhouse equipment at local market	10 (12.0)	23 (27.7)	50 (60.2)	1.48	26 (28.0)	13 (14.0)	54 (58.1)	1.30	10 (25.0)	10 (25.0)	20 (50.0)	1.25	46 (21.3)	46 (21.3)	124 (57.4)	1.36
Difficulties in complying with the recommended management practices	25 (30.1)	31 (37.3)	27 (32.5)	1.02	22 (23.7)	36 (38.7)	35 (37.6)	1.14	21 (52.5)	13 (32.5)	6 (15.0)	0.63	68 (31.5)	80 (37.0)	68 (31.5)	1.00
Labour related constraints																
High cost of skilled labour	12 (14.5)	39 (47.0)	32 (38.6)	1.24	23 (24.7)	17 (18.3)	53 (57.0)	1.32	12 (30.0)	12 (30.0)	16 (40.0)	1.10	47 (21.8)	68 (31.5)	101 (46.8)	1.25
Economic constraints																
High initial investment in construction of greenhouse	8 (9.6)	12 (14.5)	63 (75.9)	1.66	11 (11.8)	23 (24.7)	59 (63.4)	1.51	8 (20.0)	1 (2.5)	31 (77.5)	1.58	27 (12.5)	36 (16.7)	153 (70.8)	1.58
High cost of planting material/ plant protection chemicals	10 (12.0)	19 (22.9)	54 (65.1)	1.53	10 (10.8)	18 (19.4)	65 (69.9)	1.59	11 (27.5)	2 (5.0)	27 (67.5)	1.40	31 (14.4)	39 (18.1)	146 (67.6)	1.53
Lack of adequate and timely disbursement of loan from financial institutions	17 (20.5)	4 (4.8)	62 (74.7)	1.54	15 (16.1)	27 (29.0)	51 (54.8)	1.39	10 (25.0)	10 (25.0)	20 (50.0)	1.25	42 (19.4)	41 (19.0)	133 (61.6)	1.42
High cost of transportation	17 (20.5)	26 (31.3)	40 (48.2)	1.28	17(18.3)	17 (18.3)	59 (63.4)	1.45	10 (25.0)	11 (27.5)	19 (47.5)	1.23	44 (20.4)	54 (25.0)	118 (54.6)	1.34

Poor accessibility to subsidy	12(14.5)	19 (22.9)	52 (62.7)	1.48	29 (31.2)	20 (21.5)	44 (47.3)	1.16	9 (22.5)	11 (27.5)	20 (50.0)	1.28	50 (23.1)	50 (23.1)	116 (53.7)	1.31
Absence of crop insurance scheme for crops cultivated	10 (12.0)	13 (15.7)	60 (72.3)	1.60	24 (25.8)	25 (26.9)	44 (47.3)	1.22	11 (27.5)	6 (15.0)	23 (57.5)	1.30	45 (20.8)	44 (20.4)	127 (58.8)	1.38
Marketing constraints																
Fluctuation in market prices due to glut in the market	8 (9.6)	9 (10.8)	66 (79.5)	1.70	10 (10.8)	29 (31.2)	54 (58.1)	1.47	9 (22.5)	6 (15.0)	25 (62.5)	1.40	27 (12.5)	44 (20.4)	145 (67.1)	1.55
Storage facilities to preserve crops before selling it off	14 (16.9)	14 (16.9)	55 (66.3)	1.49	15 (16.1)	31 (33.3)	47 (50.5)	1.34	13 (32.5)	12 (30.0)	15 (37.5)	1.05	42 (19.4)	57 (26.4)	117 (54.2)	1.35
Inadequate exclusive markets for crops grown under greenhouse	5 (6.0)	33 (39.8)	45 (54.2)	1.48	13 (14.0)	27 (29.0)	53 (57.0)	1.43	13 (32.5)	9 (22.5)	18 (45.0)	1.13	31 (14.4)	69 (31.9)	116 (53.7)	1.39
Existence of middle men between producers and final market	14 (16.9)	32 (38.6)	37 (44.6)	1.28	16 (17.2)	44 (47.3)	33 (35.5)	1.18	15 (37.5)	9 (22.5)	16 (40.0)	1.03	45 (20.8)	85 (39.4)	86 (39.8)	1.19
Difficulty in grading the produce to various sizes at the production level	20 (24.1)	43 (51.8)	20 (24.1)	1.00	32 (34.4)	38 (40.9)	23 (24.7)	0.90	12 (30.0)	12 (30.0)	8 (20.0)	0.70	72 (33.3)	93 (43.1)	51 (23.6)	0.90
Glut of crops in the market	10 (12.0)	10 (12.0)	63 (75.9)	1.64	22 (23.7)	23 (24.7)	48 (51.6)	1.28	13 (32.5)	6 (15.0)	21 (52.5)	1.20	45 (20.8)	39 (18.1)	132 (61.1)	1.40

SC= SEVERE CONSTRAINT, MC= MILD CONSTRAINT, NC= NOT A CONSTRAINT, WC=WEIGHTED MEAN

Source: Field survey (2018)

4.8 Respondents' Adoption of Greenhouse technology (GHT)

The study revealed that across the three states, the most adopted GHTs practiced by respondents were timely harvesting ($\bar{x}$ =2.64), sorting and packing of crops accordingly ($\bar{x}$ =2.63), Training, Staking and Trellising ($\bar{x}$ =2.54) and Land preparation/Integration of nutrients ($\bar{x}$ =2.53) (Table 4.8d). This implies that out of all the GHTs, timely harvesting seems to be a widely adopted practice across the three states. Timely harvesting is usually carried out when the tomato fruit is almost ripe. This was the response recorded by different greenhouse farm managers across the three states when asked about the stage of harvesting tomatoes in the greenhouse:

'Timely harvesting is normally carried out when the tomatoes are ***almost ripe*** *in order for the tomatoes to get to the market in good shape and in good condition so as to be able to attract good prices.'*

Tomatoes are well sorted out based on the size and condition at harvest. According to KII with a farm manager in Lagos State and also my observation during tomato sorting:

"The Tomatoes are sorted into big ones, medium and smaller ones. The big and medium ones are immediately transported to different supermarkets across or outside the state using cold vans in plastic baskets, while the smaller ones may be sold to different individuals or in local markets close by." 09-05-2018

Agronomic practices such as Training, Staking and Trellising were adopted to ensure that the weight of the tomatoes is not too heavy, thereby breaking off the stems. According to KII with different farm managers and agronomists in the three states and my observation during the survey;

Training, Staking and Trellising were carried out by attaching ropes vertically and horizontally from wooden or iron frames attached to the greenhouse structure and twisting the stems with budding tomatoes around the ropes as soon as they notice the fruits are budding and becoming big.

The process of land preparation and integration of nutrients into the soil in the greenhouse is usually tedious and hectic but is being carefully carried out. For maximum yield to be achieved, the necessary and compulsory procedures must be carried out (DFK Operational Manual, 2015).

The disaggregated data revealed that the common GHTs practices mostly adopted by respondents across the states were: timely harvest ($\bar{x}$ = (2.73, 2.63 and 2.48)) and sorting and packing of crops accordingly ($\bar{x}$ =(2.58, 2.72 and 2.53)) in Plateau, Lagos and Ogun states, respectively. In Plateau State, ‘mixing of the soil with decomposed manure’ ($\bar{x}$ =2.72), in Lagos and Ogun states, ‘the use of drip irrigation' ($\bar{x}$ =2.58 and 2.53) were also commonly adopted. The benefits of using the drip cannot be overemphasized as it is required to supply water and soluble fertilizers directly to the plant roots so that the roots can conserve their energy for production (DFK Manual, 2015).

However, in the three states, the least adopted practices were the treatment of water with hydrochloride ($\bar{x}$ =1.59), Use of plastic mulch/damp-proof ($\bar{x}$ =1.81), Soil analysis ($\bar{x}$ =1.87) and Manual pollination between 12 pm and 3 pm ($\bar{x}$ =1.92). The disaggregated data revealed that the least adopted GHTs practice common to the respondents across the states i.e. Plateau ($\bar{x}$ =1.04), Lagos ($\bar{x}$ =2.03) and Ogun ($\bar{x}$ =1.73) was the treatment of water with hypochlorite. Other GHTs practice not well adopted in Plateau and Lagos states include the ‘Use of plastic mulch’ ($\bar{x}$ =1.24 and $\bar{x}$ =2.11), while in Ogun State; use of Polyfeed/NPK after transplanting for the first 4weeks for at least once per week. The low adoption of plastic mulch for preventing soil infection may be as a result of their low knowledge in the aspect of ‘the use of plastic mulch for preventing soil infection.

Table 4.8a: Distribution of Plateau State Respondents Adoption of Greenhouse technology (GHT) (N=83)

S/N	S	ALWAYS USED F	%	SOMETIMES USING F	%	USED BUT DISCONTINUED F	%	NEVER USED F	%	MEAN
A.	**Land preparation stage**									
1	Land preparation/Integration of nutrients	62	74.7	13	15.7	0	0.0	8	9.6	2.55
2	Bed shaping	43	51.8	28	33.7	1	1.2	11	13.3	2.24
3	Soil analysis	31	37.3	31	37.3	3	3.6	31	37.3	1.43
4	Mixing of the soil with decomposed manure	68	81.9	11	13.3	0	0.0	4	4.8	2.72
5	Soil and manure sterilization	18	21.7	31	37.3	3	3.6	31	37.3	1.43
6	Potting/bagging to at least 3/4bag full	36	43.4	25	30.1	2	2.4	20	24.1	1.93
7	Use of plastic mulch (Use of damp proof)	16	19.3	22	26.5	11	13.3	34	41.0	1.24
B.	**Irrigation stage**									
8	Use of drip irrigation	27	32.5	27	32.5	1	1.2	28	33.7	1.64
9	Treatment of water with hypochlorite	9	10.8	27	32.5	5	6.0	42	50.6	1.04
10	Transplanting (Irrigate soil very well before transplanting)	57	68.7	7	8.4	1	1.2	18	21.7	2.24
C.	**Nutrients and Fertilizer application**									
11	Use of Smart fertilizer (SF)	33	39.8	24	28.9	2	2.4	24	28.9	1.80
12	NPK (15:15:15) in split application per plant after transplanting	44	53.0	27	32.5	3	3.6	9	10.8	2.28
13	NPK (15:15:15) in split application per plant after 5th month	27	32.5	27	32.5	2	2.4	27	32.5	1.65
14	Use of Polyfeed/NPK after transplanting for the first 4weeks for at least once per week	33	39.8	30	36.1	3	3.6	17	20.5	1.95
15	Use of Multi-K (Potassium Nitrate) for at least once per week from the 4th week of transplanting	41	49.4	20	24.1	2	2.4	20	24.1	1.99
16	Use of Haifa Cal. (Calcium Nitrate) at Top dressing of crops after 3-4weeks from transplanting per plant as a ring band and to be covered with soil after application	30	36.1	20	24.1	5	6.0	28	33.7	1.63
D.	**Vegetative development stage**	65	78.3	8	9.6	2	2.4	8	9.6	2.57
17	Training, Staking and Trellising									
18	De-suckering	60	72.3	12	14.5	1	1.2	10	12.0	2.47
19	Manual pollination between 12pm and 3pm	28	33.7	23	27.7	2	2.4	30	36.1	1.59
20	Hand Weeding	63	75.9	10	12.0	2	2.4	8	9.6	2.54
21	Defoliation	46	55.4	23	27.7	2	2.4	12	14.5	2.24
22	Apply appropriate pesticides	54	65.1	20	24.1	1	1.2	8	9.6	2.45
E.	**Fruiting and Harvesting stage**									
23	Apply Fruit Setting Solution twice weekly	18	21.7	33	39.8	7	8.4	25	30.1	1.53
24	Timely harvesting	70	84.3	8	9.6	1	1.2	4	4.8	2.73
25	Sorting and Packing of crops accordingly	61	73.5	15	18.1	1	1.2	6	7.2	2.58

