EVALUATION OF THE EFFECTS OF E-AGRICULTURE ON CEREAL CROP FARMERS' LIVELIHOODS IN BORNO AND KEBBI STATES, NIGERIA

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ABSTRACT

The study evaluated the effects of e-agriculture information on cereal crop farmers' livelihoods in Borno and Kebbi States, Nigeria. The specific objectives of the study were; to describe the socio-economic characteristics of the cereal crop farmers; investigate the sources of information of e- agriculture and their extent of usage; examine the livelihood status of the cereal crop farmers usage of e-agriculture; ascertain the benefits derived by the cereal crop farmers from e- agriculture usage; determine the factors that influence the usage of e-agriculture; determine the perceived effects of the usage of e-agriculture information; determine the effects of e-agriculture information usage on livelihood status of the cereal crop farmers and to examine the severity of the constraints faced by the cereal crop farmers in the use of e-agriculture information in the study area. Three-stage sampling procedure was used for the sampling, the total sample size for the study is 400. The sample size was obtained from the sample frame using the Yamane sample size determination formula at 0.07 level of error of tolerance. Structured questionnaire complemented with interview schedule was used for the collection of primary data. Tools of analysis used were simple descriptive statistics, Logit regression model, Pearson product moment correlation (PPMC), Simpson Index of Diversity (SID) and ordered Probit regression model. The results revealed that the mean age of the cereal crop farmers to be 45 years. Majority (94.00%) of the cereal crop farmers were male. More so, most (88.50%) of the cereal crop farmers were married, while the pooled result indicated the mean farm size of 4 hectares, and 49.25% of them used both hired and family labour. The pooled result also revealed 68.75% of them were into farming as primary occupation. The result on sources of e-agriculture information used by the cereal crop farmers showed majority (92.00%) of them used mobile phone, 88.50% used radio, 63.75% used television and 49.00% used other farmers/friends. The result on extent of usage of e-agriculture information sources showed mobile phone (Ms = 2.70) ranked first, radio (Ms = 2.64) ranked 2nd and other farmers/friends (Ms = 2.12) ranked 3rd as highly used by the cereal crop farmers. The pooled result on livelihood status revealed that 85.25% of the respondents had moderate livelihood status. The pooled result on the benefits derived in the use of e-agriculture indicated that the cereal crop farmers in the study areas realise increased crop yields which ranked 1st, increased income ranked 2nd, improved food security ranked 3rd. The pooled result of the marginal effects of factors influencing the use of e-agriculture revealed that the coefficient of age (0.0244) and extension contact (0.1826) had positive influence on the use of e-agriculture and significant at 5% and 1% levels of probability respectively. The result of the study also revealed that inadequate training (Ms = 2.44) and policy inconsistency (Ms = 2.36) were some of the very severe constraints faced by the cereal crop farmers. The result of null hypothesis (1) revealed age (2.26), farm size (-3.81), extension contact (4.64), membership of cooperative (-4.38) and labour usage (-1.73) to have significant relationship with the usage of e-agriculture information at 5%, 1%, and 10% levels of probability respectively. Hence, the null hypothesis (1) of the study was rejected. Also, the result of null hypothesis (2) showed a direct and positive correlation with the extent of usage of computer website (0.1389), extension agents (0.1428), satellite (0.1542) and livelihood status ($P < 0.05$) levels of probability respectively, to this end, the null hypothesis (2) of the study was rejected. Farmers are encouraged to make the use of e-agriculture information a priority to realise more benefits. It is therefore recommended that technologies that suit local needs of farmers should be considered, this also should take into account the influence of e-agriculture on gender and social dynamics of the farmers.

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ADB:	Agricultural Development Bank
ADP:	Agricultural Development Project
AfDB:	African Development Bank
APS:	Agricultural Performance Survey
AHP:	Analytic Hierarchy Process
AKF:	Agakhan Foundation
ATASP-1:	Agricultural Transformation Agenda Support Program-Phase-1
Action-Line C7:	Refers to E-government Community Initiatives
BPAT:	Breeding Programme Assessment Tool
BMGT/DFID:	Bachelor of Management/Department for International Development
CARE:	Centre for Assessment Research and Evaluation
CIMMYT:	Spanish Acronym for international Maize Wheat Improvement Centre
CRS:	Catholic Relief Services
CRPs:	Centre for Research Projects
CSA:	Climate-Smart Agriculture
CD:	Compact Disc
CORAF:	French Acronym; It Stands for Institutional and Scientific Partnership
CGIAR:	Consultative Group for International Agricultural Research
DVD:	Digital Versatile Disc
DFID:	Department for International Development
DTMA:	Drought Tolerant Maize for Africa
EUI:	European University Institute

ESA:	Eastern and Southern Africa
FAOSTAT:	Food and Agriculture Organization Statistics
FAO:	Food and Agriculture Organization
FMARD:	Federal Ministry of Agriculture and Rural Development
GIS:	Geographical Information System
GAP:	Good Agricultural Practice
GSM:	Global System for Mobile
GPS:	Geographical Positioning System
GDP:	Gross Domestic Product
HSV:	Hue Saturation Value
HOPE:	Harnessing Opportunities for Productivity Enhancements
IFPRI:	International Food Policy Research Institute
IITA:	International Institute for Tropical Agriculture
IMAS:	Improved Maize for African Soil
ICARDA;	International Centre for Agricultural Research in the Dry Areas
ITU:	International Telecommunication Union
ICRISAT:	International Crop Research Institute for the Semi-Arid Tropics
ICTs:	Information and Communication Technologies
IVR:	Interactive Voice Response
ISMA:	Integrated Striga Management for Africa
KB:	Knowledge Base
Ms:	Mean score
MSV:	Maize Streak Virus
MLN:	Maize Lethal Necrosis

NARES:	National Agriculture Research and Extension Service
NARS:	National Agriculture Research Service
NITDA:	National Information and Technology Development Agency
NUME:	Nutritionally-Enriched Maize for Ethiopia
NUE:	Nitrogen Use Efficient
NGOs:	Non-Governmental Organizations
PACA:	Partnership for Aflatoxin Control in Africa
PASS:	Programme for African Seed Systems
ROM:	Read Only Memory
REFILS:	Research Extension Farmers Inputs Linkage System
RMCs:	Regional Member Countries
RRA:	Rural Rapid Appraisal
RFF:	Radio Farm Forum
RS:	Remote Sensing
SMS:	Short Messages Services
SSA:	Sub-Sahara Africa
SLA:	Sustainable Livelihood Approach
SIMLESA:	Sustainable Intensification of Maize Legume Cropping Systems in Eastern and Southern Africa
SARD-SCA:	Support to Agricultural Research for Development of Strategic Crops in Africa
STVC:	Sorghum Transformation Value Chain
SMEs:	Small and Medium Enterprises
TAM:	Technology Acceptance Mode

UNDP:	United Nation Development Programme
UN:	United Nation
USAID:	United States Agency for International Development
USDA:	United State Development Agency
USD:	United State Dollar
UNESCO:	United Nation Educational Scientific and Cultural Organization
VEAs:	Village Extension Agents
WSIS:	World Summit of the Information Society
WCA:	West and Central Africa
WEMA:	Water Efficient Maize for Africa
WAAPP:	West Africa Agriculture Productivity Programme
WSN:	Wireless Sensor Network
WFP:	World Food Programme

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background to the Study

Majority of individuals who live in rural areas depend on agriculture for a living, making it a significant sector of the Nigerian economy. Nigeria population would rise by two percent (2%), reaching close to 200 million by the year 2023. With this information at the background, it has become necessary that any means that will help improve agriculture productivity should be sourced and implemented (Mukesh *et al*., 2010). Through enhanced information and communication systems, the focus of e-agriculture is on agriculture and rural development. E-agricultural is the concept of creating, analyzing and implementing fresh ICT Applications of information and communication technology (ICT) with a focus on agriculture in rural areas (Chauhan, 2018).

E-agriculture is the idea of developing, examining, and putting to use new ICT applications in the rural areas, with agriculture serving as the main use. It is a tool to enhance various techniques for information dissemination, including improved technologies. E-agriculture received official support from the World Summit of the Information Society (WSIS), which took place in 2003–2005 (Mukesh *et al*., 2010). Engineering and science of production, processing, and extension, as well as monitoring and assessment services are only a few of the research fields that e-agriculture covers (The e-agriculture Community, 2017). As part of a global effort to improve food security and sustainably boost agricultural output, more information and communication technology and related tools are being used within the agriculture industry (E-agriculture. Org., 2017). E-agriculture is a field with a complicated process that needs a lot of input from participants and consultations with various expertise

in agriculture and other related fields. Also, various agricultural actors can better communicate and learn from one another locally, regionally and globally.

Beyond only using technology, e-agriculture promotes the blending of multidisciplinary knowledge and culture with technology. The facilitation of support for standards and norms, technical help, capacity building, education, and extension services, however, are some of the key elements of e-agriculture (Dax *et al.*, 2018). According to food and agricultural organization) (FAO) (2011), e-agriculture is a practice that occurs everywhere, and individuals from different parts of the world exchange knowledge, ideas, and materials regarding the development of agriculture and rural areas using information and communication technology (ICTs). World Summit of Information Society (WSIS) (2015), outlined the benefits of e-agriculture application in all aspects of life. The advantages include ensuring the regular distribution of information about animal husbandry to farmers, providing easy access to thorough, current, significant information and experience, particularly in remote locations, as well as fisheries and food.

It was emphasized at the World Summit on the Information Society that, there is need for agricultural partners to make the most of e-agriculture as a tool to boost productivity both in quantity and in quality, particularly in the cultivation of cereal crops. E-agriculture is very important in a country's development process and the application of e-agriculture to the agricultural sector, especially in crop production, will offers the best opportunity for economic growth and poverty alleviation in the area of food production. The most important innovations in e-agriculture will create enormous growth prospects in the agricultural, healthcare, educational, financial, and insurance sectors (Aker, 2011). Nigeria has recognized e-agriculture as one of the key factors in transforming its economy from

subsistence farming to a service sector with a high level of added information and expertise that can effectively compete on the global market (FMARD and NITDA, 2016). Regardless of gender, e-agriculture will help create new opportunities for all agricultural stakeholders. The new potential afforded by e-agriculture for networking, information exchange, business, education, media consultation, and e-commerce activities have not yet been fully tapped by many stakeholders in the agricultural sectors.

E-agriculture is a package that can help society produce a new generation of farmers because it has a high potential to pique the interest of young people in agriculture for reasons of empowerment while also assisting farmers in creating wealth, fostering agricultural development that is sustainable and, most importantly, ensuring the sufficiency and security of food. According to Mukesh *et al.* (2010), E-agriculture, particularly in Nigeria, has great potential, just like in any other region of the world. Its adoption mostly depends on how quickly and effectively e-agricultural experts and other stakeholders deliver the required services in the nation, taking into account potential obstacles.

Cereal crop farming is the practice of cultivating or producing crops such as maize, sorghum, millet, rice, oarts, barley and wheat for human consumption, animal feed, and for industrial uses such as manufacturing of starch and biofuel (Ismaila *et al.*, 2010). Cereals, or grains, as their name suggests, are members of the starchy dry fruits of the grass family Gramineae or Poaceae are the main reason for its cultivation. The primary cereal crops farmed are wheat, rice, corn (maize), rye, oats, barley, sorghum, and millet. (Douglas and Kent, 2018).

Depending on one's ethnicity or religion, cereal is eaten in a variety of ways, including as pastes, noodles, cakes, breads, drinks, and so on. For industrial uses, cereals' bran, husk, plant pieces, and other leftovers are used as animal feeds, cultures for microorganisms, wax syrup, and gum. The leftovers from cereal crops are used for various reasons by various ethnic groups in Nigeria, especially in Borno and Kebbi State. The study area produce primarily grains, including sorghum, finger millet, pearl millet, maize, wheat and rice. Also, wheat is primarily grown throughout northern Africa, especially in Sudan and Ethiopia, maize consumption is higher than that of other cereal crops in most part of the research area. The majority of the population in the area under investigation consumes cereal grains as a staple food, such as sorghum, millets, wheat, maize, and rice (FAOSTAT, 2010).

Agrarian livelihoods like farming of cereal crops, animal husbandry, and fishing are typical of Nigeria's rural areas especially the area of this research. According to Omonona (2010), persons in rural Nigeria who depend on agriculture have a greater rate of poverty than people in other occupational groups. Weather fluctuations are typically a factor in farming, and these differences may have an impact on agriculture, which may change farmers' access to food and revenue levels. At many policy levels, livelihood systems strive to reduce poverty by ensuring the rural population's food security.

According to Baro (2012), the term "livelihood systems" includes both home management techniques and the means by which relationships and agricultural production operations are carried out. The characteristics of the components of the livelihood system are determined by certain physical and social contexts' resources and values. A sustainable source of income is particularly crucial for rural dwellers since it demonstrates their ability to handle

other issues, such as good nutrition and shelter that guarantee a higher quality of life (Ayantoye *et al*., 2011).

The term "livelihood strategies" refers to the steps performed and judgement taken in order to attain living objectives, such as business operations, financial plans, and maternity arrangements. The methods by which agricultural households make a living is defined by the way they utilize nature and living outcomes for a specific objective, same way that the pursuit of livelihood goals by agricultural households does. As a result, research on adjustments to farm households' means of subsistence has recently gained worldwide attention in fields including ecoregions and geography. A plan to sustain one's lifestyle consists of getting more means of income (Zhang *et al.,* 2013).

The decision of a farm household's livelihood strategy, is based on income maximization and tolerable risks, this will unavoidably be significantly influenced by the amount of personnel and material assets that determine the opportunity cost of engaging in agricultural output. Zhang *et al*. (2013) differentiate livelihood, which is primarily made up of non-agricultural activities, is seen to be the foundation of building regional sustainable livelihood. For instance, Hao *et al*. (2010) discovered highest educational level of family members to have a noticeable positive impact on farmers' activities that are not agricultural related. But, lack of human resources has become a major factor preventing agrarian from doing occupation that are not agricultural related. As a result, it's essential to raise the level of human capital through education promotion, sanitary and medical facility improvements, and the spread of relevant agricultural techniques. The financial resources of agrarians are insufficient. This is demonstrated by their need for financial assistance from friends,

neighbors, and lenders, which suggests a limited capacity to manage risks. Therefore, giving out loans to farmers in this location is very paramount (Zhao *et al*., 2011).

Yan *et al*. (2009) has noted that social assets offer agricultural households, which struggle to produce and survive external support and assistance. The distribution of farm households' assets for their means of subsistence could be positively impacted theoretically by possessing a variety of social assets. But according to the statistical measurement of their study, societal resource had no discernible impact on farm households' decisions regarding their modes of subsistence, which could be attributed to the western mountain region's inadequate social asset development. The social asset score for farm households is the lowest of the five types of livelihood assets examined, coming in at less than one-tenth of the average values for these resources. Social resources are the farm household's requirement to implement various livelihood strategies, such as networks of trust and cooperation among families and villages, as well as various types of social embedding. These particular components are challenging to quantify. It demonstrates the importance of considering social context in addition to quantitative and qualitative study when analyzing farm home livelihood.

1.2 Statement of the Research Problem

A crucial component of e-agriculture strategy is investigating the information delivery methods that work best. Together with mobile broadband, the exponential rise in mobile phone ownership presents a fantastic opportunity for the development of e-agriculture, the food shortage and the population growth are the most challenges facing sustainable agricultural development in the study region. Advance technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and the mobile internet can provide realistic

solution to the challenges that are facing the agricultural sector. By improving agricultural production efficiency, improving livelihoods, and developing value chains, e-agriculture has a tremendous potential to distribute to economic growth and rising incomes among rural residents. It can be very helpful in addressing some of agriculture's critical issues, such as supply chain inefficiency, high individual risk, desertification, drought, and promotion of agricultural trade.

Nigeria agricultural industry faces difficulties in increasing productivity in light of the limited natural resources required for agricultural output. Africa's rural farmers, for the most part, rely on subsistence farming as their main source of income. High yield gaps and poor soil quality are some of the factors that make it more difficult to farm sustainably and to increase productivity. Population growth has increased the demand for agricultural products, which presents producers with chances to enhance production and boost their income. The first step in achieving Nigeria's agriculture vision 2020 is to find a system that guarantees efficient information transmission at all levels, from community outreach to policymaking. To realize this aim, Sidmach Technologies created the e-agricultural portal, a digital information repository on all aspects of Nigerian agriculture. Base on this fact, this study aimed at using e-agriculture in the area of study where cereal crop farmers will be investigated and digital information related to the use of e-agriculture will be transferred to them through the use of e-agriculture portal by the stake holders.