Source: Field survey (2018)

Table 4.8b: Distribution of Lagos State Respondents Adoption of Greenhouse technology (GHT) (N=93)

S/N		ALWAYS USED		SOMETIMES USING		USED BUT DISCONTINUED		NEVER USED		MEAN
		F	%	F	%	F	%	F	%	
A.	**Land preparation stage**									
1	Land preparation/Integration of nutrients	69	74.2	15	16.1	1	1.1	8	8.6	2.56
2	Bed shaping	58	62.4	24	25.8	2	2.2	9	9.7	2.41
3	Soil analysis	42	45.2	38	40.9	0	0.0	13	14.0	2.17
4	Mixing of the soil with decomposed manure	50	53.8	22	23.7	2	2.2	19	20.4	2.11
5	Soil and manure sterilization	55	59.1	21	22.6	2	2.2	15	16.1	2.25
6	Potting/bagging to at least 3/4bag full	46	49.5	32	34.4	1	1.1	14	15.1	2.18
7	Use of plastic mulch (Use of damp proof)	53	57.0	17	18.3	3	3.2	20	21.5	2.11
B.	I**rrigation stage**									
8	Use of drip irrigation	75	80.6	7	7.5	1	1.1	10	10.8	2.58
9	Treatment of water with hypochlorite	32	34.4	46	49.5	1	1.11	14	15.1	2.03
10	Transplanting (Irrigate soil very well before transplanting)	33	35.5	36	38.7	6	6.5	18	19.4	1.90
C.	**Nutrients and Fertilizer application**									
11	Use of Smart fertilizer (SF)	66	71.0	14	15.1	5	5.4	8	8.6	2.48
12	NPK (15:15:15) in split application per plant after transplanting	66	71.0	14	15.1	2	2.2	11	11.8	2.45
13	NPK (15:15:15) in split application per plant after 5th month	52	55.9	22	23.7	10	10.8	9	9.7	2.25
14	Use of Polyfeed/NPK after transplanting for the first 4weeks for at least once per week	56	60.2	22	23.7	6	6.5	9	9.7	2.34
15	Use of Multi-K (Potassium Nitrate) for at least once per week from the 4th week of transplanting	53	57.0	20	21.5	8	8.6	12	12.9	2.23
16	Use of Haifa Cal. (Calcium Nitrate) at Top dressing of crops after 3-4weeks from transplanting per plant as a ring band and to be covered with soil after application	60	64.5	16	17.2	4	4.3	13	14.0	2.32
D.	**Vegetative development stage**									
17	Training, Staking and Trellising	70	75.3	13	14.0	2	2.2	8	8.6	2.56
18	De-suckering	53	57.0	18	30.1	3	3.2	9	9.7	2.34
19	Manual pollination between 12pm and 3pm	45	48.4	34	36.5	1	1.1	13	14.0	2.19
20	Hand Weeding	64	68.8	16	17.2	4	4.3	9	9.7	2.45
21	Defoliation	63	67.7	18	19.4	2	2.2	10	10.8	2.44
22	Apply appropriate pesticides	66	71.0	17	18.2	1	1.1	9	9.7	2.51
E.	**Fruiting and Harvesting stage**									
23	Apply Fruit Setting Solution twice weekly	54	58.1	28	30.1	1	1.1	10	10.7	2.35
24	Timely harvesting	76	81.7	8	8.6	1	1.1	8	8.6	2.63
25	Sorting and Packing of crops accordingly	81	87.1	5	5.4	0	0.0	7	7.5	2.72

Source: Field survey (2018)

Table 4.8c: Distribution of the Ogun State Respondents' Adoption of Greenhouse technology (GHT) (N=40)

S/N		ALWAYS USED		SOMETIMES USING		USED BUT DISCONTINUED		NEVER USED		MEAN
		F	%	F	%	F	%	F	%	
A.	**Land preparation stage**									
1	Land preparation/Integration of nutrients	28	70.0	6	15.0	0	0.0	6	15.0	2.40
2	Bed shaping	24	60.0	9	22.5	0	0.0	7	17.5	2.25
3	Soil analysis	18	45.0	13	32.5	2	5.0	7	17.5	2.05
4	Mixing of the soil with decomposed manure	25	62.5	6	15.0	0	0.0	9	22.5	2.17
5	Soil and manure sterilization	21	52.5	14	35.0	1	2.5	4	10.0	2.30
6	Potting/bagging to at least 3/4bag full	31	77.5	1	2.5	1	2.5	7	17.5	2.40
7	Use of plastic mulch (Use of damp proof)	21	52.5	14	35.0	1	2.5	4	10.0	2.30
B.	**Irrigation stage**									
8	Use of drip irrigation	33	82.5	1	2.5	0	0.0	6	15.0	2.53
9	Treatment of water with hypochlorite	17	42.5	8	20.0	2	5.0	13	32.5	1.73
10	Transplanting (Irrigate soil very well before transplanting)	20	50.0	8	20.0	3	7.5	9	22.5	1.98
C.	**Nutrients and Fertilizer application**									
11	Use of Smart fertilizer (SF)	31	77.5	1	2.5	0	0.0	8	20.0	2.38
12	NPK (15:15:15) in split application per plant after transplanting	27	67.5	4	10.0	3	7.5	6	15.0	2.30
13	NPK (15:15:15) in split application per plant after 5th month	18	45.0	11	27.5	4	10.0	7	17.5	2.00
14	Use of Polyfeed/NPK after transplanting for the first 4weeks for at least once per week	15	37.5	9	22.5	2	5.0	14	35.0	1.63
15	Use of Multi-K (Potassium Nitrate) for at least once per week from the 4th week of transplanting	19	47.5	11	27.5	3	7.5	7	17.5	2.05
16	Use of Haifa Cal. (Calcium Nitrate) at Top dressing of crops after 3-4weeks from transplanting per plant as a ring band and to be covered with soil after application	19	47.5	9	22.5	1	2.5	11	27.5	1.90
D.	**Vegetative development stage**									
17	Training, Staking and Trellising	29	72.5	5	12.5	0	0.0	6	15.0	2.43
18	De-suckering	23	57.5	7	17.5	0	0.0	10	25.0	2.08
19	Manual pollination between 12pm and 3pm	18	45.0	12	30.0	1	2.5	9	22.5	1.98
20	Hand Weeding	21	52.5	12	30.0	0	0.0	7	17.5	2.18
21	Defoliation	21	52.5	11	27.5	0	0.0	8	20.0	2.13
22	Apply appropriate pesticides	29	72.5	5	12.5	1	2.5	5	12.5	2.45
E.	**Fruiting and Harvesting stage**									
23	Apply Fruit Setting Solution twice weekly	23	57.5	11	27.5	0	0.0	6	15.0	2.28
24	Timely harvesting	29	72.5	6	15.0	0	0.0	5	12.5	2.48
25	Sorting and Packing of crops accordingly	31	77.5	4	10.0	0	0.0	5	12.5	2.53

Source: Field survey (2018)

Table 4.8d: Distribution of the Total Respondents Adoption of Greenhouse technology (GHT) (N=216)

S/N		ALWAYS USED		SOMETIMES USING		USED BUT DISCONTINUED		NEVER USED		MEAN
		F	%	F	%	F	%	F	%	
A.	**Land preparation stage**									
1	Land preparation/Integration of nutrients	159	73.6	34	15.7	1	0.5	22	10.2	2.53
2	Bed shaping	125	57.9	61	28.2	3	1.4	27	12.5	2.31
3	Soil analysis	78	36.1	82	38.0	5	2.3	51	23.6	1.87
4	Mixing of the soil with decomposed manure	143	66.2	39	18.1	2	0.9	32	14.8	2.36
5	Soil and manure sterilization	94	43.5	66	30.6	6	2.8	50	23.1	1.94
6	Potting/bagging to at least 3/4bag full	113	52.3	58	26.9	4	1.9	41	19.0	2.13
7	Use of plastic mulch (Use of damp proof)	90	41.7	53	24.5	15	6.9	58	26.9	1.81
B.	**Irrigation stage**									
8	Use of drip irrigation	135	62.5	35	16.2	2	0.9	44	20.4	2.21
9	Treatment of water with hypochlorite	58	26.9	81	37.5	8	3.7	69	31.9	1.59
10	Transplanting (Irrigate soil very well before transplanting)	110	50.9	51	23.6	10	4.6	45	20.8	2.05
C.	**Nutrients and Fertilizer application**									
11	Use of Smart fertilizer (SF)	130	60.2	39	18.1	7	3.2	40	18.5	2.20
12	NPK (15:15:15) in split application per plant after transplanting	137	63.4	45	20.8	8	3.7	45	20.8	2.36
13	NPK (15:15:15) in split application per plant after 5th month	97	44.9	60	27.8	16	7.4	43	19.9	1.98
14	Use of Polyfeed/NPK after transplanting for the first 4weeks for at least once per week	104	48.1	61	28.2	11	5.1	40	18.5	2.06
15	Use of Multi-K (Potassium Nitrate) for at least once per week from the 4th week of transplanting	113	52.3	51	23.6	13	6.0	39	18.1	2.10
16	Use of Haifa Cal. (Calcium Nitrate) at Top dressing of crops after 3-4weeks from transplanting per plant as a ring band and to be covered with soil after application	109	50.5	45	20.8	10	4.6	52	24.1	1.98
D.	**Vegetative development stage**									
17	Training, Staking and Trellising	164	75.9	26	12.0	4	1.9	22	10.2	2.54
18	De-suckering	136	63.0	47	21.8	4	1.9	29	13.4	2.34
19	Manual pollination between 12pm and 3pm	91	42.1	69	31.9	4	1.9	52	24.1	1.92
20	Hand Weeding	148	68.5	38	17.6	6	2.8	24	11.1	2.44
21	Defoliation	130	60.1	52	24.1	4	1.9	30	13.9	2.31
22	Apply appropriate pesticides	149	69.0	42	19.4	3	1.4	22	10.2	2.47
E.	**Fruiting and Harvesting stage**									
23	Apply Fruit Setting Solution twice weekly	95	44.0	72	33.3	8	3.7	41	19.0	2.02
24	Timely harvesting	175	81.0	22	10.2	2	0.9	17	7.9	2.64
25	Sorting and Packing of crops accordingly	173	80.1	24	11.1	1	0.5	18	8.3	2.63

Source: Field survey (2018)

4.8.1 Respondents' Level of Adoption of Greenhouse Technology (GHT)

According to Table 4.8e, more than half (53.2%) of the respondents had a high degree of adoption of greenhouse technology. Adoption level across all the study locations showed that there was high adoption (78.5 and 67.5%) in Lagos and Ogun, respectively but low adoption (18.1%) in Plateau state. The high level of GHTs adoption by respondents in Lagos and Ogun could be as a result of the positive attitude of farmers in those areas to the use of greenhouse technology. Also, most of the greenhouses used by farmers in the Lagos and Ogun states were of the high-cost greenhouses which were capital intensive. In order to be able to realize the capital invested into the purchase of greenhouses within a year as proposed and calculated by the greenhouse service providers, the greenhouse farmers involved put in their best so as to be able to realize back the capital. The high level of adoption could be as a result of their preferred sources of information, which primarily are the greenhouse service providers.