The agricultural sector has introduced investors and some stake holders as well as food security, dietary habits, and consumption, finance, agriculture, agro-industry, distribution, and logistics, all pertain to food and agriculture (FMARD and NITDA, 2016). The agricultural industry in Nigeria is distinguished by tiny holdings, limited capital, and low

yield per unit of land (IFPRI, 2000). The main dietary sources of energy, supply, and considerable amounts of nutrients are found in cereal crops. Rice, sorghum, maize, sugar cane, and pearl millet are the main cereal crops farmed in Nigeria. The country's savannah agro-ecological zone is where this is primarily grown. Numerous factors, including meteorological ones (rainfall, temperature, and sun radiation), edaphic ones, migration, governmental regulations, the adoption of regional variations, the predominance of weeds, pests, and diseases, and socioeconomic ones, limit the yield of these cereal crops. To reduce poverty and raise the standard of living for Nigerian producers of cereal crops, a subtle but effective strategy should be used. Chaudan (2018) reported that more than 70% of Nigeria's working-age population is employed directly or indirectly in the agricultural sector, and more than 90% of the country's agricultural production is produced by peasant farmers who are living in the majority (60%) populated rural areas.

Without some sort of public sector intervention, the vast majority of these farmers have limited access to knowledge, contemporary inputs, and other resources that could be used to increase productivity, like access to pesticides, fertilizers, hybrid seeds, and irrigation. According to Ogunwole, *et al*. (2014), Nigerian food production has recently grown at a pace of 2.5% per year, and demand for food has increased at a rate of 3.5% per year due to an extraordinary increase in population at a rate of 2.83%. Particularly among Nigeria's rural poor farmers, access to e-agricultural instruments is on the rampage, and many of rural farmers had taken advantage of this emerging sector of agriculture and it’s potential.

E-agriculture is a field that can assist in bridging the digital divide that exists between farmers who have access to the internet and those who do not. The principal revenue source for remote areas especially the study area is agriculture, improving agricultural productivity

is the only way to improve those communities' quality of life. However, the study area is a rural agrarian community but are now using more of the modern technologies than their usual traditional methods of farming. Making sure timely and accurate information is distributed, especially in the domain of growing cereal crops, is one of the best methods to improve the rural production processes in such areas. Farmers may use quick, precise information that is suited to specific areas and situations to use their resources as efficiently as possible in constantly changing conditions. Examples include changing weather patterns, varying epidemics of pests and diseases, and changes in soil conditions. They can engage in other crucial services like input supply and linkage to effective value chains through e-agriculture, which can also help them access dependable loan sources, lucrative markets, and profitable markets.

This research has identified this crucial gap of evaluating the effects of e-agriculture in the production of cereal crops because e-agriculture is an innovative way to use ICTs in rural areas, which mostly focus on agriculture and have a variety of needs in the agricultural sector and rising demand for agricultural products especially cereal crops. Therefore, in order to generate conclusions that can be advised to small-scale cereal crop farmers, it is necessary to do a thorough investigation in this area of agriculture. In light of the aforementioned initiative, the researchers looked at how e-agriculture has affected the livelihood of farmers who raise cereal crops in the research area. Following that e-agriculture can give cereal farmers pertinent information that would improve their livelihood by boosting productivity and crop yields. As a result, the following research questions have been answered by the research:

i. What socioeconomic traits can be found among the farmers that grow cereal crops in the research area?

ii. What are the information's sources of e- agriculture and their extent of usage by the cereal crop producers in the research area?

iii. What are the livelihood status of the cereal crop farmers in the research area?

iv. How does the use of e-agriculture in cereal crop farming in the research area benefit the producers of cereal crops?

v. Which factors influence the farmers' usage of e-agriculture in their cereal crop production in the research area?

vi. How effective do the farmers of cereal crops in the research region evaluate their use of e-agriculture?

vii. What effect does e-agriculture usage have on the cereal crop farmers' livelihoods in the research area?

viii. How severe are the constraints of using e-agriculture in cereal crop farming in the research area?

1.3 Aim and Objectives of the Study

The aim of the study was to evaluate the effects of e-agriculture on the livelihood status of farmers who grow cereal crops in Borno and Kebbi States, Nigeria. The study's particular objectives include the following, to:

i. enumerate the socio-economic traits of the cereal crop farmers in the research area;

ii. investigate origin of information of e-agriculture and their extent of usage by the cereal crop farmers at research area;

iii. look at the state of livelihood of farmers growing cereal crops in the research area;

iv. determine the benefits of using e-agriculture in the research region by the farmers of cereal crops;

v. identify the factors that influence how much farmers in the study area utilize e-agriculture for cereal crop production;

vi. ascertain the perceived effects of e-agriculture used among farmers of cereal crops in the research area;

vii. ascertain the effects of e-agriculture used on the cereal crop farmers livelihoods in the research area; and

viii. examine the severity of the constraints farmers of cereal crops in the research area experience while using e-agriculture in their farming practices.

1.4 Hypotheses of the study

The null form of the following hypotheses, which were tested, is given as**:**

$H0_1$: The use of e-agriculture and the specified socioeconomic factors for cereal crop producers such as (gender, age, marital status, educational level, household size, farming experience, farm size and income) are not significantly correlated.

$H0_2$: The extent of e-agriculture information sources used and the farmers' ability to make a living (livelihood status) are not significantly correlated.

1.5 Justification of the study

As socio-economic characteristics of the farmers got unveiled, it will benefit farmers and stake holders because it will help them know how to channel their e-agriculture packages taking into consideration the difference in the farmers socio-economic traits also by enabling ICT-driven solutions to a variety of agricultural problems, such as finding the best

seeds for a given soil or climate, enabling planning based on meteorological information, offering valuable extension guidance from a distance, or supporting farmers in obtaining a fair price for their products. Sources of e-agriculture discovered in this study will help to broaden the understanding of farmers, institutions, policy makers, extension agents and others to embrace e-agriculture and design programs to farmers suitable to be transmitted through this e-agriculture information sources.

The unveiled livelihood status of the cereal crop farmers in this study, will enable the farmers to look for more information using e-agriculture to improve on their livelihood status to gain higher living standard. E-agriculture can alter how people gather, examine, store, and share information so they can decide on the best course of action. The benefits of using e-agriculture in the research region proves to be overwhelming. This discovering will enable the extension agents and other stake holders in agriculture to develop e-agriculture contents using appropriate information sources that will unleash more benefits to the farmers that will encourage them to use more of these packages.

Age, gender, marital status, educational level, household size, farming experience, farm size, extension agents, membership of cooperative, access to credit facility, labour usage and income level were the identified factors that influence the cereal crop farmers usage of e-agriculture. These factors will enable the policy makers, extension agents, and other related partners in agricultural production to project policies targeted towards these factors that will in turn benefit farmers to improve on their cereal crop production.

Farmers perception of the effectiveness of e-agriculture used, will benefit the extension agents and the policy makers to decide on the improvement of variables that indicated not effective by improving on the e-information that comes to the farmers. The effects of e-agriculture as perceived by the cereal crop farmer will determine the content of e-agriculture package to be disseminate to farmers. The effect of e-agriculture on the livelihood status of the farmers will benefit the farmers as it will increase their livelihood, in turn make the farmers use more of e-agriculture. Knowing the constraints the farmers face in their usage of e-agriculture will enable the extension agents to face out packages that are not suitable for use by the farmers. This study will also act as a catalyst for organizations and people working in agriculture, sharing information, learning from experts' experiences, and promoting rural development in agriculture and to make better decisions regarding the crucial role that e-agriculture plays in empowering rural communities, enhancing rural livelihoods, establishing sustainable agriculture and ensuring food security.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1.0 Concept of E-Agriculture

E-agriculture is the process of preparing, developing, and putting new information and communication technologies (ICTs), particularly digital ones, into use in rural areas, the emphasis should be on agriculture, which includes fisheries, forestry, and cattle. By improving access to helpful information that can help people whose livelihoods depend on agriculture to make the best decisions and use the available resources, the goal is to promote agricultural and rural development and available resources in the most efficient and sustainable way (Abdulkareem, 2016).

E-agriculture has the ability to assist a nation in a number of ways in better achieving its agricultural goals. It can have an impact on increased agricultural output, input availability, and agricultural research. In addition to other things, it impacts post-harvest management, weather information and dissemination, market access and commerce, agricultural disaster management, social safety nets, and financial inclusion, among other aspects of agriculture (IITA, 2008).

In Action line C7 of the World Society Information Summit (WSIS, 2015), e-agriculture was listed as a use case for information and communication technologies (ICTs) (e-government). The task of arranging initiatives associated with the e-agriculture Action line was assigned to the World Society Information Summit. The e-agriculture community of practice was founded in 2017 along with the financial partners. (FAO and WFP, 2014) claimed that the e-agriculture community is an international effort to improve food security and sustainable agricultural development by boosting the ICT usage in the industry. The e-

agricultural community of practice, which is supported by the FAO, acts as a focal point for networking and information sharing about the significance of sustainable agriculture and rural development. An international framework for the use of e-agriculture and rural development makes it simpler to document, manage, and communicate the lessons learned as well as the results and applications of multilateral procedures relating to these topics. The community using e-agriculture has two main goals: to make it possible for farmers to exchange agricultural knowledge and to make sure that the knowledge created is successfully utilized around the world.

According to Fabregas (2022), providing information at scale about improved agricultural practices to cereal crop farmers remains a challenge in most developing countries. Traditional dissemination methods like in-person meetings or radio programming can be costly to scale or offer to generic information. Moreover, agronomics recommendations focus on maximizing crop yields, farmers weigh multiple other factors when making farming decisions, such as the profitability of investments and risks. The proliferation of mobile phone has shifted this trend. Mobile agriculture extension can cost-effectively provide tailored suggestions to farmers and improve their use of information (Hassan, 2009).

Normative guidelines and tools, empowering networks for key stakeholders to share innovative methods and processes, ensuring that relevant digital content is being generated, filtered, mobilized, and exchanged, and other e-agriculture-based activities are among the community's additional outputs (FAO, 2017). The adoption of new technologies has significantly improved communication and decision-making in rural regions. Since the e-agriculture community was founded, ICTs like mobile phones and the internet are being

used much more often. There are roughly 608 billion mobile connections for just over 7 billion people globally (WSIS, 2015). According to Blessing and Charalampos (2013), majority of the rural poor are those who work in agriculture and related fields. This presents a phenomenal opportunity to deliver information services to these individuals, as making educated judgments is aided by having access to the proper information at the appropriate time.

In terms of e-agriculture and rural development, WSIS (2015) highlights the most current developments as well as future tendencies. One of these is mobile telephony, which has expanded the accessibility of mobile apps created expressly for the progress of agriculture. In addition, many more mobile platforms have been developed and released in order to aid small-scale farmers in bridging the digital divide, providing them with access to a wider range of information sources than they did only a few years ago (such as the internet, radio, television, newspapers, and extension agents, to name but a few) (FAO, 2005). Mobile-based information delivery has a lot of potential, it is being evaluated for usage as important channels use for information on farming activities, finances, and transfer of some necessary ideas to agrarian society, to enhance their access to market data on market prices and demand of agricultural products (Komal and Sushopti, 2017).

According to WSIS (2014), over the previous five years, short message service (SMS) was the most popular. In contrast, today's technologies include short message services, interactive voice response, smartphone applications, and social network integration. Young people have played a part in driving the spread of mobile phone usage for improvement of farming. Even though these apps might not entirely satisfy farmers' expectations, they mark a substantial advancement in the integration of agricultural production with e-agriculture

(Blessing, 2010). E-agriculture has the ability to reach more rural farmers than traditional financial service providers have been able to in terms of providing them with a variety of financial solutions. Due to lower business and traction costs, e-agriculture contributes to economic efficiency and increased service delivery. The benefits of e-agriculture on agricultural output were highlighted at the 2015 World Summit on the Information Society (Abdulkareem, 2016).

Revealing that e-agriculture enabled marketing and access to certification and marketing, improves the capabilities of small manufacturers, to boost sales by strengthening their position on the domestic and international markets. According to Campbell and Cecilia (2012), agro-metrological and geographic information system (GIS) technologies have been incorporated into programs for a number of uses, such as farm usage, preparation, plant forecasts, and early warning systems. According to Fredrick e*t al.* (2016), mobile phone use has increased for information sharing about disease prevalence and e-agriculture means for next phases of the agricultural production chain, including post-harvest, shipping, and storage. Monitoring dangers from the rising frequency of natural disasters requires the use of space technologies as well. Kolawale and Ojo (2010) asserted that the availability of scientific and educational content combined with e-agriculture (online learning) courses has increased the flow of new knowledge and education to smallholder farmers.

The advantages of e-agriculture use in different spheres of life were presented by World Submit Information Society (WSIS) in 2015. This includes ensuring the systematic diffusion of knowledge in food production, fisheries, and animal husbandry as well as providing easy access to thorough, current, and in-depth understanding of e-agriculture. Fernado (2016) emphasized that people should work to make the most of e-agriculture as a

tool to boost both quantity and quality of produce. The task of planning events for the e-agriculture Action line has been delegated widely. Agricultural production society was founded in 2007 by the founding partners and the FAO after extensive research on the subject (FAO, 2017). The eagriculture community is an international effort to improve food security and sustainable agricultural development by expanding the use of the e-agriculture sector.

The FAO-facilitated e-agriculture community of practice serves center which is used for networking and information delivery about the application of ICT to rural development and sustainable agriculture. This offers a global framework to make it easier to gather, manage, and share the findings and ramifications of multilateral activities in agricultural production. Objective of the community is to allow members to exchange agricultural information and to ensure that the knowledge produced is efficiently disseminated and used around the world (WSIS, 2014). According to Xiaolan and Shaheen (2012), utilizing e-agriculture, which plays an essential role in enhancing the rural poor's standard of living and reforming nations through higher growth and sustainable production of agricultural goods, conventional agriculture's issues are greatly reduced. According to recent studies, agriculture generates jobs for landless people and small farmers totaling 1.3 billion labourers and offers a means of subsistence for 86% of rural residents. Additionally, compared to other sectors, agriculture contributes significantly more to the growth of GDP. With the introduction of e-agriculture tools in recent years, it is now possible to identify how e-agriculture information sources might help support broader economic, social, and institutional development and agricultural development goals.

The increased desire for innovative methods, agribusiness models, best practice and design principles are used in agricultural and rural development projects aided by e-agriculture. The adoption of e-agriculture provides farmers with a lot of support (Ferroni and Zhou, 2011). Eagriculture tools are used to spread the right kind of knowledge about crops, seeds, fertilizers', marketing, and other relevant topics through a variety of media. By improving access to markets, agricultural technologies, production methods, natural resources, banking, and financial services as well as regional and federal regulations relating to agriculture, eagriculture also assists in empowering the underprivileged and those living in rural areas (Harikrishan and Hiremath, 2013).

Several government investigations have stated that the use of e-agriculture at the various levels of agricultural processes increases agricultural competitiveness. A key factor in establishing competitiveness is the management of technological information, including, among other things, price and market data, meteorological data, economic factors, peer communication, and commercial transactions (Mittal, 2012). E-agriculture offers transparency in implementation processes, which is seen in the country's paddy procurement systems and numerous other programmes for buying different crops. The money is transferred directly to farmers' bank accounts, which greatly decrease likelihood of the agent fraud and corruption problem (Urendran, 2014). The implementation, however, is impacted by a number of elements, includes: infrastructural access and ability of e-agriculture devices and facilities; network availability in production in commercial areas; outreach of awareness programs; the quality and availability of suitable information content; difficulties of the media; desires and utilization of individuals toward e-agriculture;

and others (Mittal, 2012). Crop management, agriculture output, and other areas all benefit greatly from e-agriculture.

2.1.1 Sources of e-agriculture information

According to FAO (2014), the definition of e-agriculture goes beyond the e-government aspect of agriculture because it includes a broad spectrum of infrastructure and product services offered by the public sector, the corporate sector, governmental research and extension, NGOs, and farmer organizations. Governmental agricultural services delivered via ICTs to people, such as farmers and rural communities, are also included. ICTs that can be utilized for e-agriculture include a variety of tools, networks, programs, and services. Modern internet-based technologies and sensing tools can be among them, as well as more venerable ones like radio, telephones, mobile phones, televisions, and satellites that have been in use for a lot longer (Lohento *et al*., 2013).

E-agriculture presents significant opportunities to boost economic growth, enhance incomes, and improve rural communities' quality of life through improved agricultural production efficiency and value chain development (Sheikh *et al*., 2016). E-agriculture offers opportunities to use ICT-driven solutions to address the most urgent issues in agriculture issues, including global warming, pest and disease problems, and limited market access. E-agriculture's cross-sectional nature spurs expansion in other industries. A distinctive ICT based platform can benefit a variety of industries, including agriculture, health, and transportation, by providing consumers with information on products and their quality, ensuring prompt delivery of goods to markets, and empowering farmers by fostering stronger ties with small-scale producers and markets (Thia *et al.*, 2016).

FAOSTAT (2015) identified the sources of e-agriculture information to include; Telephone for interactive voice response, Mobile phone, Computer and website internet and broadband. Food and Agricultural Organization and International Telecommunication Union (FAO and ITU, 2017) reported that e-agriculture also plays the following role in agricultural production system. These roles include;

i. Regulatory frameworks: E-agriculture aids in the implementation of regulatory frameworks, policies, and methods to track progress.
ii. Capacity development and empowerment: The reach of local communities, including women, youth, and elders, is expanded by e-agriculture, which also offers newer business opportunities, improving livelihoods.
iii. Financial services and insurance: E-agriculture makes financial services more accessible to rural communities, enabling them to better manage risks, save money, and get affordable insurance.
iv. Food safety and traceability: E-agriculture aids in the delivery of more effective and trustworthy data to adhere to global traceability standards and food nutrition considerations.
v. Agricultural innovation systems: E-agriculture fills the gap between farmers, academics, extension agents, different market players, and agricultural researchers.
vi. Sustainable farming: E-agriculture provides better access to information about climate-smart farming practices, plant protection, and animal health.
vii. Disaster risk management and early warning systems: E-agriculture offers real-time advice on risk mitigation as well as actionable information on disaster avoidance to communities and the government, such as agro-metro information.

Viii. Enhanced market access: E-agriculture makes it easier to access markets for inputs, goods, and trade.

A new subject nexus of farming knowledge, farming enhancement, and marketability is known as "e-agriculture," which describes agricultural production services, technology diffusion, and information given or improved using the internet and related technologies. However, the e-agriculture concept goes beyond technology to include knowledge and culture, with a primary focus on improving communication and the learning process among the various stakeholders in the agricultural sector that are involved at various levels (FAO and ITU, 2017).

2.2 Application of E-agriculture Tools to Agricultural Sector

2.2.1 Geographical information system (GIS)

Comparisons of several types of data visually are available using a geographic information system. It is crucial for the creation of maps, charts, and additional information relating to coordinates and time, as well as for establishing linkages between various data sets. It aids in the examination of changes in agricultural yield measurements after harvest and offers a comprehensive perspective of the production system (GIS Development, 2010). Agronomic and crop productivity spatial data can be managed and analyzed using GIS, an automated data storage and retrieval system. It can interface with other decision support tools and integrate all types of information. GIS can show studied data in maps that enable improved knowledge of the interactions between yields, soil fertility, pests, weeds, and other factors, as well as the use of such spatial relationships in decision-making (Campbell and Cecilia, 2012).

2.2.2 Handheld personal computer

Handheld personal computers are portable, lightweight devices that have been used for data collection, mobile mapping, and other tasks (Fernado, 2016). A handheld computer is one that can be used while being held in the hand and is easily stored in a pocket (Margaret 2015). Tilley (2001) described a handheld computer as a device with a smaller form factor than a typical laptop computer. It's occasionally called a palmtop computer.

2.2.3 Mobile (cellular) phone applications

According to Alemu and Negash (2015), farmers and business owners now have access to markets and more than a third of the population currently owns a mobile phone due to the fast growth of the technology, as a result, transaction costs have decreased, trade networks have grown, and the job search has become simpler. According to Bertolini (2009), the majority of farmers in Africa only use the telephone as a form of e-agriculture while, some respondents thought one of the most significant e-agriculture applications was available for mobile devices, such as SMS.

2.2.4 Community radio stations

According to Chataira (2014), community radio has the ability to provide the community it serves a voice through local language programming that respects its local culture, traditions, and interests while fostering community debate. One of the key e-agriculture instruments that gives farmers and the general public a voice and aids in community development is radio. The author went on to say that a community or people of a community own and run community radio. According to Mahanan (2016), radio is a crucial tool for distributing knowledge and information, particularly to the poor, in a variety of languages and forms. By giving resource-poor rural farmers in Zambia the chance to tune

into a radio conversation program about agricultural topics and practices, the government's Radio Farm Forum (RFF) initiative has demonstrated the value of radio in addressing their common needs and problems. Community radio is a form of service that targets the demographics of a certain region by airing popular but frequently ignored local material (Okwu *et al.,* 2007).

2.2.5 Internet and web-based applications

According to Amos (2016), a web application is a computer programme that works via the internet using web technology and web browsers. FAO (2014) noted that there are numerous active web-based application initiatives globally and that the use of the internet, e-mail, websites, and web-based applications is becoming more and more vital for transferring and exchanging agricultural information. FAO and ITU (2017) said that FAO and partners are adopting e-agriculture, focusing on the online supply of agricultural services, technology, and information, at the nexus of agricultural informatics, agricultural development, and entrepreneurialism. By encouraging the fusion of farming partners, technology, and multimedia with knowledge and culture, e-agriculture aims to improve learning and communication processes.

2.2.6 Global positioning systems (GPS)

An investigation conducted by the International Institute for Tropical Agriculture (IITA) in 2008 revealed that global positioning system is a satellite-based navigation system that may be used to locate sites anywhere on the planet. GPS provides global, ongoing, real-time, three-dimensional locating, navigation, and timing services in all types of weather. Farmers have more recently had access to site-specific technology thanks to GPS (Margaret, 2016). Farm machinery may be located using GPS within a meter of a real-world location in a

field by using a network of satellites (Richard, 2014). According to Gonzalez *et al.* (2011), availability of GPS farming methods will make it possible to connect all field-based factors. This instrument has established itself as the common link between field variables including weeds, crop production, soil moisture, and remote sensing information.

2.3 Role of E-Agriculture in Agronomic Practices

Deloitte *et al.* (2012) reported that it is helpful to think of the farming lifecycle as a threestage process when determining how e-agriculture can aid agricultural development. This includes the following:

- Pre-cultivation is the process of selecting the crop, the land, the calendar, the financial options, and other factors.
- Crop Cultivation and Harvesting; this covers input management, water management, fertilization, pest control, and soil preparation and sowing.

2.3.1 Crop variety selection

According to Zahedi and Morteza (2012), the system that recommends the best crop varieties to consumers is called the crop variety selection system. For their plantation, they provide a choice of options depending on the specifics of the farm and the user's preferences. This subsystem's domain knowledge includes the models of suggestion and selection. The three inference steps in the inference knowledge are specify, select, and count. The specified inference step uses the relationship among the appropriate varieties and the environment present in the suggestion model to suggest paddy varieties that are appropriate for the immediate environment. The "select" inference step uses the selection model, which has a relationship between the user requirements and the corresponding

varieties, to choose the best varieties that best reflect the user requirements. Only the specified varieties are counted in the 'count' inference step (FAO-UN, 2015).

2.3.2 Land use planning and management

Remote sensing techniques and Geographic Information Systems (GIS) are two essential e-agriculture technologies for managing and planning the use of land (Singh *et al*., 2015). The authors went on to say that GIS provides the option to compile many layers of data from various sources into a single spatial representation. When people using a particular territory have different values and tastes, this can be especially helpful in achieving agreement on land planning. FAOSTAT (2015) showed that RS approaches are a useful tool for monitoring land resources, particularly in a large area. While planting provides the most appropriate planting methods based on user-specific input data, land preparation gives the user particular advice on how to prepare individual land for paddy cultivation.

Xiaolan and Shaheen (2012) claimed that it takes a lot of time to finish the procedures related with amending land records, which are required in order to be eligible for government benefits and programs. E-agriculture is crucial in addressing the challenges of land management and planning, as well as the need for people to have their paperwork in order to benefit from various programmes. The farmers are given instructions on how to complete their task relating to land records with the aid of government employees. Since mobile phones have tremendously aided in altering and sparking revolutions in villages, they can benefit greatly from the programmes.

ICT solutions for land planning and management rely heavily on the use of remote sensing and geographic information systems (GIS). GIS enables the integration of numerous layers of data from various sources into a single spatial representation (Dhanaraju, 2022). There is a lot of promise for using mobile phones to educate farmers about agriculture that is climate-friendly (Urendran, 2014). A significant amount of appropriate and pertinent information about soil and other topics can be gathered and made available to farmers. Farmers and buyers of their crops have better and more efficient options thanks to mobile technology (Praduman *et al.*, 2015).

2.3.3 Soil quality assessment

According to Ospina and Heeks (2010), both at the farm and regional levels, soil quality can be assessed. On the basis of the soil, climate, and land use, it can be done at the regional level. Understanding the nature of soil and the problems it encounters as a result of management practices is made easier by some useful technologies. E-agriculture has advanced significantly in recent years. Some practical technologies, such remote sensing, are used to evaluate soil quality. Remote sensing is a method for gathering information about an object from a distance. The development of agriculture and the ensuing rise in production are two crucial benefits of e-agriculture. However, environmental concerns must be addressed in order to prevent society and humanity from being negatively impacted by increased food production and marketing. Green growth and climate change should always be the main priorities for agricultural development (Praduman *et al*., 2015).

Achieving agricultural productivity should not come at the expense of environmental repercussions. Actually, increasing agricultural output faces difficulties due to a variety of factors, including scarce resources, population increase, and environmental concerns. If

there are negative effects, these issues may be exacerbated. Therefore, using e-agriculture should solve these problems. Retailers aid farmers in several developing countries, particularly India, in deciding how much fertilizer to use; however, to increase productivity made feasible by e-agriculture tools, fertilizer installation must be automated and computed. E-agriculture is needed to evaluate and manage agriculture's effects on the environment, water, and other natural resources in novel ways (Harikrishan and Hiremath, 2013).

2.3.4 Water management technology

According to Moshe (2017), the "usage of water to a tree on monitoring each tree's needs to optimize its field" is irrigation, made possible through e-agriculture. E-agriculture is used to track each tree's actual water and nutrient needs as well as its consumption. In reaction, the system remotely initiates a continuous, optimal delivery of fertilizers and water suitable for weather situation, edaphic nature, and producer’s production plan. According to Moshe (2017), the use of e-agriculture and automation boosted irrigation water use efficiency by 10% to 50%, increased higher output per unit of water and land use by twenty to hundred percent to enhance product outlook. E-agriculture and automation in water supply facilities and networks made it possible to optimize saving water and energy, thanks to the pressure regime in delivery networks and bill customers based on their real water use. Conceptually, the adoption of the volumetric approach to water application was spurred by e-agriculture and automation. The author came to the conclusion that these developments allow for the expansion of the irrigation area, higher food output, and more farmer income (FAOSTAT, 2015).

2.3.5 Fertilizer management

According to Edrees (1999), the three main issues in agriculture that needed to be addressed were fertilizers, pesticides, and yield quality. In the vast majority of cases, professionals are needed to measure the needs that could be wasting time and this is expensive in developing nations. Image processing is one approach that can be used to precisely and affordably quantify agronomy-related characteristics (Datir and Wagh, 2014).

2.3.6 Identification of nutrient deficiencies

According to Ali *et al*. (2012), the method for determining the nitrogen content of maize leaves has undergone a revolution thanks to the software indicated above. The plan was to use image processing in a software programme to replace the human method. The background noise is removed from a photo of a maize leaf that has been taken. According to Datir and Wagh (2014), the maize leaf's colour and texture are removed. The fertilization system provides a timetable for fertilizations that specifies the kind, quantity, name, and application time of fertilizers.

2.3.7 Pests and diseases management

Amsini (2019) created a technique for detecting marijuana using image processing. The automatic sprayer received the input of the weed blocks and only sprayed in those blocks. As a result, fewer weedicides will be used to protect the plants. Rastogi *et al*. (2015) presented a case study of computer vision and image processing in the agriculture industry as cuttingedge and significant problem-solving strategies because the methods are more accurate and faster than manual methods. The authors went on to say that artificial neutral networks should be used to recognize and classify agricultural plant leaf diseases in order to solve problems involving agricultural image processing in an efficient and effective

manner. The study also showed that, following disease classification, disease grading involves estimating how much of a leaf is infected due to the use of fuzzy logic to diagnose disease.

Table 2.1: Wireless sensor network-based pest control techniques in literature (WSN)

Examining the Symptoms	Pest identification	Pest control
Using weather information, a real-time system can identify the Downy Mildew bug.	Absence of identification systems.	Automated pesticide application if there is a high risk of illness.
Maintain a constant eye on the noise level being gathered by various sensors and the comparator, which is set to a specific threshold level.	No system exists to identify specific pests.	An alarm signal alerts the operator, who can then take the appropriate steps to spray insecticides.

Source: (Datir and Wagh, 2014) and (Srivastay, *et al.,* 2013)

2.4 Utilizing Technology in E-agriculture for Harvesting and Post-harvest Operations

2.4.1 Grading agricultural products using image processing

The study also showed that disease grading which happens after illness classification involves applying fuzzy logic to determine how much of a leaf is afflicted by the disease. Patel (2013) developed a generalized approach for automated fruit sorting that is rapid, affordable, secure, and accurate. The authors' algorithm for ranking fruits like apples, tomatoes, mangoes, strawberries, dates, cherries, oranges, and lemons was tested for accuracy.

2.4.2 Harvest automation

Mangoes were traditionally mostly hand-picked or harvested using a machine which require energy, this is inefficient method and significantly lose immature fruits although they have a strong focus on power (Zahedi and Morteza, 2012). After harvesting the fruit, there are

loses of latex due to detachment, this damages the fruits and make it difficult to store. A hexacopter programme with a robotic arm attached that uses the Hue, Saturation Value (HSV) colour recognition algorithm and stereo vision can be used to solve these issues and achieve the goal of safe and efficient mango harvesting. One of the most important advancements in harvesting technology over the past 20 years has been yield monitors. Manufacturers keep developing these systems so that they can measure yield and humidity for the operator during harvesting operations and supply post-processing software (Datir and Wagh, 2014). To increase field productivity, many farmers use harvesters with autonomous steering. However, devices to enhance automated steering during corn harvesting, sensors that detect the stalks at the header have been developed. Majority of the automatic steering systems rely on GPS for guiding (Edrees, 1999).

2.4.3 Use of e-agriculture as a means of enhancing agro-metrological information

Small-scale farmers don't have access to integrated systems for processing and disseminating agro-meteorological data (Mugenda, 2003). Agricultural extension officers, farmers, agricultural research facilities, meteorological stations, and other sources of information all contribute to the flow of information in a model-like manner. The system can do a variety of actions as a result of the inference, engine processing this information using some of the ways. Small-scale farmers can then use SMS to communicate with the system and access media for information (Lwande and Lawrence, 2008).

2.4.4 Weather Forecasting

Metrological sections are used by researchers to take climatic information on a daily basis, which is then analyzed to assess climate risk and determine the most effective times to plant, grow crops, and use water (Zahedi and Morteza, 2012). In e-agriculture, weather

forecasting is essential for agricultural production. The growth, development, and yields of a crop, the frequency of pests and diseases, the requirement for water and fertilizer due to variations in nutrient mobilization and water stresses, and the timeliness and efficiency of preventative and cultural operations on crops are all significantly influenced by the weather. Every link in the chain is dependent on e-agriculture, including detection, modeling, forecasting, early warning and localization (Singh *et al.*, 2015).

2.4.5 E-Agriculture device for risk management and climate change

Due to large number of crops and the difficulty of reproducing the same conditions across different places, there are a number of instruments available to study the relationship between climate change and agriculture (IITA, 2008). Every tool is permitted to analyze various agricultural processes, from managing the economic effects of climate change on the modeling of local crops under conditions of climate change in the agriculture sector. Before using e-agriculture as a weapon to prevent climate change, it is vital to understand how much it is contributing to it (Singh *et al.*, 2015).

International Telecommunication Union (ITU) (2008) showed that e-agriculture is far from blameless when it comes to causing climate change. The abundance of consumer electronics, each of which produces heat and needs electricity, is the main cause of e-climate agriculture's change contribution. Despite the fact that poor nations lack the essential infrastructure for e-agriculture is crucial in preventing climate change. In both developed and poor countries, these technologies can be used. Intelligent transportation and building systems, dematerialization, and smart grids are some of the ways that ICTs can be used to control carbon dioxide emissions and slow climate change (Ospina and Heeks, 2010).

2.4.6 Benefits of the usage of e-agriculture

E-agriculture has greatly aided the agricultural sector, improving rural residents' quality of life and, ultimately, the nation's services, which are crucial because agriculture directly affects GDP. The following, according to Mittal (2012), are the main effects (benefits) of e-agriculture:

- Enhanced production as a result of the expansion and use of mobile e-agriculture in rural areas.
- Agriculture innovations utilizing electronic media to support instruction and training.
- The development of social and human capital is accelerated by new opportunities.
- Achieving enhanced process control and openness in market data.
- Reducing transaction costs when tracking customer requirements.
- Improved rural livelihoods and food security.
- Reducing poverty with contemporary agriculture.
- Broadening the lens through which local communities view regional, national, or international developments.
- The emergence of fresh commercial possibilities.

The aforementioned results can be observed in a variety of e-agriculture-based agricultural implementations by many government entities.