Furthermore, the demand for greenhouse tomatoes was very high in Lagos and Ogun states; therefore greenhouse farmers intensified their use of GHTs in order to satisfy market demand and avoid supply shortages, resulting in their favorable attitude toward the use of GHTs and sufficient management methods. However, the low level of positive attitude towards the use of greenhouse among respondents in Plateau State could have negatively influenced their adoption of greenhouse technology as their major customers were private individuals and buyers at the farm gate. The customers are not fixed constant ones like supermarkets, except for those who transport their greenhouse tomatoes to large stores and supermarkets outside Plateau State. Another reason that could have affected the adoption of the respondents in Plateau State to GHTs might be their use of low and medium-cost types of greenhouses. Also, not sourcing information on GHTs directly from the service providers but from fellow farmers could be another reason.

Table 4.8e: Categorisation of Respondents' level of Adoption of GHTs

Adoption level	Plateau (n=83)		Lagos (n=93)		Ogun (n=40)		Total (n=216)		Minimum	Maximum	Mean	SD
	F	%	F	%	F	%	F	%				
Low (0-58.99)	68	81.9	20	21.5	13	32.5	101	46.8	23.00	75.00	59.00	9.75
High (59.00-75.00)	15	18.1	73	78.5	27	67.5	115	53.2				
Mean ± SD	52.49±8.52		63.65±7.31		61.70±9.79							

Source: Field survey (2018)

4.9 HYPOTHESES

4.9.1: Test of correlation between selected respondents' characteristics and the level of GHTs adoption

The overall result on Table 4.9a showed significant relationship between marital status (χ^2=8.720, p=0.033), membership of social groups (χ^2=10.727, p=0.001); while no significant relationship existed between, sex, religion, the primary income generating activities of respondents; 'other income generating activities' of respondents and adoption of greenhouse technology. This implies that people's sex (male or female) and religion, as well as their primary activity and "other income-generating activities," do not necessarily influence their adoption of greenhouse technology. The significance of marital status and adoption of GHTs implies that greenhouse farming can serve as a profitable source of livelihood to married individuals since married people are with higher responsibilities and they make up the majority of the greenhouse farmers in the study area. This was confirmed by Jain (2017), who stated that being married indicates that they are accountable for family welfare and must earn a considerable amount of money from agriculture to maintain their families. The correlation between membership of social groups and adoption of greenhouse technology implies that their membership in social groups will give them quick access to quality information, social networks, safety nets and credits needed to expand their business. Auta (2012) reported that farmers are usually attracted to joining informal groups if they consider that being members of such groups will help to meet their needs.

Disaggregating the results across the state showed a significant connection between social group membership (χ^2=4.902, p=0.027) and adoption of greenhouse technology in Lagos state. This implies that the respondents in Lagos State are liable to have access to safety nets, information and credits to promote their adoption of GHTs as they participate and relate with other members of their social groups. However, no significant relationship existed between marital status, sex, religion, primary and 'other income-generating activities' of respondents, membership of social groups (in Plateau and Ogun states) and adoption of greenhouse technology in Plateau, Ogun and Lagos states.

The result on Table 4.9b also revealed that overall, age (r=-0.267, p=0.000), household size (r=-0.226, p=0.001), years of farming experience (r=-0.160, p=0.018) and the average income generated monthly from primary income-generating activities (r=-0.302, p=0.000) were significantly related to the adoption of GHT. While the years of education (r=-0.018, p=0.788), years of involvement in greenhouse farming (r=-0.047, p=0.495) and the average income generated from the other income-generating activities per month (r=-0.105, p=0.125) were not significant.

The significant but negative correlation between age and adoption implies that the younger the age of the greenhouse farmers, the more the adoption of GHTs and vice-versa. This may be because greenhouse technology is relatively new to the farming communities and thus, younger farmers tend to adopt it more than the older farmers. This is according to Rogers *et al.* (2017) that older individuals tend to slowly adopt new technology than the youths. This result is also in consonance with Udimal *et al.* (2017) that as farmers advance in age, their tendencies to adopt new technology decreases as compared to the young farmers

The negative sign of the relationship between household size and adoption of GHT suggests that farmers with smaller household sizes are more likely to embrace greenhouse technology than farmers with larger household sizes. This may be because farmers with large households will consider the risk and cost of investing in greenhouse technology which may negatively affect the welfare of the family members. According to Tijani *et al.* (2010), farmers with larger household sizes may make use of the assistance from their family members as a form of labor on the farm. But in a situation where there are other sources of labour and the distance to the farm is far, having a large household for agricultural purposes may not be relevant. As such, farmers could be reluctant to invest in a high-cost technology like greenhouse technology so as not to jeopardize the welfare of the family. This is buttressed by Mekonnen (2017) that a negatively significant effect exists between large household sizes on welfare outcomes. Hence, large family size negatively affects consumption and as such, a farmer may not want to invest greatly in an innovation that may jeopardize the welfare of his large household.

Several years of expertise in a certain agricultural operation indicates a wealth of ideas that might assist farmers in deciding whether to embrace or reject an innovation. Farmers have over time relied on personal experience or on that of fellow farmers concerning the adoption of good agricultural practices. The negative correlation between years of farming experience and adoption of greenhouse technology, therefore, infers that the greater the farming experience a farmer possesses, the lesser the chances he would adopt the greenhouse technology. An explainable reason for this could be that it is not necessary for someone aiming to be a greenhouse farmer to be previously involved in farming before they can be involved in the use of greenhouse technology. As long as a farmer is well trained in the use of greenhouse technology and is being assisted by an agronomist or the greenhouse service provider, anyone can go into greenhouse farming and still be very successful.

Therefore, farmers do not need to have long years of involvement in conventional farming before adopting greenhouse technology. It has also been observed that experienced farmers are less likely to adopt the information or knowledge-intensive practices (such as greenhouse technology), as they are less willing to change their farming practices relative to younger farmers who possess less experience (OECD, 2001). This finding contradicts the findings of Danso-Abbeam *et al*. (2017), who found that because farming is primarily about field labor, farmers with more years of farming experience embrace innovations quicker than farmers with fewer years of farming experience.

The negative significance between the average income generated monthly from primary income-generating activities and adoption of GHT implies that the smaller the income, the more the adoption of GHT. This could be due to the fact that the majority of respondents, particularly in Lagos and Ogun states were hired workers who, despite earning a small fixed salary to make ends meet, were still compelled to engage in all GHT activities and practices. This is done in order to meet market targets and ensure that farm owners maximize their profits in order to keep their jobs. Thus, despite the meager income earned by the majority of the greenhouse farmers, they still choose to adopt GHTs to the fullest to be able to make a living. This is contrary to the findings of Diiro and Sam (2015) that technology adoption is a basic means for rural households to increase agricultural income and escape poverty.

Disaggregating data among states, there was a substantial (r = -0.238, p=0.030) but a negative connection between household size and greenhouse technology adoption in Plateau State. There is no significant relationship between age, farming experience, years of schooling, years of engagement in greenhouse farming and average monthly revenue earned from primary income-generating activities and adoption of greenhouse technology. This implies that farmers with small household sizes are more likely to adopt greenhouse technology than farmers with larger household sizes (Mekonnen, 2017).

In Lagos State, there is a positive association between education and adoption of GHTs (r=0.276, p=0.007). The positive relationship of the years of education (r=0.276, p=0.007) and adoption of GHTs in Lagos State imply that the more educated the greenhouse farmers are in the state, the more the adoption of GHTs. This is in line with Paltasingh and Goyari (2018) that education is a great determinant of the likelihood to adopt new technology. This may be because most of the farmers involved in the technology are well-read. Lagos State government also carried out an Agricultural Youth Empowerment Scheme (AGRIC-YES), out of which the curricula involved allocating some portions of the greenhouse structure to the students for crop production.

In Ogun State, there is no significant association between age, household size, years of schooling, farming experience, years of engagement in greenhouse farming, the average monthly revenue from main activity and greenhouse technology adoption. This shows that age, household size, years of education, farming experience, years of involvement in greenhouse farming and average income from primary activity per month did not have any influence on the adoption of greenhouse technology within the state.

Table 4.9a: Chi-square result of the correlation between selected personal characteristics of the respondents' and the level of GHTs adoption

	Plateau				Lagos				Ogun				Total			
Variables	χ^2	Df	p-value	D	χ^2	Df	p-value	D	χ^2	df	p-value	D	χ^2	df	p-value	D
Sex	2.003	1	0.157	NS	0.126	1	0.723	NS	1.823	1	0.177	NS	0.236	1	0.627	NS
Marital status	1.615	3	0.656	NS	0.319	2	0.853	NS	0.311	1	0.577	NS	8.720	3	0.033	S
Religion	0.687	1	0.407	NS	0.003	1	0.957	NS	0.342	1	0.559	NS	2.314	1	0.128	NS
Members of social groups	1.370	1	0.242	NS	4.902	1	0.027	S	0.189	1	0.664	NS	10.727	1	0.001	S
Primary income generating activity	13.401	14	0.495	NS	8.070	11	0.707	NS	10.533	6	0.104	NS	16.440	21	0.744	NS
Other income generating activities	10.595	13	0.645	NS	20.024	12	0.067	NS	5.939	7	0.547	NS	16.730	16	0.403	NS

Source: Field survey (2018)

Table 4.9b: PPMC result of the correlation between selected personal characteristics of the respondents' and the level of GHTs adoption

VARIABLES	Plateau			Lagos			Ogun			Total		
	R-value	p-value	D	R-value	p-value	D	R-value	p-value	D	R-value	p-value	D
Age	-0.113	0.310	NS	-0.007	0.943	NS	0.090	0.579	NS	-0.267**	0.000	S
Household size	-0.238*	0.030	S	0.117	0.265	NS	0.077	0.638	NS	-0.226**	0.001	S
Education	-0.160	0.149	NS	0.276**	0.007	S	0.079	0.626	NS	-0.018	0.788	NS
Farming experience	-0.036	0.747	NS	0.113	0.280	NS	0.094	0.562	NS	-0.160*	0.018	S
Years of involvement in green house farming	-0.052	0.640	NS	0.012	0.910	NS	-0.163	0.315	NS	-0.047	0.495	NS
Average income from primary activity	-0.099	0.374	NS	-0.174	0.095	NS	-0.059	0.719	NS	-0.302**	0.000	S

* Correlation is significant at the 0.05 level (2-tailed).