2.5 Development of Agriculture and Food Production

We eat almost entirely things that are produced by flora, fauna, birds, fish, and other marine life, such as shellfish, the leaves and roots of numerous plants, as well as the fruits and seeds that they produce, are edible to humans and animal products, such as milk and numerous animal parts are edible by humans. People eat insects and the products they

create, such as honey, in many different places of the world. People used to obtain their food from the nearby plants and animals before agriculture was developed. Additionally, they gathered insects, bird eggs, shellfish, and other types of seafood. In many regions of the world, people continue to engage in all of these activities (Matt, 2019). People in the Middle East, Asia, and South America began to cultivate grasses that yielded grains like rice and wheat, as well as plants that yielded vegetables, nuts, and beans, around ten thousand years ago. In addition, they produced fruit trees and raised livestock for meat and milk. Additionally, dairy products like cheese and yoghurt were first made from sheep and goat milk around 8,000 years ago. According to the author, as agriculture advanced, farmers started to produce an increasing variety of food for their own consumption (Matt, 2019).

According to Proscovia and Marrit (2019), a crucial aspect of access to food is food security, which rural people have long struggled with. In order to support a family income and access to food, they showed that a particular intervention to support food access had raised support for market production rather than the self-sufficient aspects of subsistence production. In Western Uganda, where rice is largely a cash crop, the situation with rice is examined by the authors to further explore the impact of market production on households' food intake. They found evidence of the negative impacts of market production on caloric intake, showing that households with higher degrees of commercialization were more likely to consume less calories per adult equivalent per day than was necessary. Despite significant economic and agricultural growth over the previous three decades, 13.5% of the population in developing regions remained chronically malnourished (FAO, 2014).

According to Nord (2014), lack of food poses a risk to the public's health since it makes people more vulnerable to a variety of physical, mental, and social health issues. Kirkpatrick *et al*. (2010) reported that children and young people who go hungry, especially when it happens frequently, are more likely to be in worse health condition. Hoddinott *et al.* (2008) revealed that poor nutrition choices may cause adults to earn less money and have lower education levels. Market-driven agricultural production is viewed as a practical solution to guarantee long-term food security and welfare. Policymakers have supported it in the hope that it will increase household income while also boosting crop productivity because of increasing utilization of input. But the market production approach faces particular difficulties in low-income areas, there is possibility that increasing money and food productivity won't lead to increased food consumption ((Pingali, 1997).

Vertmeulen *et al*. (2012) indicated that gaining access to food required both physical and economic means, including having the means to buy it from markets or owning food that was grown or raised at home while for households producing goods for the market, access to food markets is crucial. Most people acquire at least some of their access to food through the market when they have the money to buy a sufficient diet rather than producing it fully. However, having enough money depends not just on how much one makes but also on how much food costs. (Staatz *et al*., 2009). Depending on its resources, each household has experienced repercussions unique to the move from production for survival to production for market.

The general finding was that resource-poor households still experienced food insecurity notwithstanding their participation in market production because of the limited supply and restricted access (Misseelhorn *et al.*, 2012). Von Braun *et al.* (1991) discovered that

households with a lower subsistence orientation consumed fewer calories overall, though the amount of calories consumed was much higher when calorie revenue from cash crops was higher.

2.5.1 Overview of cereal crop farming in Africa

Only 252 million ha (19.36%) of the 1.3 billion ha of agricultural land in Africa, a continent with a massive surface area of 3 billion ha, are used for growing crops (FAO, 2011). Sorghum, finger millet, pearl millet, teff, and African rice are just a few of the cereals that are mostly produced in Africa and have their origins there. While wheat is commonly grown in northern Africa, Sudan, and Ethiopia, maize has replaced these traditional cereals as a major grain. Subsistence farming is the main form of agriculture in Africa. The majority of small-holder farmers engage in agriculture, which presents challenges for sustainable farming and earnings due to huge yield gaps, poor soils, and other factors. The main staple meals for the majority of people are the cereals. These are raised on 98.6 million hectares of land, yielding 162 million tons (FAOSTAT, 2014).

Table 2.2: Africa's grain crop production and geographic distribution

Crops	**Africa**	
	Area (ha)	**Production**
Maize	34,075972	70,076,591
Millet	19,998,008	16,008,838
Rice paddy	11,206,813	28,798,202
Sorghum	23,142,595	23,350,064
Wheat	10,224,952	24,704,201
Total	98,226,080	162,422,507

Source: FAOSTAT, 2015

2.5.2 Maize

The most common crop found in Africa is corn, it is the most frequently grown main food crop, taking up more than 33 million acres annually. The crop, which is planted in a number of locales is consumed by individuals from a range of socioeconomic situations and food preferences (IITA, 2008). Since 1961, corn and other grains output have expanded dramatically on cultivated land throughout SSA. Africa is home to 16 of the 22 countries where corn is the major calorie consumed. The highest average yields are found in West Africa, where it is 1.7 t/ha, followed by East Africa, 1.5 t/ha, and Southern Africa, 1.1 t/ha (IITA, 2008). Even while certain countries, like Ethiopia with >3 t/ha, have had large production advances, this is still the case. Eleven (11) varieties of nitrogen-use-efficient (NUE) maize were released by project partners in 2014, and 2,300 MT of seed were produced (Smale *et al*., 2011). Among the major staple foods consumed by people in sub-Saharan Africa, maize is grown in a range of agroecological zones and agricultural techniques with a wide range of dietary preferences and socioeconomic status (SSA). Similar to rice or wheat in Asia, maize serves as SSA's primary staple food, with eastern and southern Africa (ESA) having the greatest consumption rates (Nuss and Tanumihardjo, 2011).

Difficulties in growing maize:

i. Challenges in supplying the anticipated demand for maize due to poor harvest: rise in yearly consumption of corn by the people of Africa, has been estimated to reach 52 million tonnes by 2020, countries are having trouble meeting this need given the present development in yield gains, which averaged only 1% (Bouis *et al.*, 2011). In all regions, maize and other crops have significant yield gaps, which are common in the fields of

smallholder farmers in Africa. Similar to this, improper grain management after harvest causes an estimated 20% of losses that could have been prevented. Saving half of this loss will increase the amount of maize in the African economy by 10% and the efficiency with which resources are used to grow crops should be improved (Mahuku, 2015).

ii. Impact of persistent biotic and abiotic stressors and climate change: A constant problem for maize productivity in SSA has high prevalence drought, extreme heat, and little soil nitrogen, illnesses, insect pests, and parasitic plants also exist. In addition to the drought and low soil fertility, biotic stressors include the parasitic weed, Gray Leaf Spot, Southern Leaf Rust, Turcicum Leaf Blight, Maize Streak Virus, and Turcicum Leaf Blight, Striga hermonthica are found (Bouis *et al*., 2011). Similar to how maize is particularly susceptible to aflatoxin contamination, it is difficult to improve the health of Africans and increase earnings. Aflasafe, a country-specific bio-control product, has been produced in 11 countries, and several other countries have asked for the development of similar products for their benefit. The African Union has underlined the need to lessen the burden of aflatoxin by means of its subsidiary Partnership for Aflatoxin Control in Africa (PACA) (Grings *et al*., 2013).

iii. Food security in eastern Africa is threatened by maize lethal necrosis (MLN): Since 2011, MLN has become a significant danger to the region's food security. The estimated loss for Kenya was 0.3 million tonnes annually, or 23% of its estimatedUS$ 110 million ($365/tonne) average yearly production (Adejuwon, 2013). Since more than 95% of the commercial maize types available on the eastern African seed market are susceptible to MLN, the situation is extremely dire. This indicates that unless immediate and extensive

action is taken, Kenya and its neighbouring countries is at risk of severe food insecurity in the countries where the disease has been documented.

iv. Adoption of improved climate-resilient maize varieties is hampered by a number of significant factors, including; Lack of better seed availability, lack of knowledge, lack of financial availability, high seed pricing, and restricted capacity of seed firms that prevents product distribution (Fisher *et al.*, 2015).

v. Insufficient use of sustainable intensification techniques and improved genetics in maize based agricultural systems: Crop productivity is mostly determined by more effective agronomic methods, fertile soil, water management, weed control, and encouraging legislation, expanding and scaling down specialized conservation agriculture practices will be necessary to greatly increase maize yields (Adejuwon, 2013).

vi. Enough money has been spent on developing new technology, such as better agronomy and genetic advancements: Due to low R4D funding, some SSA nations, including Togo, Burkina Faso, and other nations have experienced significant difficulties in the development of improved agronomic approaches and new maize varieties that can be tested, released, and put into use (FAOSTAT, 2014). Support is needed to boost the production of healthier, more nutrient-efficient, and resistant to multiple stresses varieties of maize, stop the spread of corn lethal necrosis (MLN), boost the corn production aspects, boost the ability of subsistence enterprise industries, sustainably intensify corn-based agricultural food production systems, and produce better Aflasafe goods (Mahuku, 2015).

Opportunities involved in maize farming:

i. Effective crop management techniques and stress-tolerant maize varieties: Because there is high yielding, stress tolerant, and nutrient-rich maize varieties that can be produced and distributed to farmers, maize can significantly contribute to closing the SSA has a food supply and demand gap (Balasubramanian *et al*., 2009).

ii. To decrease protein and micronutrient deficiencies, a variety of nutritious corn is available: Supplements and fortified meals are not widely available in some areas, maize is thought to be the best option for improving and delivering provitamin-A (Bouis *et al*., 2011). IITA and CIMMYT have made provitamin development, testing and release considerable strides in collaboration with the Harvest plus Challenge Program. Other SSA nations with comparable agricultural settings can be included in the production and deployment of nutrient-dense maize varieties (Kamara, 2008).

iii. Strong connections with the business sector, community-based seed growers, and nongovernmental organizations have resulted in significant public-private partnerships for product distribution (NGOs) have made it possible to deploy products designed for the SSA at much larger scales, which will have a stronger effect on a farm level (Balasubramanian *et al*., 2009).

iv. Existence of novel methods to increase genetic gains: there are few unique and cutting-edge methods and approaches that must be applied consistently and heavily in order to increase access to genetic improvement in SSA (Smale *et al*., 2011).

v. Increased usage of maize that has been supplemented with provitamin A gives poultry meat and eggs an appealing yellow colour: As a result, there would be a huge increase in the demand for maize grain and its usage in the production of chicken feed. Aflatoxin hurts

birds, prevents growth and has other harmful effects, hence it is critical to make aflatoxin-safe maize accessible (Alene, 2009).

vi. Maize with two uses: As farms grow smaller, cattle are pushed out reducing their number. More competition between food and feed will result from the model of designating some area for crops and another for livestock feed. Dual-purpose maize can help by ensuring that crops and animals can coexist (Grings *et al*., 2013).

vii. Corn cultivars and their accessibility can promote various uses for the grain, boost options for farmers and processors to make money off of it, lessen the need for women to work at home, and help cut down on wastage (Prasanna and Mahuku, 2015).

viii. Improving Aflasafe products, delivery methods, and management systems for aflatoxin: Only a few nations currently offer country-specific products that have been registered and are ready for registration. More goods are needed for use in nations that do not already have any (AfDB, 2010). Aiming to boost private sector investment in technological diffusion and scale-up, it is necessary to establish and put into place systems and delivery mechanisms for the management of aflatoxin, which calls for an integrated strategy. Aflsafe manufacturing facilities in five nations are also necessary to make the items accessible throughout the region (Smale *et al*., 2011).

2.5.3 Sorghum and millets

With 22% of the total cereal area under its cultivation, Sorghum ranks second in terms of significant cereal after maize. Millets (pearl and finger) account for the remaining 19% and the trend that reflects the sustained demand for these commodities was in the past fifty (50) years (FAOSTAT, 2015). The fact that sorghum and millets have lagged behind other cereals in crop improvement efforts, as well as these crops are raised in farming systems

with difficult weather conditions, limited resources, and low inputs, have contributed to the unfortunate fact that the increase in demand has not been matched by crop output. Additionally, the Land deterioration, climate change, and other issues are significant in such dry land areas, inadequate attention, isolation, and inadequate national institutions are also part of the problems faced.

Despite these obstacles, there is a compelling argument in favour of stepping up efforts to create technology supported by markets, agronomic management and institutions (Idem and Showemimo, 2011). African countries are the primary producers of a number of grains, including sorghum, finger millet and rice. Most small-holder farmers engage in subsistence farming, which has huge yield gaps and poor soils among other challenges that make it difficult to sustain farming and incomes (Adejuwon, 2013).

Some of the most popular cereals are Guinee corn, pearl millets, wheat, corn, and paddy rice these are commonly consumed by the people. These cereals are farmed on 98.6 million acres of land, yielding 162 million tonnes occupying 22% of total farm area. As a subsistence crop, pearl millet can withstand harsh climates and is produced there. A significant step toward agricultural transformation will be raising the productivity of smallholder farmers, closing yield gaps by giving the right inputs combined with superior technology helping farmers to better manage climate risk. Sorghum and millets are commonly used for food in Africa as a main source of income (Grings *et al*., 2013).

Over the past 50 years, there has been a trend in Africa toward increasing productivity of crops but has not meet-up the requirement (Klapwijk *et al*., 2014). The result of the extreme environmental conditions, slow crop improvement efforts, and low-input

agriculture used to grow these crops is very evident. Therefore, it is instantly clear that agronomic methods to rise production are necessary, especially given the shrinking quantity of land that can be used for agriculture for these crops (Kostandini, 2015). Implementing interventions in 2009, has demonstrated that improved cultivars and related enhanced agronomic practices can increase productivity by increasing yields for these crops by as little as 17 to as much as 141 percent. Sorghum, finger millet, and other crops are among those for which there are several projects underway right now that the existing approach can take advantage of (FAO, 2011). According to IITA (2008), the introduction of high yielding enhanced sorghum and millet varieties that are adapted to the target countries' agro-ecologies is a notable achievement as a result of these progr

IITA (2008) reported that ATASP-1 outreach programme, which IITA, ICRISAT, and Africa rice are implementing in collaboration with a number of building rural infrastructure, promoting agribusiness, adding value to regional agricultural goods, and enhancing farmers' access to financial services and markets are all goals of NAREs and private companies. A variety of bilateral programmes funded by ICRISAT aim to strengthen seed systems, agricultural technology, value addition, and national partner capacity building. In order to give farmers, the tools they need to manage their natural resource base sustainably, a system that use little or no tillage, hasten the adoption of new sorghum and millets technologies, as well as the development of their products (Kostandini, 2015).

Following are practical strategies expected to have the potential to boost productivity, have an impact, and improve the standard of living for smallholder farmers:

i Enhance Crop Development: Klapwijk *et al*. (2014) have developed novels that have production ability to endure significant challenges. Continue your breeding activities and

work to increase the NARS institutions' adoption of contemporary breeding platforms and approaches.

ii Increase distribution of improved seed varieties: in order for farmers to adopt superior cultivars, production and distribution techniques must be developed (ESA). It is on this basis that the semi-arid regions of the target countries can be more productive; a large portion of the populace will consequently have access to nutrient-rich food, especially young children under the age of five. According to Dorward *et al*. (2008) improved system effectiveness will make better seed more cost-effective, and higher efficacy will make it simpler to enforce and maintain quality standards. By working together with a functioning business sector and neighbourhood-based farmer's organizations, enhanced cultivars and other inputs can be made available.

iii. Accelerate the creation of new sorghum and millets goods and the scaling out of those technologies: Raising awareness of new technologies should be the main goal of this component, both among farmers and among those who have a responsibility or motivation to give farmers access to technology. Farmers' increased demand will open up new markets for suppliers, especially for better services for seeds and inputs (Kostandini, 2015).

iv. Making it easier for farmers to access markets and production inputs: If acceptable, appropriate, affordable, useable, and accessible, resource-constrained, subsistence producers will adopt Guinee corn and millet technologies that are upgraded, to access trustworthy marketplaces to sell their extra produce (Belt *et al*., 2015). The product market accounts for a major portion of the demand for inputs that increase productivity, such as seed and fertilizer. Smallholder farmers' ability to now use upgraded inputs is constrained by both uneven external demand for output and inability to offer better seed, fertilizer, funding, and supply-side knowledge. Farmers should be given access to the inputs required

for production as well as the markets for getting rid of excess farm output (Dorward *et al*., 2008).

v. According to FAO (2011), services for agricultural extension in various African nations are either non-existent or insufficient, so it is important to strengthen and maintain the technology delivery system. The results of numerous donor-inspired initiatives to modernize agricultural extension in SSA have been disappointing, primarily due to the fact that money have run out to keep the system running. NGOS and a number of farmer organizations have tended to step up to fill this void left by the absence of a robust, centrally organized extension programme, but to varying degrees on a country-by-country basis. Strong technology delivery programmes and processes must be developed to guarantee that smallholder farmers have access to the location-specific, timely and accurate information they need to make informed decisions. In some nations, digital solutions like utilizing mobile devices and short text messages (SMS) can help close this gap to comprehend remote farmers.

vi. Examining policies related to agriculture: Several SSA nations regulations controlling a number of crucial areas of agricultural output require a thorough review. These include crucial facets like Land tenure or ownership, gender relations, and women's rights to property ownership are all related to the certification, production, and distribution of seeds. A number of characteristics requires more than just changing the policies and is a tedious, drawn-out process. But it is evident that addressing such areas requires immediate action (Evenson *et al.*, 2014).

vii. Bringing back deteriorated soils and guaranteeing sustainability: The soils in farming systems based on millet and sorghum are severely deteriorated and lacking in organic matter and plant nutrients (Lal, 2015).

viii. Farmers must be given the tools they need to manage their natural resource base sustainably. These tools include crop rotation, Crop-livestock systems, as well as integrated management of crop-livestock systems to mention but a few. For smallholder farmers, livestock can be a better business option. Extension systems are required so that farmers can continuously acquire new techniques for carrying out both existing and new activities in order to enhance productivity while protecting the environment and the land's potential for yield (Toth *et al*., 2018).

ix. Gaining knowledge of agricultural livelihoods and potential intervention effects: Farm households are extremely diverse organizations that face several labour, financial, and resource access constraints in addition to functioning in very climatically changeable situations (Adebayo and Kehinde, 2015). According to IITA (2008), application that takes into account the biophysical and socioeconomic composition of farm households, as well as approaches that make use of re-usable technologies for computer-based modeling that can partially capture these intricacies is a systems analysis. These techniques, when used collaboratively with farmers and partners, produced effective intervention solutions that help smallholders escape poverty.

Challenges involved in sorghum and millets farming:

The hardest environmental obstacles are found in the environments where sorghum and millets are grown. These obstacles include:

i. How to manage the substantial risks involved in dryland agriculture while overcoming its inherent poor productivity and profitability. The root causes of issues include little and unpredictable rainfall, hot weather, bad soils, and incorrect cultural activities.

ii. Addressing widely issues of land degradation and climate change. Dryland cereal grains will eventually be suitable for growing in regions where other crops are currently cultivated as settings that are currently deemed favorable for agriculture warm and dry up with time (Adebayo and Kehinde, 2015).

iii. To achieve a developmental goal for market orientation and adoption of agronomic practices, it is necessary to address the neglect and isolation of the drylands. Lack of funding for infrastructure, such as market and storage facilities, hinders the potential involvement of the private sector. We will examine how contemporary digital technology can help address these issues and promote improved communication and education (FAO, 2011). Demand for food, education, and employment possibilities is rising quickly throughout Africa, particularly in its dryland regions, as a result of the continent's fast population expansion (Adejuwon, 2013). In addition to the fact that Hunger-related causes account for 25% of all childhood deaths before the age of five; those who do survive frequently have delayed physical growth and diminished mental clarity (both the result of malnutrition). The average daily income in these communities is only $1.25 for about half the population (FAO, 2011).

iv. Poor farmers lack access to the capital required to invest in innovative business models and are unable to access the significance of potential productivity and habitats that are physiologically viable in these locales (Grings *et al*., 2013). In major part of Africa, the development of effective agricultural inputs markets is severely hampered (Adebayo and Kehinde, 2015). Additionally, the mistrust and poor acceptance of such inputs, particularly in hazardous situations, is caused by counterfeits (Grings *et al*., 2013).

v. Weak national institutions: The agencies responsible for guiding the development of agriculture in several African countries (such as value chain operators, research, and extension services) are weak and frequently lack the operational funding and human resources necessary to efficiently fulfill their duties. A lot of national studies organizations lack the necessary technological mass and facilities to carry out the intricate scientific procedures required by modern science, which results in significant staff turnover as talented national scientists frequently leave the country in pursuit of better chances (Adejuwon, 2013). Current Sorghum Production in Nigeria by the Value Chain Project seeks to expand cereal production in order to promote nutrition and guarantee increase sorghum productivity and profitability by connecting farmers with processors and markets (Balasubramanian *et al*., 2009).

Possibilities for growing sorghum and millet:

Africa's drylands provide fantastic prospects for growth and achieving food security by growing the right crop, the elements below are seen to be the main forces behind the demand for agricultural products in the drylands.

i. The demand for locally grown food is rising due to Africa's fast population growth, particularly in the dryland areas where millets and sorghum are important cereal crops. This is related to the fact that, although if the bulk of the poor still reside in rural regions, a growing proportion of the population is moving there in quest of non-farm jobs. Due to this, there is a greater need for food produced for consumption rather than for subsistence (Balasubramanian *et al*., 2009).

ii. Sorghum and millets are becoming more in demand, opening up a market potential products. Africa's diets are changing as incomes rise, and there is a rising demand for livestock goods (meat, milk, eggs, and so on). An increase in the demand for value-added goods in urban marketplaces is also linked to rising wealth. For instance, in Kenya, there is a huge gap between demand and availability for finger millet porridge. Finger millet has very high quantities of calcium, fibre, and iron. In therapeutic eating plans for diabetics and people who cannot consume gluten, finger millet is also used. Agro-processors that provide supermarkets and other retail outlets with these and similar products have expanded investment as a result of the growing demand (Ogunwole, 2014).

According to Bouis *et al*. (2011), ICRISAT is currently engaged in a number of programs with the goal of maximizing these opportunities. Certain of these initiatives try to scale up new technology so that farming communities can use it more widely. Examples include:

- The widespread dissemination of technologies for millet and sorghum systems. The project's goals are to improve the value chain for sorghum and millet by increasing farmers' understanding of innovative sorghum and millet production methods and making it easier for farmers to acquire these technologies. The Catholic Relief Services (CRS), the Aga Khan Foundation (AKF), farmers' associations, and regional NGOs are important collaborators with ICRISAT in putting this endeavour into action (Nuss and Tanumihardjo, 2011).

- Promoting program for education on being wise and resilient technology to increase smallholder farmers' ability for adaptation (Adebayo and Kehinde, 2015).

2.5.4 Rice

For the sake of ensuring food security in Africa, rice has taken on a very strategic and important role. Due to rapid urbanization, high rates of population increase, and changes in eating patterns, consumption of rice is increasing more quickly compared to any other important staple food on the continent. It is the third-most important dietary energy source in all of Africa and a large one in West Africa (Bouis *et al*., 2011). A major issue for the rice industry in Africa as a whole is that there has never been a time when local supply can meet demand despite the fact that local rice output expanded quickly following the 2007–2008 food crisis. As a result, the continent still depends on imports to satisfy its rising rice demand (Seck *et al*., 2013). There is a lot of opportunity for speeding up and Africa badly needs a green revolution, which will increase agricultural productivity.

Africa has the land and water resources to support the production of rice needed to feed its burgeoning population. Less than 10% (920,000 hectares) of the 8.9 million hectares of potential irrigable land in West Africa alone are used (Baudron, 2015). Utilizing multi-stakeholder innovation platforms are intended to be beneficial resource-constrained small farmers (IPs). To encourage a wider adoption of rice knowledge and technology, the centers' IPs are linked to important national and local rice development initiatives (Childs, 2015). African agriculture's rice industry has the ability to propel the continent's economic development and help end severe poverty and food insecurity using a reasonable value chain approach with several stakeholders (Bouis *et al*., 2011).

More so, Africa has to start commercializing the parts of the rice value chain by expanding their seed markets. This necessitates radical transformation by enacting rules that are pro-market, allocating greater funding banks and industries, fostering conations that encourages

farmers' involvement (Baudron, 2015). Africans consume more rice than any other main food averagely 5.5%. Urbanization, which is associated with changes in food patterns, and population expansion are the main causes of this increase. In 2012, SSA used over 24 million tonnes (Mt) of rice annually. The domestic production of rice only provides 60–80% of domestic demand, which results in 10–12 Mt of imports. Using this as a comparison, one-third of the rice traded globally would be rice (Seck *et al*., 2012). By 2035, there will be a 30 Mt rise in demand for milled rice in SSA, or a 130% increase in rice consumption.

Challenges involved in rice production:

According to Balasubramanian *et al*. (2009) and Bouis *et al*. (2011), the following are just a few of the significant obstacles to the effective growth of the African rice sector which are:

i. Appropriate production system selection: Rain-fed agriculture has received more attention in African production systems than irrigated agriculture. Only 4% of Africa's arable land is currently irrigated, despite the fact that 20% of it has the capacity to be. An opportunity to be taken advantage of is provided by the choice to balance the usage of rice production technology (Balasubramanian *et al.*, 2009).
ii. The entire rice value chain, from production to marketing, is highly fragmented. Smallholder farmers are the primary force behind production, with their primary objective being self-consumption (Grings *et al.*, 2013).
iii. Low product quality due to insufficient rice milling facilities makes domestic rice less competitive (Seck *et al*., 2012).

iv. High production costs: The continent of Africa faces a number of production-related challenges. Yield levels are low as a result of numerous biotic and abiotic stresses, which underscores the difficulties farmers who routinely use out-of-date cultivars face with seed renewal (Balasubramanian *et al*., 2009).

v. Limited access to agricultural inputs: Rice farmers in Africa has very little to no access to agricultural inputs like seeds and fertilizer. In Asia, an acre of fertilizer is sprayed with 100 kilograms on average, while wealthier countries spray around 150 kg per acre. Nigeria has fewer than 10 tractors per 100 square kilometres, compared to other countries (Bouis *et al*., 2011).

vi. Due to inadequate market intelligence, expensive transportation, and inadequate road infrastructure and networks, a large portion of food products cannot reach the market (Seck *et al*., 2012).

vii. The rice value chain lacks sufficient human resources, and the majority of the seasoned rice scientists working on NARS projects in Africa become more senior. Graduates in agriculture are also not employed by farms, university research institutions, or the ministry of agriculture. The volume and intensity of skill of those involved in the rice value chain, such as extension agents, must rise (Grings *et al*., 2013).

Most government policies are defective and incoherent, and they do not promote an atmosphere that is favourable for the growth of Africa's rice sector. But for these challenges, the African rice business might become competitive, profitable, and employment-generating through the use of e-agriculture (Bouis *et al*., 2011).

Opportunities in rice production

In order to control man power shortages, increase farm power with appropriate-scale mechanization should be put in place (Baudron, 2015). The following should be considered;

i. Wheat varieties that are improved to have high yields, endurance, suitable properties, usage locations are considered appropriate (Prasanna and Mahuku, 2015).

ii. Innovative seed delivery methods (speed delivery of the proper seed to farmers) (Ogunwole *et al.*, 2014).

iii. By incorporating all parties, they encourage efficient technology transfer (Baudron, 2015).

iv. Encourage the growth of regional and national markets that are more effective. Consumer demand already exists and is anticipated to increase much more (Mason, 2012).

v. There is a lot of potential for increasing agricultural output in order to bring about the much-needed green revolution in Africa. In Africa, there is enough land and water to grow enough rice to support the continent's growing population (Balasubramanian *et al.*, 2009).

vi. Less than 10% (920,000 hectares) of the 8.9 million hectares of irrigable land estimated to be in West Africa alone are used largely for rice and other crops. Irrigation gives the most rice per hectare and allows for the possibility of two to three crops. When we get past the patchy rainfall in rain-fed ecosystems, expanding irrigation offers a lot of possibilities (Ogunwole *et al*., 2014).

vii. In the years to come, economic growth in Africa is expected to be driven by its large and youthful population, ten years in addition to the continent's abundance of natural resources.

There are a tonne of opportunities for youth involvement in agricultural development in Africa (Childs, 2015). The important rice-growing locations and market prospects throughout African nations are represented by the rice sector development centres, which Africa Rice and its partners have adopted. Utilizing platforms for multi-stakeholder innovation, such as the rice hubs designed to benefit resource-constrained small farmers (Baudron, 2015).

2.5.5 Wheat

In Africa, wheat is cultivated on about 10 million acres. Significantly is a common crop cultivated widely and as result of population growth, shifting dietary choices, and socioeconomic change brought on by urbanization. African nations imported millions of tons of wheat, valued using dollar. Sixty percent of the wheat consumed in Africa and 80% of the countries in the Sub-Saharan (SSA) region are imported (Ogunwole *et al*., 2014). The highest per capita intake of wheat is found in North African nations, where it accounts for up to 50% of daily protein and calories. Wheat consumption in the rapidly urbanizing sub-Saharan region of Africa is predicted to increase by 38% by 2023, with imports of 23 million tonnes of wheat costing $7.5 billion in 2013. The African Union Heads of State approved the recommendation of their agriculture Ministers to include wheat for food security in Africa. A step toward agricultural transformation will be raising the productivity of smallholder farmers and closing yield gaps by giving the right inputs combined with better technology (Kolawale and Ojo, 2010).

Improvements must be made to innovations and technologies on wheat in addition to making it possible to create new, improved, and sustainable innovations and technologies based on wheat that are appropriate for various agro-ecological zones in Africa, support is required. Due to the continent's expanding population, shifting dietary habits, and rapid urbanization, wheat consumption has been rising significantly in all African nations over the past 20 years. As a result, imports have filled a large portion of the continent's growing "food gap" in all regions (FAO, 2014). Less than 30% of the region's annual wheat consumption is supplied by indigenous supply. The price of wheat has climbed significantly over the past five years, both for producers and on the global market, related to the expansion in SSA's imports of wheat.

Many SSA nations already have significant issues with their foreign currency reserves and annual trade balance due to the price and volume of wheat imports. Therefore, it is crucial and timely for SSA countries to examine the current potentials for wheat production and productivity. These potentials can then be utilized by putting in place the appropriate policies, institutions, and market arrangements, as well as providing take-off to participants in the wheat production (Bouis *et al.*, 2011). SSA produces 1.7 tonnes of wheat per hectare on average, which is around 50% less than the global average. Within SSA, different nations have different national averages for wheat productivity, as a result, there is a sizable, frequently higher than 5-fold. Yield gap between typical farm yields and the yield potential as well as improved institutional and commercial frameworks that offer wheat producers and other participants incentives, can close this yield difference (FAOSTAT, 2014).

Challenges involved in wheat production:

i. Wheat accounts for up to 50% of daily caloric and protein consumption and is consumed most frequently in North African nations (AfDB, 2010).

ii. Wheat consumption is projected to increase expanding at a quicker rate of 5.1% each year (Mason, 2012).

iii. The cost of importing food is rising: in 2013, African nations imported more than 45 million metric tonnes of wheat, valued at almost 80% of the imported wheat (FAO-UN, 2015). Forex reserves are used up by imports, import subsidies from exporting and importing nations are hidden in food prices. The main factors influencing Sub-Saharan Africa's increased wheat consumption are salaries, expanding populations, women entering the workforce at a higher pace than men, and wheat food assistance. In Sub-Saharan Africa, wheat consumption is anticipated to rise considerably more quickly over the next few decades based only on population forecasts. More than 8t/ha has been gained by Ethiopian farmers, while On-farm production remains very high, frequently exceeding 5 times, compared to potential yield. Most of Africa's wheat-based systems are significantly underperforming in terms of productivity, production, and wheat quality (FAOSTAT, 2014).

iv. In Eastern and Central Africa, globally virulent stem and yellow rust races (such as Ug99) are emerging quickly, endangering supply (Seck *et al*., 2012).

v. Mechanization: Sub-Saharan Africa has a stagnant number of tractors and draught animals, and SSA smallholder agriculture is relying more and more on manpower, or human physical power, even as a labour shortage becomes a problem. In Eastern and Southern Africa, more than 50% of cropland is farmed by hand. There is a possibility to introduce equipment that satisfies SSA smallholder farmers' needs (Bouis *et al*., 2011).

vi. Many farmers, particularly small farmers, are unable to supply the need to satisfy customer demand in order to import (FAOSTAT, 2014).

According to Seck *et al*. (2012), there is a huge opportunity to increase wheat productivity, even though it is most likely to be negatively impacted by climate change due to things like, unpredictable temperatures between day and night and newly discovered illnesses. Only a small number of farmers in African nations (Egypt, Ethiopia, Namibia, Zambia, and Zimbabwe) are able to produce some of the best spring wheat yields in the world. The results of the IFPRI-CIMMYT simulation research, according to FAO (2014), offer compelling evidence of viability nations under consideration findings, which are call for further, in-depth regional and local investigation.

Possibilities for sorghum and millet cultivation:

i. Large nations are particularly commercial and sustainable. According to Prasanna and Mahuku (2015), if value chains work better, this becomes a reliable cash crop in addition to other sources of farm revenue (diversification) and non-farm income.

ii. Quickly expanding demand by consumers presents tremendous opportunity for creating an expanding and diversifying markets on wheat, and increasing interregional commerce (Grings *et al*., 2013).

iii. Expand current programmes' operations that concentrate on developing resistant varieties and giving farmers seed. In East and Central Africa, the majority of wheat types susceptible to rust should be replaced through a much-increased effort (FAO, 2011).

iv. Encourage the growth of regional and national markets that are more effective. Consumer demand already exists and is anticipated to increase much more and to create a

more successful wheat value chain system based on analyses of the opportunities and constraints faced by multiple stakeholders (Mason, 2012).