Source: Field survey (2018)

4.9.2: Test of the relationship between selected farm enterprise characteristics of the respondents' and the level of GHTs adoption

The overall result of the three states on Table 4.9c revealed that there is a significant correlation between ownership status of greenhouse structure (χ^2=12.157, p=0.016), sources of planting materials (χ^2=22.573, p=0.000), the type of GH structure used (χ^2=33.468, p=0.000), the type of labour used for greenhouse tomato farming used (χ^2=9.703, p=0.021) and adoption of GHTs. However, no significant relationship existed between the methods of cultivating tomatoes in the greenhouse and access to information from Extension Agents and adoption of GHTs. The significance of the sources of planting materials to the adoption of GHTs implies that the more accessible the planting materials needed for the effective use of GHTs from the point of purchase, the higher the adoption of most aspects of the technology by the greenhouse farmers. This can be seen as most of the greenhouse farmers access their planting materials from agro-dealers.

The significance of the type of labour used for greenhouse tomato farming to the adoption of GHTs implies that the higher the availability of labour, the higher the adoption of GHTs by the greenhouse farmers. In this study, labour in form of hired labour was mostly used to carry out the tedious management practices required for the smooth running of the greenhouse. The relationship between the type of GH structure used and adoption of GHTs implies that the more sophisticated the greenhouses, the more intensive the management practices involved and the more the adoption of GHTs in order to recoup the capital invested into the greenhouse business. The relationship between the Ownership status of greenhouse structure and adoption of GHTs implies that the ownership of the greenhouse structure will encourage the profitable use of all aspects of the GHTs.

Disaggregating the result into different states, there is a significant relationship between greenhouse structure ownership and GHT adoption in Lagos (χ^2=14.214, p=0.007), but no significant relationship exists between the type of GH structures used; Sources of planting materials, type of labour used for greenhouse tomato farming, the methods of planting tomatoes in the greenhouse and access to information from Extension Agents and adoption of GHTs. This indicates that most of the greenhouse farmers in Lagos State are farmers working for the owners of the technology and must adopt every aspect of the technology as specified by the owners and managers of the greenhouse farm in order to earn a living. However, majority of the greenhouses in Plateau and Ogun states are being owned, maintained and managed by the owners. The non-significance of the type of GH structures used; sources of planting materials, type of labour used for greenhouse tomato farming, the methods of planting tomatoes in the greenhouse and access to information from Extension Agents and adoption of GHTs implies that they did not have any effect on the adoption of GHTs in anyway.

A significant relationship also existed between the type of GH structures used and adoption of GHTs in Plateau State (χ^2=10.042, p=0.007) and Ogun State (χ^2=11.420, p=0.003). No significant relationship was observed between ownership status of greenhouse structure, sources of planting materials, type of labour used for greenhouse tomato farming, the methods of planting tomatoes in the greenhouse and access to information from Extension Agents and adoption of GHTs. This implies that the more sophisticated the type of GH structure, the more the adoption of GHTs to be able to get the best from the use of the technology.

The Pearson Product Moment Correlation (PPMC) result for the three states on Table 4.9d revealed a significant relationship between greenhouse tomato pricing during off-season (r=0.172, p=0.012) and on-season (r=0.199, p=0.003) and GHTs adoption. Also, a significant relationship existed between the prices of greenhouse tomatoes during the off-season only in Lagos State (r=0.214, p=0.039). This suggests that the increase in prices derived from greenhouse tomatoes during the off-season and occasionally during on-season motivated the adoption of GHTs by the respondents in the three states, especially in Lagos State.

Though the bulk of the tomatoes cultivated in the greenhouse are targeted towards the off-season, we still cultivate tomatoes during the on-seasons to meet our customers' demand (KII, Epe, Lagos State). 09-05-2018

There was no significant relationship between farm size used for greenhouse farming; the average tomato yield and adoption of GHTs.

Table 4.9c: Chi-square result of the correlation between selected farm enterprise characteristics of the respondents' and the level of GHTs adoption

VARIABLES	Plateau				Lagos				Ogun				Total			
	χ^2	Df	p-value	D	χ^2	Df	p-value	D	χ^2	Df	p-value	D	χ^2	Df	p-value	D
Ownership status of Greenhouse structure	2.819	3	0.420	NS	14.214	4	0.007	S	3.643	4	0.456	NS	12.157	4	0.016	S
Sources of planting material	4.917	4	0.296	NS	6.166	5	0.290	NS	3.291	4	0.510	NS	22.573	5	0.000	S
Type of GH structure used	10.042	2	0.007	S	3.349	2	0.187	NS	11.420	2	0.003	S	33.468	2	0.000	S
Type of labour used	1.556	3	0.669	NS	3.748	2	0.153	NS	2.326	3	0.508	NS	9.703	3	0.021	S
Methods of planting tomatoes in the greenhouse	2.870	3	0.412	NS	1.846	2	0.397	NS	0.546	2	0.761	NS	2.996	3	0.392	NS
Information from Extension Agents	2.461	2	0.292	NS	3.719	2	0.156	NS	3.381	2	0.184	NS	1.257	2	0.533	NS

Source: Field survey (2018)

Table 4.9d: PPMC result of the correlation between selected farm enterprise characteristics of the respondents' and the level of GHTs adoption

VARIABLES	Plateau			Lagos			Ogun			Total		
	R-value	p-value	D	R-value	p-value	D	R-value	p-value	D	R-value	p-value	**D**
Greenhouse farm size	-0.035	0.751	NS	-0.066	0.527	NS	0.190	0.239	NS	0.058	0.395	NS
Average Tomato yield/stand	0.025	0.820	NS	-0.200	0.055	NS	0.097	0.552	NS	-0.039	0.564	NS
Price during off-season	-0.017	0.880	NS	0.214	0.039	S	0.109	0.502	NS	0.172	0.012	S
Price during on season	-0.064	0.568	NS	-0.040	0.706	NS	0.214	0.184	NS	0.199	0.003	S

Source: Field survey (2018)

4.9.3: Test of the relationship between respondents' level of knowledge of the activities involved in operating greenhouse technology and the level of GHTs adoption

Results on Table 4.9e showed that there was a substantial and positive association between respondents' understanding of greenhouse technologies and their adoption of greenhouse technology (r=0.265, p=0.000). This suggests that the farmers had a sufficient understanding of the benefits of greenhouse farming as well as greenhouse farming management techniques, which impacted their adoption of greenhouse technology. Farmers in Lagos (r=0.216, p=0.037) and Ogun (r=0.427, p=0.0506) had a significant association, but farmers in Plateau had no significant relationship between knowledge and use of greenhouse technology (r=0.075, p=0.503). This implies that farmers in Lagos and Ogun states have adequate knowledge of benefits and management practices of greenhouse farming while farmers in Plateau State have inadequate knowledge of benefits or management practices of greenhouse technologies.

According to Vejlgaard (2018), knowledge is crucial in innovation dissemination since it is a critical component of the decision-making process for adopting new technologies. It also implies that having adequate knowledge of technology is essential for the management and adoption of the technology. Therefore, having adequate knowledge of greenhouse technologies by the respondents would not only determine their decision to undertake or operate a greenhouse enterprise but also enhance their decision to adopt the latest innovations that can improve their productivity. This finding corroborates Etuk *et al.* (2013) who asserted that the education of farmers on technologies is important in the adoption and utilization of innovation. Oluwayemisi *et al.* (2017) also posited that the positive relationship that existed between knowledge on the usage of enhanced maize seed types and technology adoption showed that farmers must be taught and trained on how to utilize better technologies. Danso-Abbeam *et al.* (2017) also proposed that farmers who have the opportunity to attend agricultural conferences, seminars and workshops organized by international and local NGOs are exposed to new farm processes, their benefits and cultivation process, which increase their knowledge level and their zeal for adoption.

Hence, inadequate knowledge about greenhouse farming practices may give farmers a negative perception about it which would discourage the decision to adopt, irrespective of any potential inherent benefits. In addition, the unfavourable attitude reflected in the respondents of Plateau State compared to other states towards greenhouse technologies as earlier observed can be traced to the farmers having less knowledge of greenhouse technologies when compared with the level of knowledge of farmers from the other two states. Consequently, knowledge is a key predictor of the decision to adopt management practices, especially for technologies where there is a relatively ample time difference between adoption and impact (Dwasi, 2017).

Furthermore, it might be due to the type of greenhouse structure used within the states and the management practices involved in their use. Most of the structures used in Plateau State were medium-cost greenhouses and the knowledge on how to use the GHT is being passed across to the farmers through fellow farmers and the greenhouse personnel in charge of the greenhouse construction. But in Lagos and Ogun states, most of the greenhouse structures used are of the high-cost greenhouses. These are directly purchased from renowned greenhouse service providers in the state(s) who trained the farmers and still conduct regular seminars and training to update their knowledge. Also, a trained agronomist is attached to farmers who purchased up to five (5) greenhouse kits for a whole year.

According to the KII (DIZENGOFF NIGERIA), it is our duty to install and train farmers in the use of greenhouse technology and we attached an agronomist that has been trained in the use of greenhouse technology to farmers who purchase up to five kits. (06-10-2016).

Table 4.9e: Correlation between respondents' level of knowledge of the activities involved in operating greenhouse technology and the level of GHTs adoption

VARIABLES	Plateau			Lagos			Ogun			Total		
	R-value	p-value	D	R-value	p-value	D	R-value	p-value	D	R-value	p-value	D
Knowledge	0.075	0.503	NS	0.216	0.037	S	0.427	0.006	S	0.265	0.000	S

*Correlation is significant at the 0.05 level (2-tailed)

Source: Field survey (2018)

4.9.4: Test of difference in the management practices involved in the use of GHTs based on the type of greenhouse structure used for tomato cultivation

The ANOVA result on Table 4.9f revealed a significant difference (F=11.842, p=<0.000) in the management practices involved with GHTs based on the type of greenhouse structure used for tomato farming across the three sampled states. This means that management practices vary with the type of greenhouse structure used. This implies that the type of greenhouse structure used will determine how rigorous the management activities to be carried out in such a greenhouse structure would be. It can be inferred that crops/vegetables produced using the imported structures would be well managed and the management practices may be more rigorous and detailed. This is due to the fact that a farmer investing and purchasing an imported greenhouse kit would have gathered enough knowledge before investing in it and would have ensured that the farmers working on the kit are well trained in the use of GHTs, so as to realize back on time the large money/capital invested into purchasing the kit without running at a loss. While the management practices/activities carried out by a greenhouse farmer using the medium cost greenhouse might also be rigorous, but the intensity may not be as much as that of the farmer working with/using the imported type of greenhouse structure. Consequently, a large difference is expected to be between the management practices exerted by farmers using a low-cost greenhouse structure and that of an imported and medium-cost greenhouse structure.

The result of Duncan test presented on (Table 4.9g) further showed a separation of means across the three types of GH structures available for tomato production. It revealed that the management practices carried out by the respondents using imported GH structures significantly differed ($\bar{x} \pm$ SD =5.17±1.17) from those using medium-cost greenhouses ($\bar{x} \pm$ SD =4.39±1.19) and low-cost greenhouses $\bar{x} \pm$ SD =4.36±1.22). It revealed that the level of management of practices involved with the use of GHTs was highest for respondents using the imported type of GH structures, followed by those using medium-cost types and lastly those using the low-cost greenhouses.