While likely hardest impacted by climate change, there is a significant opportunity to boost wheat productivity in SSA. Only a small number of farmers in African nations (Egypt, Ethiopia, Namibia, Zambia, and Zimbabwe) are able to produce some of the best spring wheat yields in the world (Ogunwole *et al*., 2014). Countries with potential for wheat production were identified in a CIMMYT/IFPRI study in SSA using modeling-based yield projections for rain fed and irrigated wheat agricultural systems. These preliminary findings, which are based on large-grid data, call for additional, in-depth regional and local investigation (FAO, 2011).

Suggestions for the future of wheat farming:

These preliminary findings, which are based on large-grid data, call for additional, in-depth regional and local investigation (FAO, 2011).

- Encourage the use of wheat-based systems that can protect the environment, provide resilience for sizable production gap (AfDB, 2010).
- In order to deal with labour shortages, farm power with appropriate-scale mechanization should be increased (Baudron, 2015).
- Enhancing the value chain-wide, sustainable diffusion.
- Create and implement creative platforms (IP) to encourage efficient technology transfer pathways by involving all wheat value chain players (FAO, 2014).
- Recognizing constraints faced by a variety of players to establish market outlets for farmers and stakeholders (Carswell, 2000).

- Examine the in-depth potentials for producing wheat and nations identified by CIMMYT/large-scale IFPRI's investigation (FAO, 2014).
- Establishing supportive, helpful, government to promote personal sectors and make it easier for farmers to access loans, production inputs, machinery, and wheat markets. In order to increase domestic wheat production's competitiveness, agricultural policies should be developed to minimize the stress of obtaining cultivation materials so as to improve marketing effectiveness and reduce transaction costs (Anne, 2009).
- Growing creative small-scale agribusinesses inside the existing Innovation Platforms throughout all project intervention sites and nations to generate employment opportunities for women and young people in rural areas.
- Increase institutional capacity for research for development by building out research infrastructure and purchasing essential tools (Defour *et al.,* 2000).
- Building to encourage technology transfer, knowledge sharing, and to improve ties and collaboration (Anne, 2009).

2.7 Constraints Associated with E-agriculture Usage in Cereal Crop Farming

The following are seven crucial success elements that are cited as difficulty to the usage of e-agriculture:

Content: The challenge of adapting content to local needs, languages, and contexts persisted. For the e-agriculture initiative to be successful, reliable intermediaries are required. If the information does not adequately address farmers' needs in terms of relevance and format, information dissemination may be hampered. Despite the ability to deliver a lot of information, e-agriculture does not guarantee its effective use.

Development of ability: Strengthening individual ability, organizations, and institution is necessary. The rural digital divide has not yet been reduced to the extent that was hoped for due to the emphasis on expanding availability of production, knowledge continues to be hampered by illiteracy, limited proficiency with using sophisticated devices for information search, and cultural issues and the foundation for capacity development requirements and roles. The study by WSIS showed that, in some countries, the cost to acquire agricultural e-knowledge has become sky rocket. The cost of internet or mobile services is a positive impediment to the most vulnerable demographics, including women, young people, older farmers, and residents of the most remote areas (ITU, 2008).

Gender and diversity: As a result of unequal access and opportunity distribution, there exist asymmetries that need to be addressed by targeted policies that address the causes of the inequalities (WSIS, 2015). The study found that availability of electronic agriculture, such as the internet are barriers for women, young people as well as aged farmers in the rural localities. Distance in gender inequalities, are still major problems in the digital economy (Datir and Wagh, 2014). The digital divide is a complex issue that involves more than just technological infrastructure and connectivity. For instance, older farmers and illiterates frequently lack developed digital skills, making them less likely to adopt e-agriculture, and insufficient human resource and institutional capacity are other factors contributing to the problem (Bouis *et al*., 2011). The WSIS study also found that productive and sustainable farming methods also prevent women from doing so, and that prevent female farmers from innovating to become successful (FAOSTAT, 2015).

Availability and participation: The WSIS (2015) found that not everyone has equal access to e-agriculture. A gender-based digital persist, as was previously mentioned, is more common in rural than urban areas. Despite an increase in internet users, the gender gap in digital literacy is widening. The gender digital divide cannot be closed just by expanding access to e-agriculture. Regarding difficulties, effective planning and execution participation method involving the society will reduce knowledge that will bring innovation to the area.

Partnerships: Partnerships is acknowledged as a key component required in businesses, locale Production Company, and society-based nongovernmental organizations frequently had access to societal resources to offer reliable knowledge and standard services (Datir and Wagh, 2014). Farmers' varied needs are more likely to be met by a variety of advisory and extension services (FAO, 2011).

Technologies: Technologies should be appropriate for regional demands and content, and their selection should increasingly consider how e-agriculture affects sexes and changes in social status (Singh *et al*., 2015).

Economic, Social and Environmental Sustainability: Finding viable business models and expanding pilot e-agriculture programs to millions of smallholder farmers remain difficult tasks. Pricing is essential for community-level sustainable agriculture business models, according to the International Telecommunication Union (ITU) 2008, investments are necessary to pay for the price of producing content and gathering data. On the other side, if stakeholders' roles and obligations are unclear, social sustainability may suffer. The

effectiveness of e-agricultural interventions in agriculture frequently varies from instance to case (Anne, 2009).

2.7.1 Other constraints associated with e-agriculture information sources in the rural areas

According to Swanson (2010), impediments to accessing e-agriculture information sources in Nigeria's rural areas include the expense and a lack of a common language. Computer education is therefore either not available or very expensive. In addition to these obstacles, access to training has been hampered by financial limitations, distance from home, lack of time, cultural inhibitions, and preconceived notions. The adoption of computer technology is influenced significantly by attitudes, according to a growing corpus of study in management studies, information systems, and psychology. Evidence suggests that views depend on the characteristics of the system and on the circumstances that influence its use (Franz and Robey, 2011).

According to Ajzen and Fishbein (2013), there are two perspectives on how attitudes affect the adoption of computer technologies in agricultural production. One emphasizes how attitudes toward the features of the technology object stimulate action, while the other places emphasis on how individuals perceive the advantages of these technologies. The theory of reasoned action, a psychological process model that mediates observed relations between attitudes, is based on the latter viewpoint. According to this model, a person will have a positive attitude toward engaging in a particular behaviour if they believe doing so will result in a favourable response from important others.

The more likely it is that someone's intentions will be carried out, as determined by favourable attitudes and norms (Baro, 2012). The general model of the theory of Reasoned Action was applied by Davis *et al*. (2009) to the area of technology acceptance in agricultural production. To account for the psychological elements influencing computer acceptability, they suggested the technology acceptance mode (TAM). The TAM substituted the Theory of Reasoned Actions' attitudinal determinants with a set of two variables unique to the setting of technology acceptance, namely perceived usability and ease of use. The former alludes to the idea that utilizing a computer will not need any mental effort, while the latter refers to the idea that doing so will improve performance. Later, a new variable called computer self-efficacy, which refers to an individual's assessment of their own computer skills, was added. According to Szajna (2006), ease of use has no impact on how users form intentions unless they find an information system to be useful. Briefly stated, behavioural intention to adopt computers in agricultural production is most strongly predicted by perceived usefulness.

Arokoyo (2011) identifies three key obstacles that, despite the global ICT-agriculture revolution, severely restrict the adoption of e-agriculture packages in agricultural output, particularly in rural areas. These comprise:

- Insufficient access to e-agriculture packages from developing nations in general, not just from Research and Extension organizations;
- Extremely underdeveloped ICT-infrastructure, including a dearth of and sparsely populated telephone lines, the majority of which are still operating in analog mode;

- Extremely underdeveloped gateways and portals to global networks and satellite systems;
- Unreliable and unstable power supply, as well as expensive alternating electricity provided by backup generators;
- The scarcity and exorbitant cost of landline and GSM telephone services.
- Limited access to computers and even worse connectivity to the Internet make even the most fundamental networking for information exchange inside and between organizations nearly impossible;
- The absence of a communication strategy by the majority of emerging nations' governments;
- Extreme poverty in rural areas;
- Computer illiteracy among farmers, researchers, and extension personnel, as well as high levels of illiteracy among farmers;
- Restricted access to international databases on CD-ROMs or DVDs because of restrictions on foreign exchange;
- Internet “content”. This refers to the appropriateness and relevancy of internet site to the rural people. Finding the few websites with the technical data on agricultural market information and helpful contacts that are pertinent to their needs is fairly difficult because the vast majority of websites are irrelevant to those living in rural areas. This problem is further compounded by problems of language, location and connectivity;
- Policy inconsistencies in both the agricultural and the telecommunications sectors by the governments of various developing countries especially before the current wave of democratization, have effectively kept private investors at bay. With deregulation and liberalization, there has been some explosion in the GSM phone world in most countries in Africa especially Nigeria which is estimated to have the fastest growing GSM trade in

the whole of Africa. Finally, the commercialization of government radio stations has adversely limited the use of the channel for extension delivery especially where rural radio is non-existent as in Nigeria

2.7.2 Challenges associated with e-agriculture usage

According to Harikrishan and Hiremath (2013), the use of e-agriculture in the majority of agricultural implementations is becoming more and more important, however there are several implementation issues with e-agriculture-based services that demand attention and extensive research. These are the principal difficulties:

- Limited availability of e-agriculture tools.
- A lack of comprehension and awareness of the requirements and difficulties faced by small-scale farmers
- The use of E-agriculture in national poverty reduction programs is not standardized.
- To attain the desired goals, it is necessary to address pertinent sociocultural concerns.
- Bad connectivity, scant electricity, and information driven by users.

The usage of e-agriculture by extension agents and its eventual adoption have been attributed in large part to socio-economic considerations. According to Akpabio *et al.* (2007), research, poor e-agriculture infrastructure development, expensive broadcast equipment, high fees for radio and television presentations, expensive access and internet connectivity, and electricity power issues were among the barriers preventing agricultural extension officers from using e-agriculture.

2.8 Concept of Livelihood and Livelihood Status of Rural Farmers

According to Akinwale (2010), the term "livelihood" relates to how people support themselves, which is dependent on their abilities, resources, and activities. The term "income producing possessions" refers to the nature and man possession necessary for human to thrive, and they can be distributed, traded, or held to produce income and gain other advantages. As defined by Zhifei *et al.* (2018), livelihood strategies include manufacturing, and marketing plans. Comprehending desired option and coping mechanisms, of household and people depend on the circumstances and means of subsistence households owns. The diverse livelihood results that people seek cannot be obtained by relying solely on one form of livelihood asset; rather, to get good results from their struggles and attend favourable outcome, households most own different means of living.

2.8.1 Livelihood and co-production in agriculture

Scoones (1998) defines income producing possessions as "the competencies, possessions (containing both physical and social means), as well as task necessary to sustain life" Scoones (1998) is cited in Anne (2009). However, this definition does not incorporate the notion of improvement. The author developed the idea of co-production in order to incorporate this component as well. A farming system is created through a process known as "co-production," which denotes a partnership between humans and nature, presumptuously human features and natural characteristics are changeable.

It is believed that natures are improve through time in order to rise the people’s autonomy and so strengthen the farm's foundation (Hua, 2014). This increased autonomy can be interpreted as less reliance on outside variables and hence less exposure risk. In other

words, the idea that farmers work to improve their wellbeing by enhancing the basic foundation of their livelihoods is implicit in the concept of co-production. This could entail making investments in livestock, agricultural machinery, or soil fertility, but it could also imply that farmers are looking for alternatives outside of the (conventional) farming sector. It is also feasible for farmers to completely stop farming under the latter scenario, in which case their primary source of income would no longer be a farm but rather something else (Hua, 2014). Diversifying your income through occupations other than farming is referred to as livelihood diversification.

In order to survive and raise standards of living, Shi *et al.* (2014) define this as the creation of an "increasingly varied portfolio of activities and assets." Different diversification activities are categorized by Baro and Batterbury (2015) based on their nature and the location in which they are carried out. This classification is helpful when attempting to highlight the direction that farmers are looking for chances to enhance their standard of living. Extensification and intensification are two additional livelihood strategy prototypes to improve productivity. Agricultural intensification refers to the expansion of the land area utilized for farming without increasing the ratio of labour or capital inputs per unit of land. Any method that increases output per hectare of land through greater labour or capital inputs per unit of land and improved efficiency is referred to as intensification.

Additionally, intensification enables more frequent land cultivation without reducing production (Ramisch, 1998). Carswell (2000) makes a distinction between two agricultural intensification pathways, the one driven by labour, and the other driven by capital. A key characteristic of the labour-led road of intensification is an increase in labour input per unit of land. Signs of this pathway include increased weeding, increased manure use, tighter

cultivation, and less fallow. More external inputs are needed per unit of land when intensification is driven by capital. Improved seeds, more fertilizer use, and increased plowing are a few examples of these.

2.8.2 Determinants of nature livelihood

There are many different methods that farmers attempt to increase their means of subsistence. This heterogeneity is the result of household characteristics such as variations in household size or composition and internal dynamics, the assets owned or the access to land or water are not only by land but also by local land attributes, the climate, and the management history (Tittonell, 2008). As a result of the numerous decisions that each farmer makes while establishing their farming system and the various approaches they use to achieving certain objectives, farming systems are also unique. Farmers may react differently even under identical conditions due to attitudinal variations. However, differences in household traits, background, and attitudes are not the sole factors shaping particular livelihoods. Living conditions are a part of larger structures and forces, such as political networks (Baro and Batterbury, 2015).

Baro and Batterbury (2015) added to this by stating that in order to understand livelihoods, it is not sufficient to focus solely on the household because a lot of actions, choices, and decisions are made in response to signals and limitations from the outside world. Due to this, the purpose of this study is to assess how e-agriculture has affected the livelihoods of farmers of cereal crops in Borno and Kebbi State, Nigeria. This will assist determine how much e-agriculture has enhanced their ability to diversify their produce and how this has affected their quality of life. According to Anne (2009), household traits and attitudes as well as larger structures and forces that are themselves changed by globalization and

liberalization processes also have an impact on farmers' livelihoods. People all across the world are becoming more and more aware of the cultures and ways of life of other people as a result of these processes. Due to increased movements of goods, information, and capital, they have also resulted in a greater connection between local and global market places.

2.8.3 Famers' livelihood strategies

Zhifei *et al*. (2018) unveiled that farm households use portfolios made up of many asset kinds to manage risks and shocks, and their livelihood strategies are dependent on the state of their assets. In order to comprehend farm household livelihood conditions and develop sensible poverty reduction policies, it is helpful to explore the relationship between the assets that farm households utilize for their livelihood and their livelihood tactics. The study's findings suggest the following:

(i)The desires of living options made by people is strongly influenced inversely by both nature and physical possessions. The more people have natures gift and physical possessions they are likely to pursue living standard that involve engaging in agricultural output. (ii) Monetary and human possessions significantly enhance the livelihood strategy that farm households choose. Specifically, the likelihood that farm households will pick livelihood options involving participation in non-agricultural output rises with the amount of human capital and monetary possessions.

(iii) Public possessions don't significantly affect how farm households choose their mode of subsistence (Liu *et al*., 2018).

The term "livelihood strategies" refers to the steps performed and judgement taken in order to attain living objectives, such as business operations, financial plans, and maternity arrangements. The methods by which agricultural households make a living is defined by the way they utilize nature and living outcomes for a specific objective, same way that the pursuit of livelihood goals by agricultural households does. As a result, research on adjustments to farm households' means of subsistence has recently gained worldwide attention in fields including ecoregions and geography. A plan to sustain one's lifestyle consists of getting more means of income (Zhang *et al.,* 2013).

Agricultural growth, agricultural intensification, and diversification are the key livelihood methods used by farm households, population movement, sustainability, and other factors. However, severe changes also occur in farm household livelihood assets along with the drastic environmental change in emerging nations (for example, climatic change, fast urbanization, and economic development), the external environment and unstable environment (such as natural catastrophes and price shifts) frequently cause changes in farm household livelihood strategies (Lobell *et al*., 2011).

According to Zhang *et al*. (2013), the primary focus of contemporary research on the diversity and dynamics in farm household living decisions replacement of the primary source of income. The former describes the process by which livelihood activities go from being singular to being varied, while the later describes the process by which the previous method of life is fully supplanted by a new means of support, focusing on poorer regions. Changes in people's living standards have a big impact on things like Land usage, environmental protection, and sustainability of livelihoods. The framework, which offers a

study methodology for farm household livelihood, aids in elucidating the intricate linkages between farmers who survived in a specific environment of vulnerability (Su *et al*., 2009).