Table 4.9f: Analysis of variance on the management practices involved in the use of GHTs based on the type of greenhouse structure used for tomato cultivation

Variable		Sum of squares	Df	Mean square	F	Sig
Management practices	Between groups	33.247	2	16.623	11.842	0.000
	Within groups	299.007	213	1.404		
	Total	332.254	215			

Source: Field survey (2018)

Table 4.9g: Post Hoc (Duncan Multiple Range Test DMRT) showing the difference in management practices involved in the use of GHTs based on the type of greenhouse structure used for tomato cultivation

Type of greenhouse structure	N	Management Subset for alpha =0.05		
		1	2	3
Low cost greenhouses	28	4.356±1.22		
Medium cost greenhouses	85		4.391±1.19	
Imported type	103			5.167±1.17
Sig.		0.882	0.882	1.000

Source: Field survey (2018)

4.9.5.1: Test of difference in the yield of farmers based on the type of greenhouse structure used for tomato cultivation

The ANOVA result on Table 4.9h revealed that there was no significant difference ($F=0.159$, $p=0.853$) in the yield of tomatoes cultivated based on the type of greenhouse structures used. This indicates that irrespective of the type of greenhouse structure used, the yield from greenhouse farming may be the same. The yield from the imported GH structures would normally have been assumed to be more than those from the medium cost and low-cost greenhouses. However, the consistency of the routine management practices carried out within the GHTs seems to largely determine the tomato yield than the type of the structures used. This was observed in the yield obtained by the ASTC GH farmers (in Plateau State) as well as the greenhouse farmers in the AGRIC YES scheme (Lagos State) who made use of imported and sophisticated GH structures provided by the government but which are poorly managed by those in charge of the technology. Their yields were relatively low compared to their counterparts using imported GH structures owned by private individuals in Lagos and Ogun states. Hence, the basic determinant of the yield in GHTs is about how well the routine management practices are being carried out.

The post hoc test on Table 4.9i further revealed that though there was no significant difference in the tomato yield based on the type of greenhouse structure used. The yield of the imported greenhouse structure ($\bar{x} \pm \mathrm{SD} = 7.50 \pm 4.74$) was not so significantly different from those of the medium cost greenhouses ($\bar{x} \pm \mathrm{SD} = 7.24 \pm 3.81$) and the yield obtained using the medium cost greenhouses was not much from the low-cost greenhouse ($\bar{x} \pm \mathrm{SD} = 7.07 \pm 3.53$). Though the yield obtained from the imported type could not be compared with the low-cost greenhouses, it was still within the same range. This is supported by Gruda and Tanny (2015) who stated that high-tech greenhouses generate excellent yields but have high initial expenditures, whereas naturally ventilated plastic tunnels and greenhouses are a low-cost option appropriate for farmers with little capital or in locations with variable demand.

Table 4.9h: Test of difference in the yield of farmers based on the type of greenhouse structure used for tomato cultivation

Variable		Sum of squares	Df	Mean square	F	Sig
Yield	Between groups	5.749	2	2.875	0.159	0.853
	Within groups	3844.899	213	18.051		
	Total	3850.648	215			

Source: Field survey (2018)

Table 4.9i: Post Hoc Tests showing the difference in the yield of farmers based on the type of greenhouse structure used for tomato cultivation

	N	Yield Subset for alpha =0.05		
Type of greenhouse structure		1	2	3
Low cost greenhouses made type	28	7.071±3.53		
Medium cost greenhouses	85		7.235±3.81	
Imported type	103			7.504±4.74
Sig.		0.626	0.626	0.626

Source: Field survey (2018)

4.9.6.1: Test of difference in the adoption level of GHTs among the respondents across the states

The ANOVA result on Table 4.9j revealed significant difference (F=42.374, p=0.000) in the adoption of GHTs across the three sampled states. This implies that the adoption of GHTs varied across the three states. The difference in the adoption of respondents could be as a result of the variation in the disposition of the farmers to the use of GHTs and how well the GHTs are being carried out (management practices). For example, farmers in Plateau State have an unfavourable attitude and low level of management practices of GHTs which could have affected their adoption compared to farmers in Lagos State. The greenhouse farmers were more favorably disposed to the use of GHTs and have an effective level of management of the GHTs. The ownership status of the technology and the type of GH structure used could also cause a difference in GHTs adoption across the states. Most of the Greenhouse Farms in Lagos and Ogun states made use of the imported types of GH structures and are owned by some private individuals whose hired workers strictly adhere to every aspect of the technology. Unlike in Plateau State, the major types of GH structures used were of the medium cost and the low-cost and are owned by private individuals who manage it as they deem fit. It could also be as a result of their source of information on GHTs (fellow farmers).

The post hoc test on Table 4.9k further showed a separation of means across the three states. It revealed that the adoption of the respondents significantly differed across the states with Lagos State having the highest level of adoption ($\bar{x} \pm \mathrm{SD} =$63.65±7.31) followed by Ogun State ($\bar{x} \pm \mathrm{SD} =$61.70±9.79) and Plateau State with the lowest level of adoption ($\bar{x} \pm \mathrm{SD} =$52.49±8.52).

Table 4.9j: Test of difference in difference in the adoption level of GHTs among the respondents across the states

Variable		Sum of squares	Df	Mean square	F	Sig
Adoption	Between groups	5811.563	2	2905.781	42.374	0.000
	Within groups	14606.437	213	68.575		
	Total	20418.000	215			

Source: Field survey (2018)

Table 4.9k: Post Hoc Tests showing the difference in adoption level of GHTs among the respondents across the states

Adoption across states	N	Adoption Subset for alpha =0.05		
		1	2	3
Plateau	83	52.494±8.52		
Ogun	40		61.700±9.79	
Lagos	93			63.645±7.31
Sig.		1.000	0.190	0.190

Source: Field survey (2018)

4.9.7: Contribution of the independent variables to the adoption of GHTs in the study area.

The multiple regression analysis on Table 4.9l showed the variables that determined the adoption of GHTs across the three states. Overall, three variables were observed to be predictors of adoption of GHTs: Management practices carried out in the greenhouse, attitude to use of GHTs and constraints faced in the use of GHTs. Results showed that a direct relationship existed between Management practices carried out in the greenhouse; attitude to use of GHTs and the adoption of GHTs; while constraints faced in the use of GHTs were inversely related to the adoption of GHTs by the respondents. The results also showed that the significant determinants of adoption of GHTs were: Management practices carried out in the greenhouse ($\beta=0.33$; $p<0.05$); Attitude to use of GHTs ($\beta=0.28$; $p<0.05$) and Constraints faced in the use of GHTs ($\beta=-0.13$; $p<0.05$). Furthermore, the R^2 value was 0.424. This means that the independent factors accounted for about 42.4% of the variation in the dependent variable (adoption of GHTs of the respondents), indicating that the overall contribution was significant at 5% level.

Other variables were not significantly related to the adoption of GHTs. The effective management within the greenhouse would likely affect the profitability of GHTs as well as the adoption of GHTs of the respondents. Having a favourable attitude to the use of GHTs will also promote the adoption of GHTs and the lesser the constraint faced in the use of GHTs, the more the likelihood of adopting every aspect of GHTs. This is in accordance with Shiferaw *et al*. (2015) that when farmers who are willing to adopt new technology are faced with multiple constraints, they may eventually not be able to adopt. The results on Table 4.9l further showed that two variables: Management practices carried out in the greenhouse ($\beta=0.45$; $p<0.05$) and Attitude to use of GHTs ($\beta=0.26$; $p<0.05$) were observed to be significant determinants of adoption of GHTs in Plateau state.

The results also revealed that there were a positive relationship between management practices carried out in the greenhouse; attitude to use of GHTs and adoption of GHTs. This implies that carrying out the right management practices and having a favourable attitude will improve the adoption of GHTs among the respondents in the state. Results on Table 4.9m also showed a R^2 value of 0.36, which indicated that the significant independent variables above accounted for 36% variation of GHTs adoption.

The study also identified the three variables: Attitude to use of GHTs ($\beta=0.30$; $p<0.05$), Management practices carried out in the greenhouse ($\beta=0.26$; $p<0.05$) and the source of planting materials ($\beta=-0.21$; $p<0.05$) to be the main significant determinants of adoption of GHTs in Lagos State, with an R^2 value of 0.412. This means that the significant independent variables above accounted for a 41.2% variation of GHTs adoption. The result showed that a positive (direct) relationship existed between management practices carried out in the greenhouse and attitude to use of GHTs, while the 'source of planting materials' was inversely related to constraints faced in the use of GHTs by the respondents. This implies that if the planting materials are not from a reputable source, it would affect the level of adoption of GHTs by the respondents. According to most of the GH farmers in the three states;

"The planting materials (seeds, plant nutrients, Ultraviolet tarpaulin covers) used in the greenhouse are either obtained from reputable agro-dealers or through direct importation. Also, most of the seedlings transplanted were either raised by greenhouse service providers or the agronomist attached to the farm with adequate knowledge of how to raise and transplant the seedlings.

In Ogun State, two variables: Management practices carried out in the greenhouse ($\beta=0.57$; $p<0.05$) and years of involvement in greenhouse farming ($\beta=-0.59$; $p<0.05$) were the variables observed to contributed significantly to the adoption of GHTs by the respondents. The R^2 value for all significant independent variables was 0.608, which means the variables contribute about 60.8% to the adoption of GHTs by the respondents. The inverse significance of years of involvement in greenhouse farming implies that no matter how little the number of years a greenhouse farmer has been involved or has invested into the use of GHTs, it could not reduce or affect their adoption of GHTs. According to Ainembabazi and Mugisha (2014), if a farmer can access information based on the outcomes gained by other farmers who are already utilizing technology, the requirement for personal farming experience is an explanatory variable in the adoption model might be unnecessary.

Across the states, the independent variables contributed significantly to the adoption of GHTs (F=7.15; p≤0.05) as revealed in Table 4.9n. In Plateau (F=1.75; p≤0.05) and Lagos (F=2.52; p≤0.05) states, the independent variables contributed significantly to the adoption of GHTs. While in Ogun State, most of the independent variables did not contribute significantly to the adoption of GHTs (F=1.39; p≤0.05).

Table 4.9l Regression Analysis of Independent Variables

Variables	Overall Beta value	t-value	p- value	Plateau Beta value	t-value	p- value	Lagos Beta value	t-value	p- value	Ogun Beta value	t-value	p- value
(Constant)		2.660	0.008		0.823	0.414		3.430	0.001		0.859	0.401
Primary income	-0.063	-1.048	0.296	-0.128	-1.001	0.321	-0.107	-0.966	0.337	0.154	0.622	0.542
Ownership status of greenhouse structure used	0.067	1.062	0.289	-0.026	-0.198	0.844	0.056	0.405	0.687	0.380	1.433	0.169
Tomato yield	-0.045	-0.754	0.452	0.160	1.289	0.202	-0.097	-0.668	0.506	-0.018	-0.102	0.920
Price off-season	0.066	1.067	0.287	0.071	0.554	0.582	-0.099	-0.685	0.495	0.114	0.424	0.677
Management practices	**0.333**	**5.211**	**0.000**	**0.450**	**3.722**	**0.000**	**0.257**	**2.448**	**0.017**	**0.569**	**2.226**	**0.039**
Primary income-generating activity	-0.081	-1.459	0.146	0.031	0.248	0.805	-0.044	-0.430	0.668	-0.398	-1.803	0.088
Other income-generating activities	-0.063	-1.006	0.316	-0.220	-1.672	0.100	-0.031	-0.268	0.789	0.432	1.893	0.075
Years of involvement in greenhouse farming	-0.119	-1.853	0.065	-0.121	-0.913	0.365	-0.074	-0.654	0.515	-0.590	-2.188	0.042
Type of greenhouse structure used	0.096	1.563	0.120	0.017	0.138	0.891	-0.032	-0.275	0.784	0.133	0.581	0.569
Type of labour used	0.003	0.058	0.954	-0.178	-1.399	0.167	0.126	1.218	0.227	-0.061	-0.293	0.773
Source of planting materials	-0.023	-0.402	0.688	0.049	0.413	0.681	-0.209	-2.065	0.043	0.118	0.500	0.623
Knowledge	0.076	1.185	0.237	0.164	1.231	0.223	-0.091	-0.707	0.482	-0.175	-0.574	0.573
Attitude	**0.280**	**4.493**	**0.000**	**0.255**	**2.121**	**0.038**	**0.299**	**2.443**	**0.017**	**0.131**	**0.610**	**0.550**
Constraint	**-0.128**	**-2.141**	**0.034**	**-0.138**	**-1.077**	**0.286**	**-0.162**	**-1.582**	**0.118**	**0.161**	**0.589**	**0.563**
Education (in years)	0.020	0.326	0.745	-0.184	-1.490	0.141	0.161	1.404	0.165	0.238	0.999	0.331
Years of farming experience	0.048	0.631	0.529	0.039	0.265	0.792	0.101	0.873	0.386	0.283	0.909	0.376
Age	-0.138	-1.754	0.081	0.023	0.152	0.880	-0.126	-0.971	0.335	-0.228	-0.803	0.433
Sources of information	0.029	0.351	0.726	0.176	1.150	0.254	0.130	0.880	0.382	-0.427	-1.174	0.256
Access to Extension agents	0.054	0.618	0.537	-0.014	-0.085	0.932	-0.012	-0.072	0.942	0.370	1.051	0.307
Household size	-0.015	-0.247	0.805	-0.114	-0.912	0.365	0.113	1.081	0.283	-0.279	-0.954	0.353

Significant level at 5%

Source: Field survey (2018)

Table 4.9m Model Summary

	R	R Square	Adjusted R Square	S. E of the Estimated
Total	0.651	0.424	0.365	7.77
Plateau	0.601	0.361	0.155	7.83
Lagos	0.642	0.412	0.248	6.34
Ogun	0.780	0.608	0.172	9.00

Source: Field survey (2018)

Table 4.9n **ANOVA**

Model		Sum of Squares	Df	Mean Square	F	Sig.
Total	Regression	8644.367	20	432.218	7.152	0.000
	Residual	11724.406	194	60.435		
	Total	20368.772	214			
Plateau	Regression	2148.144	20	107.407	1.751	0.048
	Residual	3802.603	62	61.332		
	Total	5950.747	82			
Lagos	Regression	2024.837	20	101.242	2.520	0.002
	Residual	2892.453	72	40.173		
	Total	4917.290	92			
Ogun	Regression	2260.274	20	113.014	1.394	0.241
	Residual	1459.162	18	81.065		
	Total	3719.436	38			

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The goal of this study was to figure out what factors influenced tomato producers' adoption of GHTs in three selected states of Nigeria. This was necessitated by the high domestic demand for tomatoes (2.3 million metric tons) which surpasses the supply (1.8 million metric tons), with barely half of the tomatoes produced (0.9 million metric tons) making it to the table for consumption due to a variety of variables, including climate change. This has resulted in an immediate 1.4 million metric tonnes gap which has previously been filled by importation, with the Nigerian government spending approximately $1.5 billion annually on tomato product importation from China and other countries despite having the resources to produce enough tomatoes to meet its national demand and even have more for export. This led to the promotion of greenhouse technology (GHT) by some state governments to mitigate the effect of climate change on the production of vegetable crops especially tomatoes as well as to ensure that fresh tomatoes are available all year round to curb the issues of seasonality and the unnecessary hike in prices of tomatoes during the off-seasons. Hence, the study aimed at ascertaining the factors that determine the adoption of GHTs among tomato farmers in Plateau, Lagos and Ogun states where the governments of the state, some private individuals and organizations have embraced the technology.

Personal and farm enterprise characteristics of greenhouse tomato farmers; sources of information on GHTs; knowledge on the activities involved in operating GHTs; attitude towards the activities involved in GHTs; management practices of GHTs; constraints faced in the use of GHTs by respondents; and the level of adoption of GHTs by respondents were the specific objectives used in addressing this issue. To determine the relationship between the independent and dependent variables, hypotheses were developed. Also, test of difference was also conducted. The study's respondents were chosen using a multistage sampling procedure. Purposive sampling was used to select the three states (Plateau, Lagos and Ogun) where the study was carried out. Data was collected from 83, 93 and 40 respondents from Plateau, Lagos and Ogun states, respectively, using quantitative questionnaires and qualitative key in-depth interviews (KII). Quantitative data were presented using percentages and means while the inferential results were analyzed using Chi-square, PPMC, ANOVA and Linear Regression.

5.2 Summary of Major Findings

The findings of the study showed that majority (39.8%) of the respondents across the states were within the age range of 29-39 years with a mean age of 35.73±10.85 years, 41.83±12.14, 31.65±7.32 and 32.55±9.12 years for Plateau, Lagos and Ogun states, respectively; and 72.7% were males, with only few women (27.3%) across the states. Most of them were married (50.5%) across the states while majority of the respondents were single in Lagos (61.3%) and Ogun (52.5%) states, but Plateau State had a high number of married respondents (66.3%) than single ones (26.5%). Most (85.2%) of the respondents are Christians across the states with Plateau, Lagos and Ogun having majority (96.4, 79.6 and 75.0%, respectively) being Christians.

The average household size and average number of years of education of respondents from Plateau, Lagos and Ogun states and the combined samples were 5.25±2.97, 3.45±2.22, 3.05±2.14 and 4.07±2.68 members and 12.20±7.09, 10.01±6.38, 13.10±6.51 and 11.43±6.77 years, respectively. The average years of farming experience of respondents; and average years of involvement in greenhouse farming of respondents in Plateau, Lagos and Ogun states and across the states were 13.63±11.65, 6.27±5.97 and 7.48±10.01 and 9.32±9.86; and 4.06±2.65, 2.42±2.12 and 2.45±1.54 and 3.06±2.38, respectively. Most (65.7%) of the respondents across the states were not members of any social group as only 34.3% belong to a social group, but in Plateau, Lagos and Ogun states, the vast majority of respondents do not belong to any social group (53.0, 74.2 and 72.5), respectively. Majority of respondents in Plateau (67.5%), Lagos (82.8%) and Ogun (75.0%) states and across the states (75.5%) have farming as their primary occupation;

while 44.6, 52.7%, 45.0 and 48.1% have no other income generating activities in Plateau, Lagos, Ogun states and across the states, respectively.

The overall farm size used for greenhouse farming across the states by most (45.8%) of the respondents as well as in Lagos (61.3%) and Ogun (50.0%) states was between 1 and 3 acres, while most (62.7%) of the farmers in Plateau State have greenhouse farm size of less than one acre. Overall, most of the greenhouse farmers made use of only one (1) greenhouse structure on their farms (33.3%) which are mainly of the imported type (48.1%). Most of the respondents in Plateau State (42.2%), also have one GH structure which is mainly of the medium cost type (53.0%), while in Lagos and Ogun states, most of the respondents have more than six greenhouse structures (24.7 and 35.0%) which are mainly of the imported type (60.2 and 72.5%), respectively. Across the states, most of the greenhouse farmers were hired workers in the greenhouse farms (52.8%) which was also applicable to Lagos (73.1%) and Ogun states (62.5%), but in Plateau State, most (57.8%) of the greenhouse farmers personally acquired the greenhouse structure used for tomato cultivation. Most of the greenhouse farmers across the states, in Plateau, Lagos and Ogun states (46.3, 38.6, 49.5 and 55.0%), respectively started making use of GHT for the first time between the years of 2016-2018. Only a few of them (13.9, 8.5, 9.7 and 5.0%) discontinued the use of GHTs for a year across the three states, in Plateau, Lagos and Ogun states, respectively.

The planting method observed by the respondents across the states (49.1%) and Lagos State (57.0%) are similar as they nurse their tomato seedlings in the nursery and later transplant it on beds constructed on the greenhouse floor. While in Plateau and Ogun states, 47.0 and 55.0%, respectively, the respondents nurse their tomato seedlings in the nursery and later transplant it into pots/bags. Most of the respondents across the states, in Plateau, Lagos and Ogun states cultivated tomatoes in the greenhouses twice in a year (75.4, 63.9, 80.6 and 87.5%) and thrice (20.4, 27.7, 19.4 and 7.5%); with an average yield of between 4-8kg per plant stand (61.1, 68.7, 57.0, 55.0%), respectively. Tomatoes prices are more lucrative during the off-season as most (39.4, 40.9 and 65.0%) of the respondents sold their tomatoes between N601 and 800/kg across the states and in Lagos and Ogun states respectively. Most (49.4%) respondents in Plateau State sold their tomatoes between N401 and 600/kg; but during the on-season, most (48.6, 65.1 and 38.7%) of the respondents sold their tomatoes between N201 and 400/kg across the states and in Plateau and Lagos states, respectively; while most (50.0%) respondents in Ogun State sold their tomatoes between N401 and 600/kg.

Most of the respondents purchased planting materials from agro dealers (55.1, 57.8, 51.6 and 57.5%); have never had contact with extension services (55.1, 59.0, 49.5 and 60.0%); and made use of hired labour for their farm work (79.6, 72.3, 82.8 and 87.5%) across the states and in Plateau, Lagos and Ogun states, respectively. All the greenhouse farmers cultivated tomatoes at one time or the other but also cultivated other crops such as: Green pepper (47.7, 44.6, 48.6 and 52.5%), cucumber (43.1, 50.6, 32.3 and 52.5%), Red pepper/Habanero (41.2, 43.4, 38.7 and 42.5%), Yellow pepper (29.2, 32.5, 22.6 and 37.5%) across the states and in Plateau Lagos and Ogun states, respectively during tomato peak season in the open-field. Most (50.9, 71.0 and 67.5%) of the greenhouse farmers sold their tomatoes to supermarkets across the states and in Lagos and Ogun states, respectively, while most (53.0%) of the farmers in Plateau State sold their tomatoes to private individuals.

Fellow farmers (mean=1.27, 1.24 and 1.32) were the major source of information for respondents across the states and in Plateau and Lagos states, respectively; while most (mean=1.38) of the respondents in Ogun State got their information from greenhouse service providers. The level of knowledge of the activities involved in operating GHTs was high (62.5, 57.8, 65.6 and 65.0%) among respondents across the states and in Plateau, Lagos and Ogun states, respectively. The level of respondents' attitude towards use of GHTs was favorable (56.5, 72.0 and 55.0%); the management practices was high (51.9, 58.1 and 62.5%) and the adoption level of GHTs were high (53.2, 78.5 and 67.5%) across the states, in Lagos and Ogun states, respectively. However, the level of respondents' attitude towards use of GHTs was unfavorable (39.8%); the management practices was low (60.2%) and the adoption level of GHTs was low (18.1%) in Plateau State. The major constraints considered severe by the respondents across the states, in Lagos and Ogun states, respectively were: high initial investment in the construction of greenhouse ($\bar{x}$ =1.58, 1.51 and 1.58), fluctuation in market prices due to glut in the market ($\bar{x}$ =1.55, 1.47 and 1.40) and high cost of planting materials/plant protection chemicals ($\bar{x}$ =1.53, 1.59 and 1.40). While in Plateau State, fluctuation in market prices due to glut in the market ($\bar{x}$ =1.70), high initial investment in the construction of greenhouse ($\bar{x}$ =1.66) and glut of crops in the market ($\bar{x}$ =1.64) were the major constraints experienced by respondents.