The foundational elements of the sustainable livelihood framework in this situation are livelihood assets which dictate the methods used by farmers to attend their desired living standards. For instance, social-economic considerations might have an impact on ecological land change (Hao *et al*., 2010). We can use the framework's key implications to describe how different livelihood strategies differ from one another. Despite the fact that several studies concentrates on connections that exist in farmers lifestyle possessions and their methods of living, deeper quality investigation on its mechanism is still lacking. A family's or an individual's conditions and the type of assets they hold for their livelihood serve as the foundation for understanding their options, livelihood plans, and risk environment (Lu and Xie, 2018). Under various circumstances, external variables affect farmers' strategies. Farm households employ portfolios of their many asset kinds to manage risks and shocks, and their chosen livelihood strategies are dependent on the assets they own. The research will aid farmers understand their livelihood circumstances and the development of sustainable poverty reduction programs (Su *et al*., 2009).

In a groundwater funnel area, Xie *et al.* (2017) looked at the conditions that affect farmers' willingness to leave winter wheat in a fallow state, ecological compensation requirements, and farmers' reactions to those policies. Agricultural labour supply decreases as a result of changes in labour resource availability. The relationship between the assets that farm households utilize for their livelihood and their livelihood strategies was the subject of a quantitative study by (Su *et al*., 2009). Zhao *et al.* (2011) investigated how the choice of livelihood Strategies was influenced by assets that support a livelihood. Shi *et al*. (2014)

used multivariate logistic regression analysis and other methods to study the link in respect to famers' choice of lifestyle and their living tactics.

A variety of livelihood activities make up and are carried out by livelihood strategies. The traits of reliance and asset variety manifest in livelihood assets under various asset conditions and work in concert to achieve livelihood strategies. As a result, acceptance and modification of these people living choices depends on the circumstances surrounding their farm household assets. Farm households have more options and the flexibility to switch between different sorts of livelihood strategies as necessary to secure their survival the more livelihood assets they own. Depending on their asset portfolio, farm households adopt a variety of behavioural methods to support their way of life (Farida and Bombay, 2009).

Farmers use living strategies to achieve balance in income and manageable hazards, assuming that they are sensible (Hua, 2014). A farm household's choice of livelihood strategy, based on the ideal balance, is influenced by changes in the number and structure of livelihood assets. Zhifei *et al*. (2018) identified livelihood strategies based on a detailed second layer is called the criteria layer, and it consists of resources such as material goods, human resources, social resources, and financial resources. The second hierarchy's specifics are included in the third, which completes the system's 15 indexes, which are scientific and have a predetermined reference value, are the essential and primary indexes for assessing assets used to support a livelihood (Su *et al*., 2009). By comparing degrees of relevance, the aforementioned indices are graded by professionals and decision-makers layer by layer, and they confirm the weighted value of the indexes in accordance with the matrix's eigenvector to support the decision analysis (Hao *et al.*, 2010).

Farm household livelihood strategies can be categorized using two basic categories, (1) the one decided by Institute of Rural Development and Chinese Academic of Social Sciences in 2002. Here, farmers who receive greater than 95% of their earnings from agricultural activities are consider as farmers who use agriculture for their income, and farmers who receive greater than 95% of their earnings from other activities outside of agriculture are considered as farmers who do not use agriculture for their income. According to this method, rural households are defined as those that compared to non-farming households, who generates above 95% of their income from sources other than agriculture (Hao *et al*., 2010).

Hua (2014) reported that farmers that receive their income from other activities other than agriculture determined for five to ninety five percent of their income, this are categorized as not – full time farmers, and are separated to two categories owning to the major source of their earning, is termed, agricultural production wage. The other category, is based on the rural farmers research intended by the State Statistics Bureau in October 2004, 95% is adjusted to 90%. Considering the actual conditions in the study region and the convenience of analysis, according to the degree of non-agriculturalization and the diversity of the livelihood of farm households, referring to the current research results of the farm household classification, and based on their non-agricultural income percentage in total family income, farm households with different livelihood strategies are classified into the following types:

i. Farm households whose non-agricultural income accounts for less than 10% of total family income are identified as rural households,

ii. Farm households whose non-agricultural income accounts for 10% to 90% of total family income are identified as part-time households.

iii. Farm households whose non-agricultural income accounts for more than 90% of total family income are identified as non-farming households.

2.8.4 Farm household livelihood methods' effects on rural farmers' ability to support themselves

Zhifei *et al*. (2018) indicated that farm households' livelihood strategies can be categorized into three groups depending on the circumstances in the study area, including constant farming (poor farmers), running a side business, and involving vocational activities. Nature-based resources' impact: demonstrates that natures resources have a noticeable inverse association (at one percent level, and the sign is negative) with the desire of living standard for both households' farmers. The result suggested the assessment of the use of constant farming as the preferred, farm households who possess more natural assets are more likely to do concurrent businesses and non-agricultural vocations (non-farming families). Land currently ranks as the most significant natural asset for Chinese agricultural households. Farms can be separated to production land, infrastructural land, ecological land, and so on in accordance with the development objectives of farm management. Land resources owned by farm families had noticeable impact on their desire to get involved in farming activities or not, and portioning of land has a significant impact on the desired amount of agricultural land obtained (Areti *et al*., 2011).

Impact of human resources: demonstrates that the presence of manpower assets has a large beneficial impact to farmers' desire for living standard in the models (noticeable at one percent level, and is positive). According to this finding, the more increases in human

resources by farming families, the more likely they will choice a concurrent business over constant farming and may choose to get involve in other occupations than agriculture over constant farming. This result demonstrates that farmers' decisions to do other business ventures and pursue other living standards are significantly influenced by the caliber of their work force. This outcome is largely the result of farm households choosing their livelihood strategies.

Impact of tangible resources: demonstrates the choice of livelihood strategy made by farm households of the two models is significant but negatively influenced by material assets (both effects are noticeable at one percent level with an inverse sign). This result shows that in the evaluation that uses continuing to farm (rural households) as the reference, farm households will desire constant farming than to have other business activities that is not agricultural occupations, the more material assets non farming households will own. This outcome is mostly due to the fact that farm household material assets include the essential tools and infrastructure needed to support economic activity. The essential circumstances for agricultural output, and their state will unavoidably have a big impact on how farm households choose to make a living. Agricultural production facilities tend to be more convenient and farm households' motivation to choose agriculture is generally higher the more sophisticated agricultural production gear they own.

The impact of monetary resources: demonstrates that financial resources significantly and positively influence the selection of living standard made by farming families in both the side farming and non-farming models (noticeable at one percent level, with positive sign). This indicate that, in the assessment that involves constant farming, farm families are likely to prefer operating concurrent businesses than constant farming and may prefer doing other

business activities over constant farming the more financial assets they own. This finding demonstrates monetary resources to have a noticeable impact on farmers families' decisions to engage in parallel businesses and embrace other occupation that are not agricultural base for their living standard options. Monetary resources primarily refer to a financial reserve that is available for usage and the many types of borrowing used by farm households for financing. If farm households have greater monetary resources, they will put more money and effort into non-agricultural businesses to increase income from other sources that are not agricultural base. This is especially true for farm households in the western mountainous region.

Impact of societal resources: Social assets are the social resources that farm households need to implement various forms of subsistence farming, such as farmers and community movement, and so forth. The distribution of farm households' assets for generating a living is supposedly positively impacted by having a variety of social assets. Social resources do not, however, significantly affect the choice of livelihood options for farm households, according to the empirical examination of these findings. It demonstrates the need of considering social context in qualitative as well as quantitative analyses of farm households' means of subsistence.

2.8.5 Assets for farm households' livelihood and the mechanisms through which theyaffect livelihood choices

According to Zhao *et al*. (2011), this is the first mechanism that has been conceptually examined. After that, a quantitative analysis of the assets used by farm households to support their livelihood is done by creating an index system. Using a multinomial logit model, statistical measurement of the impact of farmers living resources on living standard

tactics is then carried out in the study region. The findings indicate variety of living standard resources varying in degrees of impact on the livelihood strategy that farm households choose. The precise findings are as follows:

(i) The decision of farm households about their modes of subsistence is significantly impacted negatively by natural and material resources. Accordingly, farmers' family will likely pursue livelihood options involving agricultural production when they own more nature's resources and physical resources;

(ii) The availability of manpower and financial resources significantly influences the choice of livelihood options made by farm households. In other words, farm households are more likely to pursue livelihood choices that involve engaging in non-agricultural output the more resources they have available to them in terms of both personnel and financial resources;

(iii) The livelihood methods chosen by farm households are not much influenced by social assets.

Natural resources and material resources are necessary conditions for farming, and their state will unavoidably have a significant impact on a farmer's decision to engage in faming activities as its primary source of income. In the context of widespread agrarian human resource mobility and part-time farming, it is essential to enhance agricultural intensification, specialty, arrangement, and contents. Should we encourage or discourage the increased segregation of farm households? Which farmer is likely to become effective in farming industry? How can we make this determination? These questions need to be answered. Parttime homes in the study region may develop into a household of specific size. The development of part-time households is mostly constrained by insufficient fixed

assets and land resources. As a result, land circulation should be promoted in order to progressively develop big professionalize crop and livestock products and to increase the size of cultivated land required by part-time families. Increased subsidies should be given to labour-saving equipment such small farm machinery (Yan *et al*., 2009).

2.8.6 Strategies adopted by Cargill to assist farmers improve their livelihood

Cargill (2018) stated that they assist farmers in raising their standard of living by:

i. Promoting greater productivity and market accessibility,

ii. Advancing agricultural methods that contribute to a future with more sustainability,

iii. Making investments to support agricultural commodities.

Cargill (2018) also found that farmers worldwide were embracing new technology at a faster pace, enabling them to maximize profitability, enhance yields, and safeguard soil conditions for continued success. Farmers all over the world are utilizing equipment that improve effective utilization of agricultural resources while minimizing loses. They support farmers at all productivity levels by giving them the information they need to manage risk, increase yields sustainably, and find dependable markets for their commodities. These are all necessary for these farmers to be able to participate more fully to ensuring a future that is both more sustainable and food secure.

The research supports pricing that is transparent and based on the market throughout all supply chains so that farmers can be certain they are getting a fair price for the products they cultivate, harvest, and raise, as well as for the animals they rear. This will give them a better idea of what to expect. According to Cargill (2018), they partner with farmers to create entrepreneurial ideas and work with them to manage price risk and maximize

profitability. In its work with farmers, this organization acknowledged that agriculture is a risky industry. Markets shift, crops can be harmed by weather disturbances, and prices can fall due to a bumper crop or a glut of stored produce. This program aids farmers in putting plans in place for certain scenarios so they can survive changes from one season to the next. For the purpose of enhancing farmers' livelihoods, they created farmer field schools that educate thousands of subsistence farmers about agricultural best practices, provide them with inputs like seed and fertilizer, and aid them in forming cooperative society so they can increase their collective capacity and fortify their communities.

In order to boost yields and profitability, Cargill (2018) taught tens of thousands of farmers over the world in sustainable farming methods. To achieve food security, farmers need to be able to increase their output over time on the same amount of land while raising livestock and growing crops. Farmers need trustworthy outlets where they may sell their produce each season. This initiative aids farmers in creating long-lasting supply networks and gaining market access. They aim to strengthen the livelihood of the communities in order to help them become more resilient, and they assist in providing farmers with crucial linkages across all supply chains. In the areas where they operate, they try to raise the standard of living.

Cargill (2018) has invested in and taken the following actions, dietary intake and health. Since 2008, the initiative has given close to $50 million to organizations and programs that work to enhance the health and nutrition of local residents in the area where they are active. To enhance nutrition and rural health, they supported educational programs in their important agricultural areas throughout Central America. People are trained on diets and agricultural as part of area program called "Back to school with Cargill."

i. Education. The research program was created to assist in enhancing agricultural communities' access to high-quality education. For instance, Cargill (2018) collaborates with CARE to boost primary enrolment rates in Ghana.
ii. Gender equality. To bridge gender gap in the palm business, for instance, the research has created initiatives at Indonesian farms that support community members and female workers in pursuing economic and professional advancement. Additionally, they provide employee education on topics including family health, reproductive health, and nutrition for women.

Establishing a link between sustainable coconut oil and global markets to enhance farmers' living standards. Farmers raise, gather, and dry coconuts, selling the dried kernels to this researcher who crushes them to extract the oil. The oil is used in consumer goods including cooking oil, lotion, and shampoo, generating employment opportunities across a variety of industries.

The manufacturing of coconut oil helps support the 20,000 direct employments that FEDOIL, the trade association for producers of vegetable oils and protein meals, estimates are created in Europe, one of the largest export markets for the commodity. Not only are those procedures beneficial to the environment and consumer choice, but certified sustainable coconut oil attracts higher prices from growers. Farmers that achieve sustainability certification requirements can increase their incomes by 10%. It fits into the company's larger objective of enhancing the livelihoods of smaller holding farmers. Support for managing a farm's finances and education regarding the global coconut oil market are also included in the training, explanations for price fluctuations and information on food safety. The company provided dryers to farmers as a means of reducing the health

concerns associated with, for instance, sun-drying coconuts. The initiative assists farmers in running their farms like businesses. It raises their level of financial literacy, increases their understanding of good agronomic techniques, and aids in their comprehension of the world market.

According to Abayneh and Beneberu's (2014), small farmers in India are characterized by dispersed, small land holdings, fewer livestock members, little capital and assets, a propensity for migration, and vulnerability to natural disasters. The rural poor frequently face barriers when attempting to get essential amenities like housing, drinking water, sanitation, health care, and education that help them develop their capital. They live in distant, marginal lands that are isolated physically, lack access to proper agricultural information, have poor or non-existent transportation options, and have no electricity. They are susceptible to environmental dangers including diseases, starvation, floods, and pollution. This predicament is true, especially for rural communities in the majority of emerging nations (UN, 2007).

Most people in developing nations lives in villages where their primary source of revenue is agriculture. They live in an agrarian civilization and are cut off from the outside world as a result of the inadequate facilities and infrastructure in the developing nations. Most farmers in an agrarian society are peasants, who are characterized by small, fragmented land holdings, seasonal migration in search of off-farm income-generating occupations, and vulnerability to dangers Small-holder farmers' and peasants' livelihoods are unstable and marked by their fragility. These farmers are especially vulnerable to unpredictably excessive rainfall, flooding, draughts, illness, and pest infestation (Abayney and Beneberu, 2014). In their study on the living standards of small-scale farmers in agrarian area of India,

Abayneh and Beneberu (2014) utilized appropriate adapted methods that were produced for the livelihood capitals from the DFID model and the Chambers and Conway 1992 definition. This includes;

- Physical capital (affordable transportation, different types of housing, materials in the home, adequate water supply and sanitation),
- Human capital (access to medical facilities for treatment, availability of health facilities, transportation, and availability of food, education, and labour),
- Financial capital (the resources available to people in the form of credits and savings that give them a variety of means of subsistence),
- Natures capital (the natures capital resource stocks from which resources flows useful for livelihoods are derived that includes types of irrigation facilities and livestock compositions are taken into account),
- IC capital (under this capital, ownership of media and ICTs, as well as the extent to which they are used),
- Political capital (in this capital membership in political organizations and benefits realized from participation) and
- Communication capital (that enables the farmers in pursuit of their livelihoods). As the current global scenario is highly dependent on the availability and utilization of information and communication, neglecting this capital has great significance to the livelihood of the rural farmers directly or indirectly, typically in a country like India where agriculture is the basis (Mundy and Sultan, 2010).

2.9. Empirical Review on Socio-Economic Characteristics of Cereal Farmers' Livelihood

2.9.1 Age

Age is the farmer's actual age at the time the research was conducted. The majority of the sampled farmers, according to Aderinoye-Abdulwahab *et al.* (2015), were above the age of 56 years. There were few children (19-36 years) and many adults (37-55 years) in the research area. According to their study's demographic sample, larger number of the sample population were above the age of 56 years. There were however more adults age range between 37-55 years than youths age range of 19 - 36 years in the sampled population. According to some of the elderly respondents, the majority of young people in the research area may have moved to urban areas in search of higher standard of living. Bedi (2009) found that agricultural activities and rural development and intervention program are targeted at both men and women in their youthful mid age.

However, the qualitative data showed that if their capacity was increased, community members would be willing to pursue agriculture as a business. This might inspire young people and jobless recent graduates to settle back in their hometowns and start profitable farming operations. According to Almaszabeen and Uma (2018), another element affecting rural living is old age. This demonstrates that the bulk of the study's participants are adults and older people. If the population at the research region is able to accept agriculture as a business while creating an environment that allows farming to be done at a cheaper cost, young people and other marginalized groups will be encouraged to pursue farming as a lucrative industry. There is a direct correlation between the population's ages and that of the rural region. The population is highest among the elderly (old), and it declines as people's ages rise (Aderinoye-Abdulwahab *et al.*, 2015).