The Chi-square results showed that in the overall result, there was a significant relationship between marital status (χ^2=8.720, p=0.033), membership of social groups (χ^2=10.727, p=0.001), Ownership status of greenhouse structure (χ^2=12.157, p=0.016), Sources of planting materials (χ^2=22.573, p=0.000), the type of GH structure used (χ^2=33.468, p=0.000), the type of labour used for greenhouse tomato farming (χ^2=9.703, p=0.021) and adoption of GHTs. Disaggregating the results, significant relationship existed between membership of social groups (χ^2=4.902, p=0.027), ownership status of greenhouse structure (χ^2=14.214, p=0.007) and adoption of GHTs in Lagos State; the type of GH structure used in Plateau State (χ^2=10.042, p=0.007) and Ogun State (χ^2=11.420, p=0.003) and adoption of GHTs. The PPMC result showed that age (r=-0.267, p=0.000), household size (r=-0.226, p=0.001), years of farming experience (r=-0.160, p=0.018), the average income generated monthly from primary income generating activities (r=-0.212, p=0.002); the prices of greenhouse tomatoes (during the off-season (r=0.172, p=0.012) and on-season (r=0.199, p=0.003) and adoption of GHTs were all significant across the states. However, a significant relationship existed between household size (r=-0.238, p=0.030) in Plateau State, education (r=0.276, p=0.007) in Lagos State and adoption of GHTs.

Furthermore, significant positive relationship existed between respondents' knowledge of greenhouse technologies and adoption of greenhouse technology (r=0.265, p=0.000; r=0.216, p=0.037; r=0.427, p=0.006) across the states, and in Lagos and Ogun states, respectively. While there was no significant relationship between knowledge of farmers in Plateau State and adoption of GHTs (r=0.075, p=0.503).

The ANOVA result revealed a significant difference (F=11.842, p=<0.000) in the management practices involved with GHTs based on the type of greenhouse structures used for tomato farming across the three sampled states. The management practices involved in GHTs were most (5.17) carried out by GH farmers using the imported structures and least (4.36) carried out by GH farmers using the low cost greenhouse structures. In the same vein, a significant difference ($F=42.374$, $p=0.000$) existed in the adoption of GHTs across the three sampled states with Lagos State having the highest level of adoption of GHTs (63.65) and Plateau State having the least (52.49). However, there was no significant difference ($F=0.159$, $p=0.853$) in the yield score based on the type of greenhouse structures used for cultivating tomatoes.

Finally, the study revealed that the following factors: Management practices carried out in the greenhouse ($\beta=0.33$; $p<0.05$); Attitude to use of GHTs ($\beta=0.28$; $p<0.05$) and Constraints faced in the use of GHTs ($\beta=-0.13$; $p<0.05$) significantly contributed to the GHT adoption among greenhouse farmers in the study area.

5.3 Conclusion

The study concluded that the determinants of GHTs adoption in the study area were greenhouse management practices, attitude to use of GHTs and constraints faced in the use of GHTs in the study area. Respondents in the study area had high knowledge of the activities involved in operating GHTs. The respondents in Lagos and Ogun states had high management practices and favorable disposition toward the use of GHTs, while the management practices and attitude towards the use of GHTs among respondents in Plateau State was low. ‘High initial investment in construction of greenhouse’ was the major constraint encountered by the respondents in the study area. Also, adoption level across the states was high except in Plateau State.

The study also concluded that the greenhouse farmers were youths, with little number of years of involvement in greenhouse farming. The farm size used for greenhouse farming was relatively small but the farmers were still able to obtain great yield. Most of the greenhouse farmers in the Lagos and Ogun states were hired workers working on greenhouses owned by private individuals, while most of the greenhouse farmers in Plateau State personally acquired the structures used for greenhouse farming. Most of the greenhouse farmers also cultivated tomatoes twice in a year with a cycle for harvesting that extends up to six months. Agro-dealers served as the main source of planting materials to the respondents, whose major outlet/sales point were supermarkets and big retail shops. Furthermore, extension services were not involved in the dissemination of the relevant technologies associated with greenhouse technology and farmers rely mainly on fellow farmers and greenhouse service providers.

5.4 Recommendations

1. According to this study, there is a dearth of extension service involvement in greenhouse technology. Extension services should be adequately involved in the dissemination of GHTs by all the stakeholders involved in the promotion of GHTs. Since extension serves as a link between Farmers, research and government, there is a dire need for extension workers to be more pro-active in learning about GHTs. This is necessary so as to be able to disseminate useful, relevant and time-based knowledge on GHTs to farmers to facilitate their interest in the use of the technology. Extension should go a step further in educating the government (especially in southwest) of the benefits of GHTs so that there will be lesser dependence on the tomatoes from the northern states.
2. Greenhouse farmers in the study area, especially in Plateau State should endeavor to embrace right attitude towards the laid down GHTs management practices in order to be able to derive maximum benefit from the use of the technology.
3. In order to mitigate the severity of the high initial investment in construction of greenhouse which was the major constraint encountered by the respondents in the study area; stakeholders involved in the tomato value chain should endeavor to set up greenhouses (type notwithstanding). The GHs could be partitioned into significant sizes that farmers can rent/lease at affordable prices or pay for in affordable installments and still get yield and income to boost their standard of living.
4. Since most of the greenhouse farmers are youths, government and corporate establishments should invest in GHT as a means of job creation (employment) within each state. Also, the youths should be employed as the main stakeholders for the effective running of the technology. This is due to the fact that most of management practices involved in the use of GHTs are tedious and there are needed for much energy to be exerted to carry out such tasks. The salaries given to them should also be attractive and encouraging.
5. There should be high level of compliance to the management practices laid down for the effective running of the GHTs especially in Plateau State. The presently existing

greenhouse structures especially the government owned structures should be optimally put to use and not allowed to waste away.

6. The study revealed that farmers obtained great yield using relatively small farm size. Therefore, it is possible to produce more than enough tomatoes that can meet the local demand as well as have enough for export using GHTs. Hence, government should endeavor to reduce tomato importation and establish more greenhouses for tomato production within the states to ensure year round availability of tomatoes and also be able to meet up with the high demand for tomatoes.

5.5 Contributions to Knowledge

1. Significant determinants to the adoption of greenhouse technology were: Management practices carried out in the greenhouse, attitude to use of greenhouse technologies (GHTs) and constraints faced in the use of GHTs which are veritable tools for programme planning and policy formations on greenhouse technology adoption for improving tomato production in Nigeria.
2. Tomato yield derived was not influenced by the type of greenhouse structure (s) (high-cost, medium-cost, or low-cost greenhouses) a farmer uses, as long as the farmer complies with the laid down greenhouse management guidelines.
3. Quantitative data on the yield that can be generated from a tomato plant using greenhouse technology with strict compliance to the management practices was provided.
4. The opinion of a previous study that greenhouses were mainly owned and used by teaching and research institutions for research purposes due to the prohibitive cost of construction and maintenance was eradicated.
5. The sources of information on GHTs to farmers in Nigeria were mainly fellow farmers and greenhouse service providers as against the general belief of extension agents and radio being the conventional means of dissemination of information on new technologies among farmers was provided.
6. Hence, the paucity of information on GHTs in Nigeria was eradicated and knowledge on GHTs in the field of social science worldwide was contributed to.

5.6 Areas of Further Research

1. Comparative analysis of the effectiveness of greenhouse owned by private individuals and the governments
2. Analysis of the productivity of greenhouse technology when used for different types of vegetable crops
3. Willingness to adopt GHTs for the production of other crops apart from tomato.
4. Effect of retraining on GHT management practices on tomato yield and on the adoption of GHTs among greenhouse tomato farmers in Nigeria.

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APPENDIX

DEPARTMENT OF AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT

UNIVERSITY OF IBADAN, NIGERIA

QUESTIONNAIRE ON THE DETERMINANTS OF ADOPTION OF GREENHOUSE TECHNOLOGIES AMONG TOMATO FARMERS IN THREE SELECTED STATES OF NIGERIA

State: ________ Local government area (LGA):________ Town: ________

Introduction to inform participants of the purpose of the study

I would like to explain to you the aim of the study. I am a PhD student in the University of Ibadan and I am conducting a study on the 'Determinant of Greenhouse Technology Adoption among Tomato Farmers in three selected states of Nigeria'. I am particularly interested in the factors that encourage or discourage farmers from adopting Greenhouse Technology. It is very important that you tell us exactly what you feel can encourage or discourage farmers from using greenhouse technology. I am very grateful for your time to help fill this questionnaire. Thank you and God bless you.

A. Personal Characteristics of the Respondents

1. Age: (In years) ……………
2. Sex: Male ( ) Female ( )
3. Marital status: Single ( ) Married ( ) Widowed ( ) Divorced ( )
4. Religion: Christianity ( ) Islam ( ) Traditional ( ) others (specify)…………………
5. Household size: (actual number) …………………….
6. Education (number of years of formal education): _______________
7. Years of farming experience (in years): ______________________
8. When did you start making use of greenhouse technology? (Actual year) _______

9. Do you belong to any social organization? (a) Yes ( ) (b) No ( )

10. What is your primary occupation? __________

11. What is the average income that you generate from your primary occupation per month?

12. What other income-generating activities do you engage in? List them all_____________

B. Farm Enterprise Characteristics (tick as many as applicable in the option provided)

13. What is the size of your greenhouse farm (in acres)? _________________

14. How many greenhouse units do you have? (i) 1 (ii) 2 (iii) 3 (iv) 4 (v) 5 vi) 6 (vii) more than 6

15. What is the ownership status of greenhouse structure used? ((i) Personally acquired (ii) Hired workers (iii) Government leased/rent (iv) Individually leased (v) Research institutes

16. Which type of greenhouse structure do you use? (i) High-cost greenhouses (ii) Medium-cost greenhouses (i.e. a mixture of both local and imported materials) (iii) Low-cost greenhouses

17. When did you start making use of greenhouse technologies? (State the number of years)

18. Have you ever discontinued the useof greenhouse technology? (i) Yes (   )
(ii) No (   )

19. If yes, for how long? (State the number of years)______________

20. How do you plant your crops? (i) Directly in the greenhouse unit (ii) In the nursery and later into pot/bags (iii) In the nursery and later on the greenhouse floor (iv) Others (specify)

21. How many times do you cultivate tomatoes in a greenhouse unit within a year: (i) Once (ii) Twice (iii) Thrice (iv) More than thrice

22. How much do you sell your tomatoes per kg during the off-season period? (Actual price/kg)

23. How much do you sell your tomatoes per kg during the on-season period? (Actual price/kg)

24. How many kilograms per stand of tomato do you derive in the greenhouse?

25. Where do you get your planting materials/inputs? (i) Previous harvest ( ) (ii) Research institutes ( ) (iii) Agro-dealers ( ) (iv) Greenhouse kit providers ( ) (v) Government agencies ( ) (vi) Direct importation ( ) (vii) others (specify)

26. What type of labour do you use in the greenhouse farm? (i) Family labour ( ) (ii) Cooperative labour ( ) (iii) Self labour ( ) (iv) Hired labour ( )

27. What types of crops do you cultivate in the greenhouses? List all

28. Where do you sell your produce? (i) Local markets ( ) (ii) Private individuals ( ) (iii) Supermarkets ( ) (iv) Hotels ( ) (v) International market ( ) (vi) Processing industry ( ) (v) On the farm ( ) (vi) Others ____

C. Sources of information on Greenhouse technologies

29. What are your sources of information on Greenhouse technologies?

Sources of information	Always	Occasionally	Never
Greenhouse service providers			
Television			
Radio			
Newspapers			
Farmers' association			
Extension agents			
Internet			
Fellow farmers			
Handbills			
Seminars			
Conferences			
Workshop			
Friends and neighbors			
Others			

D. Knowledge of respondents on greenhouse technologies and the activities involved

30. Please, kindly respond by picking either 'true' or 'false' to each of the following knowledge questions on GHTs

S/N	Knowledge statements	True	False
1	Pollination is done manually in the greenhouse		
2	The use of drip irrigation supplies regulated amount of water directly to plant roots		
3	Training of crops should be carried out at the mid of the day to avoid stem and branch breakage		
4	The nets acts as an air filters to the crops from dust and environmental wastes		
5	The drip lines cannot be easily filled and drained		
6	The plastic cover used in the greenhouse is ultraviolet degradable		
7	The spread of light in the greenhouse unit is not uniform		
8	The drip system encourages foliar wetting and bacterial wilt		
9	The soluble fertilizers should be applied directly to each plant		
10	The soil should be dug to a depth of 60 cm to ensure proper drainage when planting directly on the ground		
11	When putting the soil into the pot/bag, each bag should be filled to the brim		
12	Putting plastic mulch on the ground before arranging the pot/bags prevents soil infection with the ground		
13	Over-irrigation leads to tomato fruits cracking		
14	Water treated with calcium hypochlorite can be used immediately after treatment		
15	The nursery tray grooves should be filled with soil up to ¾ of each tray groove		
16	Drip irrigation can also be used to irrigate the nursery trays		
17	The feeding regime of plant nutrients to water before transplanting should be 1 day of fertilizers and 3days of plain water		
18	Two seedlings should be put in one pot/bag when transplanting to ascertain germination		
19	Removal of the upcoming lateral shoots from the tomato stem before they overgrow helps to prevent fungus infection build-up and flower abortion		

E. Attitude of respondents towards the activities involved in greenhouse technologies

31. What is your attitude towards the use of greenhouse technologies?

S/N	Attitudinal statements	SA	A	U	D	SD
1	Cleaning the drip filter on a daily basis could be stressful and so not necessary					
2	Leaves removed during defoliation process may be left on the greenhouse floor to rot and decay to add more nutrients to the soil					
3	In order to ease transplanting, it is advisable to irrigate the soil-manure mixture put in the pot/bags for three day before transplanting.					
4	Complying to the arrangement of two drip emitters per pot/bag below the drip lines is not so important; one drip emitter is enough to irrigate each per pot/bag					
5	The position of seeds when planting it in the nursery tray does not really matter					
6	Irrigating the seedlings in the nursery trays can be done at any time of the day when it is convenient for me					
7	Waiting for the soluble fertilizer to completely dissolve in a bucket before pouring it in the fertilizer tank does not affect its rate of absorption by the plant					
8	Reducing the recommended rate of fertilizer used for my crops should not significantly affect crop growth					
9	De-suckering of each plant is necessary to ensure great yield					
10	Sorting harvested crops according to their size and colour improves my reputation before my customers for packing high quality products					
11	Harvesting crops when they have matured, but not overripe will help me earn good money, because my crops will get to					

	the market in good shape					
12	I can prevent disease transmission from one plant to another by sterilizing the pruning tools during the de-suckering process					
13	Laying plastic mulch on the greenhouse floor before arranging pots/bags is not so necessary					
14	It is very necessary to regulate rate and frequency of the irrigation calibration with the drip irrigation system					
15	I can use the water I just treated with calcium hypochlorite without letting it stay for 12 hours and it will have no effect on my crops					
16	When I keep the records of each activity carried out on the farm, I will be able to watch the progress or otherwise of my crops					
17	Carrying out crop rotation will save me more money because I will be able to break the breeding cycle of some stubborn crops pests					
18	Strictly following the recommended management practices could help to boost my yield and income					
19	Sorting and packaging of crops immediately after harvest might help to prevent postharvest losses and reduction of my income					
20	Removing all leaves below ripe and mature fruits may prevent hiding places for insect pests and diseases' pathogens					
21	Gently tapping the trellis or training lines in the afternoon might induce pollination and increased yield					
22	Frying of soil and manure mixture could be very laborious					
23	Training and staking prevent the stem from breaking off and touching the ground due to the weight of the tomato fruits and thus I will be able to get better yield and income					
24	GHT is a controlled system of farming where high quality					

	crops devoid of chemicals are expected, therefore the use of pesticides even once awhile should be totally avoided					

KEYS: SA- STRONGLY AGREED; A- AGREED; U- UNDECIDED; D- DISAGREED; SD- STRONGLY DISAGREED

F. **Management practices of greenhouse technologies by respondents**

32. How often do you make use of the laid down greenhouse management practices and how easy is it to use?

S/N	Management Practices in greenhouse technologies	Frequency of use			Ease of use	
		Always	**Sometimes**	**Never**	**Easy**	**Difficult**
1.	Land preparation/Integration of nutrients					
2	Bed shaping					
3	Soil analysis					
4	Soil and manure sterilization					
5	Bagging					
6	Use of plastic mulch (Use of damp proof)					
7	Use of drip irrigation					
8	Setting up of the nurseries					
9	Fertilization of the nurseries					
10	Hardening of crops before transplanting					
11	Application of appropriate fertilizers and nutrients to crops					
12	Regular checking of the irrigation systems and filters					

13	Disinfection of the water for irrigation					
14	Regular and constant irrigation of crops in the greenhouse					
15	Weekly flushing of the irrigation system					
16	Proper record keeping					
17	Application of recommended pesticides when necessary					
18	Training, Staking and Trellising					
19	Pruning					
20	Hand weeding					
21	De-suckering					
22	Application of fruit setting solution twice weekly					
23	Defoliation					
24	Harvesting					
25	Sorting and Packing					
26	Regular cleaning of the drip filters					
27	Proper sanitation and biosafety in the greenhouse					
28	Crop rotation					

G. Constraints to the use of Greenhouse technologies

S/N	Constraints to the use of Greenhouse technologies	Severe constraint	Mild constraint	Not a constraint
A	**Environmental constraints**			
1	Relatively higher perishability of fruits			
2	Scarcity of water for irrigation under greenhouse			
3	Strong winds			
4	Poor drainage of soil			
5	Low soil fertility status due to leaching			
6	Occurrence of physiological disorders e.g. disordered fruit shape			
7	Erosion			
8	Blowing off of flower petals			
B	**Technical constraints**			
9	Lack of scientific knowledge about crop production under greenhouse			
10	Non-availability of required quantity and quality planting material/inputs on time			
11	Limited and irregular power supply			
12	Non-availability of quality greenhouse equipment at local market			
13	Difficulties in complying with the recommended management practices			
C	**Labour related constraints**			
14	High cost of skilled labour			

D	**Economic constraints**			
15	High initial investment in construction of green house			
16	High cost of planting material/ plant protection chemicals			
17	Lack of adequate and timely disbursement of loan from financial institutions			
18	High cost of transportation			
19	Poor accessibility to subsidy			
20	Absence of crop insurance scheme for crops cultivated			
E	**Marketing constraints**			
21	Fluctuation in market prices due to glut in the market			
22	Storage facilities to preserve crops before selling it off			
23	Inadequate exclusive markets for crops grown under greenhouse			
24	Existence of middle men between producers and final market			
25	Difficulty in grading the produce to various sizes at the production level			
26	Glut of crops in the market			

H. Adoption level

33. How often do make use of the greenhouse technologies?

S/N	GREENHOUSE TECHNOLOGIES	ALWAYS USING	SOMETIMES USING	USED BUT DISCONTINUED	NEVER USED
A.	**Land preparation stage**				
1.	Land preparation/Integration of nutrients				
2	Bed shaping				
3	Soil analysis				
4	Mixing of the soil with decomposed manure				
5	Soil and manure sterilization				
6	Potting/bagging to at least 3/4bag full				
7	Use of plastic mulch (Use of damp proof)				
B.	I**rrigation stage**				
8	Use of drip irrigation				
9	Treatment of water with hypochlorite				
10	Transplanting (Irrigate soil very well before transplanting)				
C.	**Nutrients and Fertilizer application**				
11	Use of Smart fertilizer (SF)				
12	NPK (15:15:15) in split application per plant after transplanting				
a.	NPK (15:15:15) in split application per plant after 5th month				

b.	Use of Polyfeed/NPK after transplanting for the first 4weeks for at least once per week				
c.	Use of Multi-K (Potassium Nitrate) for at least once per week from the 4th week of transplanting				
13	Use of Haifa Cal. (Calcium Nitrate) at Top dressing of crops after 3-4weeks from transplanting per plant as a ring band and to be covered with soil after application				
D.	**Vegetative development stage**				
14	Training, Staking and Trellising				
15	De-suckering				
16	Manual pollination between 12pm and 3pm				
17	Hand Weeding				
18	Defoliation				
19	Apply appropriate pesticides				
E.	**Fruiting and Harvesting stage**				
20	Apply Fruit Setting Solution twice weekly				
21	Timely harvesting				

KII WITH A FEMALE GREENHOUSE FARMER AT PLATEAU STATE (I); INTERVIEW SCHEDULE WITH A GREENHOUSE FARMER AT PLATEAU STATE (II); THE RESEARCHER WITH THE GREENHOUSE FARMERS ASSOCIATION OF NIGERIA PRESIDENT AT HIS FARM IN PLATEAU STATE (III); POT/ BAGGING OF STERILIZED MANURE AND SOIL MIXTURE (IV).

LAND PREPARATION STAGE WITH DRIP IRRIGATION (V); NURSERY STAGE (VI); TRELLISING AND TRAINING OF TOMATO (VII-VIII)

TRAINING AND TRELLISING OF CROPS BY THE RESEACHER (IX); A MEDIUM COST GREENHOUSE IN PLATEAU STATE (X); INTERVIEW WITH AN AGRONOMIST AT A MEDIUM COST GREENHOUSE IN LAGOS STATE (XI); HIGH-COST GREENHOUSES AT ASTC PLATEAU (XII)

HIGH COST GREENHOUSES AT ASTC PLATEAU STATE (XIII-XIV); HIGH-COST GREENHOUSE IN A DILAPIDATED AND ABANDONED CONDITION AT ASTC PLATEAU STATE (XV-XVI)

LOW COST GREENHOUSES IN PLATEAU STATE (XVII-XVIII); HIGH COST GREENHOUSES AT LAGOS AND OGUN STATES (XIX-XX)

INTERVIEW WITH AN AGRONOMIST AND FARM MANAGERS AT DIFFERENT HIGH COST GREENHOUSES AT LAGOS AND OGUN STATES (XXI-XXIII)