2.9.2 Gender

Gender refers to the character of being a male or female. The use of e-agriculture requires people that are exposed to information. Men are expected to be more exposed to information than women. This is because most women in the study area are full-time house wives and are usually restricted to the house work, women are rarely exposed to information from outside. Men on the other hand have more access to information as they move about freely and interact with people from outside (Johanson, 2011). Women in particular have demonstrated the ability to use e-agriculture for business development among small-scale businesses in developing nations (Johanson, 2011). In the Indian town of Kizhur, Pondicherry, a group of women made the decision to launch a modest business producing incense sticks. They started out as subcontractors, but after using the neighborhood tele-center, they gained more self-assurance and business. They acquired the abilities needed for branding and marketing their incense, consequence to some searches the telecentre operators conducted. The women swiftly established nearby stores for their goods, and they are now confidently utilizing the telecentre to find more far-off clients (Colle, 2000).

Especially in impoverished nations, women entrepreneurs make up the larger number of retail business owners find ICT-agriculture and electronic commerce (e-commerce) appealing because they can use these technologies to minimize both period and cost while trying to reach out to new customers in both domestic and international markets. All developing country regions have a successful tale in business-to-consumer (B2C) retailing or electronic retailing (e-retailing), indicates how women have employed the Internet to increase their clientele in foreign markets while also managing to balance caring for their

families with rewarding employment. Information and Communication Technology (ICT) barriers can exacerbate the digital divide and prevent women from accessing new opportunities to improve their social status and transform their lives in a century characterized by globalization and technological advancement.

Learning about contemporary technologies paves the way for new opportunities in networking and planning. It increases women's self-esteem and confidence and lessens their reliance on male family members. E-agriculture gives women more options and gives them informal decision-making power. According to Aderinoye-Abdulwahab *et al*. (2015), the population sampled was primarily made up of men, and educational attainment was generally low. There were more households in the study area with female heads of household than those with male heads, according to a wealth ranking done for the farmers in the study. Given that there were more men than women in the study, this is quite unexpected. Nevertheless, the wealth ranking activities also revealed that a relatively small percentage of the community's residents were commercial farmers who are far wealthier than other community members. The findings also indicated that men participated in non-farm enterprises whereas women worked in off-farm enterprises. This supports claims that rural households deploy many businesses as a risk management tactic.

Further research revealed that most female in the study area were engaged in the shea butter processing industry, the complementary gender roles were also displayed in the seasonal calendar. The implication is that equal attention was paid to men and women in intervention programs for agricultural cultivation and improvement of the rural areas. The primary occupation of women in the study area was processing shea butter, which might have helped their salaries increase. The seasonal calendar attests to businesses which is

(vulcanizing, commercial business, basket making, and carpentry) that people in the study area engage in additional sources of income. Additionally, men were more involved in wet season farming, according to the qualitative data, while women were more involved in dry season farming.

2.9.3 Education

Education is a variable which tends to increase one's access to opportunity to diverse knowledge, especially in the usage of e-agriculture, it refers to the ability to read and write. The literacy world is replete with works on e-agriculture either in the rural or urban context. Warren (2002) identified several studies on the role of e-agriculture information sources in various disciplines encompassing new processes, computer and internet technology, enterprise management information systems, and other technologies. The urgent need for less financially able nations to bridge the educational gap with wealthy nations is what is driving the growth of distance education. According to the United Nations Educational, Scientific, and Cultural Organization (UNESCO), only 3 percent of young people in sub-Saharan Africa and 7 percent of those in Asia, of whom 1 and 2 percent, respectively, are female, are enrolled in post-secondary education, Comparatively, the United States has an unemployment rate of 81 percent, compared to an overall industrialized country average of 58 percent (Arunachalam, 2003).

With 1.5 million students, two-thirds of whom are enrolled in degree programs, China Central Radio and Television University primarily serves working adults. It airs lectures on radio and television at predetermined period to it targets audience at 2,600 branch campuses, 29,000 study centers, and workplaces (World Bank, 2002). For rural poor people to receive elementary and secondary education, radio and television are crucial instruments.

The Tele-secundaria program in Mexico now offers televised classes and a thorough curriculum to more than 800,000 secondary-school students in remote villages. It does this with the aid of closed-circuit television, satellite transmissions, and teleconferencing between students and professors. According to studies, the program only costs 16 percent more per student served than conventional urban secondary schools, despite the fact that pupils benefit from much lower student-to-teacher ratios. When compared to their peers in regular urban schools, rural kids start the program with much lower maths and language test scores; nevertheless, by graduation, they have equaled those levels in maths and have cut the language score deficit by half (de Moura *et al*., 1999). Few members of the sample had no formal education, according to Aderinoye-Abdulwahab *et al*.'s (2015) report, which indicated that educational levels in the population were relatively low. In total, more than half of the members never received any formal education. The more educated are likely to be the ones who have moved to urban areas, leaving the less educated with few options for a means of support.

2.9.4 Occupational level

Primary occupation refers to the main occupation a respondent is engaged in, while secondary occupations refer to other occupation a farmer is engaged in, aside their main occupation. According to Sharma (2000), The National Dairy Development Board uses ICT agriculture in milk collecting facilities and cooperatives to check the milk's quality, measure its butterfat level, and quickly pay the farmers. As a result, there are no longer any incentives for milk temperas, payments are made in less than 5 minutes instead of 10 days, and farmers now have more faith in the cooperative system. The milk market has expanded to new heights thanks to all of these causes. The use of ICTs creates opportunities for

employment in two categories. Unemployed persons can utilize ICTs to find employment prospects in the first place, and they can also work in new positions made possible by the usage of ICTs. Because they frequently lack access to information about them, less financially capable audience generally lack employment prospects.

ICTs are used, among other things, to offer online recruitment services through electronic labour exchanges in public employment services or other placement agencies. Typically, job brokering operates as a closed system with intermediaries working on behalf of their clients (Best and Maclay, 2002). ICT's increased transparency creates opportunities for information seeking that is more targeted. For example, open job seeker banks that are electronically linked to job vacancy banks allow employers to search and instantaneously access resumes.

Tools have been created to help companies scan resumes or to send emails to job searchers automatically when job postings matching specific pre-selected criteria are made available (Best and Maclay, 2002). Aderinoye-Abdulwahab *et al*. (2015) reported that out of all the households included in their research, 53% were deemed to be "asset poor," and the primary source of income in the locales area is trading of non-agricultural products. According to the data, cultivation of crops and cattle was the second most common activity in the research after trading. However, it becomes clear that agriculture is the study's main enterprise when crop and livestock cultivation are combined.

2.9.5 Household size

The term "household size" refers to the overall population of a home. The majority of households, according to Aderinoye-Abdulwahab *et al* (2015) study, were between one and

eight individuals in size. Other households ranged in size from one to four individuals, this suggest that the average household size of rural farmers in this survey is greater than four people. The authors also noted that sales of farm products came in second to trading as the primary means of financing agricultural operations in the research areas. Diversification is necessary to raise the farmers' livelihood status, which is still on the low side in the research region. However, based on this study, these sources are not the only ones that contribute to the farmers' livelihood.

According to the analysis of wealth distribution, women headed the majority of farming households, and they had better access to food than men. The seasonal calendar also showed that while men were more interested in other work than agriculture, women were busy with post-harvest work. Additionally, women are more active in farming during the dry season using irrigation and male farmers dominate wet season farming (Omotayo, 2015). The two biggest obstacles to farmers' different lifestyle highlighted are insufficient financial facilities and old age. The wealth ranking found that income level is low despite the fact that agricultural productivity is high (Abayneh and Beneberu, 2014).

The authors suggest introducing a straightforward and practical microcredit distribution system that would allow farmers to receive loans in order to expand and develop their economic activity based on their results and conclusions. In order to aid the enterprise groups in achieving their objectives and ensuring the creation of jobs, business consulting services should be made available to them. Understanding livelihoods as well as the livelihoods constraints connected to various strategies can help to potent planning, monitoring and evaluation made by planners, policy makers and voluntary organizations

who are concerned with promoting rural welfare in the villages, while implementing local agricultural extension and rural development programs and policies.

Abayneh and Beneberu (2014) concluded in their findings that small farmers in the survey area were more than half of their population sample where livelihood of respondents were at a considerable level. The authors further reported that, majority of the respondents, marginal and small farmers lack veterinary facilities in the villages, difficult bank loan procedures, limited skill development trainings, and lack of hospital facilities and lack of public toilet and others as major constraints. Ali *et al.* (2008) in their study revealed that living conditions are determined by a household's capacity, activities, and resources through institutions and interpersonal relationships. These factors collectively determine the household's ability to earn a living.

2.9.6 Access to credit

This refers to the ability of the farmer to use e-agriculture to secure access to finances to better control hazards in their farming activity, they can make savings, locate reasonable insurances, and acquire instruments. Additionally, it refers to the farmer's capacity to secure financing from financial institutions. Aderinoye-Abdulwahab *et al*. (2015) according to their study, communities' primary goal was access to credit facilities, and the existing groups were not powerful enough to exert market control or act as a lobbying force to change communities' access to credit facilities. Thus, they further recommend that in order to expand and strengthen their economic operations, stakeholders should implement an easy-to-use microcredit distribution system that would give them access to loans. To further aid in the achievement of these objectives, business counseling services should be made available to the company groups.

Since there was no external aid for credit facilities, farmers' ability to obtain loan for farming was a significant issue. These findings imply that ability to financing for agricultural operations is highly likely to encourage farmers' production, leading to higher household incomes. The outcome supports the claim that peasant farmers prioritize the development of food crops in order to enhance their households and generate cash. The limitations impeding rural farmers' ability to diversify their sources of income were examined in the study. Diversification of livelihoods was shown to be significantly impacted by the lack of access to finance facilities. This suggests that the savings and microcredit initiatives will aid in these people's efforts to diversify and enhance their sources of income. It will keep them employed, and they might be able to grow their clientele over time. This may also make it easier for people to find jobs in their communities. Other limiting reasons include the contradiction between using e-agriculture and the causes of illness and disease, marketing issues, drought, and natural disasters (Abayneh and Beneberu, 2014).

2.9.7 Types of credit accessed

According to Wulandari *et al*. (2017), maintaining the production of agricultural goods depends on having access to money. Additionally, having access to finance promotes production and efficiency and helps people earn more money. Armendarize and Labie (2011) revealed that, there are different types of finance providers, this includes banks and microfinance institutions (MFI), agricultural traders, farmers associations, kiosks, friends, relatives, private money lenders, and credit cooperatives.

The authors further revealed that, bank and MFI offers loans; farmers' associations and traders offer in-kind assistance, traders offer financial assistance and agricultural inputs kiosks offer flexible payment options for inputs. Each type of finance provider has a different way of providing financing. Despite the fact that both cooperatives and banks offer credit, they focus on different requirements. For instance, banks view a farmer's character in terms of their history of loan repayments, their ability to repay the loan, and their ability to manage their farms as being very important requirements. Farmers must also be members of a registered farmers association in order to get funding in kind, although traders considered a sales contract and a farmer's capacity to be the most crucial conditions. The most crucial prerequisites, according to agricultural input kiosks, were the traits of farmers.

2.9.8 Farm size

Farm size refers to the total number of farm land that has being effectively in used by the farmer and that is still in use and owned by same farmer till the time of this research. The fair payment of small farmers in Gujarat is made possible by computerized milk collection facilities. Producers were given reward in every ten days, and they had to rely on cooperative staff members' manual calculations of milk quality and quantity to determine the fat content of the milk, which were done hours after the milk was received. Farmers often claimed that the old system resulted in malfeasance and underpayments, but such charges were hard to prove. Computerized milk collection now increases transparency, expedites processing, and provides immediate payments to farmers (World Bank, 2002). In a study by Abayneh and Beneberu (2014) shows that the size of farms that were cultivated, the capacity of borrowers to secure social group loans as collateral, and the promptness of

loan repayment determined the level of poverty in communities. Unexpectedly, households with male heads made up the majority of those who lacked access to food in the sampled population.

The results on the reason why farmer establish an enterprise revealed that, profit was utilized as an objective for variety of living standard tactics. However, the circumstances mentioned are preventing this goal from being accomplished. Following income stability, food security was the next justification given by farmers for starting businesses. It was clearly demonstrated that the majority of farmers prefer to sell their food on the open market, as opposed to just one farmer who prefers selling to processors and two farmers who would prefer to consume it. Due to the fact that only one agricultural product is marketed to processors, value addition is not a popular practice among residents of the study area (Abayneh and Beneberu, 2014). Their primary means of subsistence is agriculture, primarily related to crop production and marketing, and the majority of the samples have households with five to eight members.

2.9.9 Income level

According to Adam (2020), the revenues and losses made from running a farm or other agricultural business are referred to as farm income. According to the author, a farm income Statements are summaries of the income and expenses that were incurred throughout a given accounting period. For farmers, this is typically the calendar year (January 1 – December 31). Thomas *et al.* (2002) in their findings disclosed that, Farmers' information shops served as a point of information transmission at the level of end users. Villagers can communicate with each other or with people elsewhere through this shop. The amount needed to start an information kiosk is less than the government can pay, but there are

programs with the District Rural Development Agencies and the Prime Minister Swarna Jayanti Rojgar Yojana to help educated rural youth start such businesses with soft loans. These stores exchange information with the extension center regarding farmer outreach and then provide it to the final consumers.

The information may also be clarified by using plain-English text and audio-visual graphics in the local tongue, which may be posted on noticeboards at kiosks. The primary distribution channels include farmers' periodicals, newspapers, posters, booklets, handbooks, radio, television, films, and videos. Other means of information dissemination, such as mobile telecommunication systems, can still be tested with plenty of space. Although most cities have access to e-agriculture information sources, there are now opportunities to involve rural communities as well (Omotayo, 2015). Parker (1999) and Cooke and Park (2001) identified the most effective areas to which e-agriculture packages have been used as utilizing decision support systems, records and accounts may be accessed more quickly and easily, and the operational costs are lower while communicating with others.

These authors also identify that through the World Wide Web, a huge amount of information is quickly accessible. E-agriculture has additionally been recognized as a valuable auxiliary value for other related inventions. The Internet that is a functional member of the ICT family is particularly very effective in providing possibilities for distance learning and training, which can help agricultural farms and family-run small companies overcome some of the issues of geography and lack of time (Fuller *et al*., 2006).

Baiti (2017) revealed that publications from the internet are now also available in downloadable electronic form rather than paper format, making material accessible that was previously only available after visiting a specialized library in some remote, frequently unreachable locales. Munyau (2000) claims that e-agriculture is efficiently used in agricultural production systems and structures. These systems and structures are more effective thanks to improved management of information and limited resources, such as the usage of databases and networking software. With the help of search engines, the web, and databases, for instance, ICT-agriculture packages are also successfully used for information search and packaging on demand as well as for investigating alternative agricultural production options and technologies.

E-agriculture can be used effectively to provide market information that is timely and sensitive, for example, by using radio and television, as well as a normal weather forecast, a warning system for disease/pest outbreaks, and other disasters before they occur (Asian Development Bank (ADB), 2003). E-agriculture, such as the use of the phone, video conferencing, and networking software, are crucial for networking among and between the major players in the Research-Extension-Farmers-Inputs-Linkage System (REFILS). E-agriculture can be used to mobilize communities, for instance, through the use of radio, television, and public address systems (Arokoyo, 2011).

If e-agriculture information sources are adopted and properly applied, they have the potentials to really transform agricultural production especially in cereal crop farming in developing countries, thereby transforming the livelihood status of the rural farmers. There are instances where e-farming knowledge sources improved distribution of agricultural goods in rural India. The existing cooperative structure has been combined with cutting-

edge technology to equip cooperative societies with internet connectivity as part of the Warna Wired Village Project, which spans 70 villages in Maharashtra. By building network booths throughout the villages, it is intended to enlighten the inhabitants (de Moura *et al.*, 1999). The Information Villages Project of the M.S. Swaminathan Research Foundation aims to provide rural communities in Pondichery with the advantages of contemporary ICT- agriculture.

In order to provide a variety of services, four information stores have been created in various communities, including the value addition center, which serves as the information network's hub, in the village of Villianur (Sharma, 2000). According to Anastasios *et al*. (2010), factors affecting internet access in rural areas include factors like income, gender, and whether or not there is a young child in the family for basic users, the digital divide between rural and urban locations, and the skill level of the farmer for "farm-oriented users." According to Mwombe *et al.* (2014), factors such as age, gender, income, and the amount of land planted with bananas had an impact on how frequently smallholder banana farmers used e-agriculture tools as a source of agricultural information.

2.9.10 Method of land acquisition

Stefania (2016) reports that the majority of the households in her sample population in the study area had access to multiple plots of land (on average, two), with an average plot size of 0.4 hectares. Most of the households in the same study area obtained their homes and farmland through inheritances. The author went on to say that vetiver grass and soil bunds made up a bigger portion of the lands used for cultivation. Compared to other forms of acquisition, renting a plot has a lesser financial benefit from implementing conservation measures. The study also found that plots that were rented were typically closer to

population centers and less likely to be situated in steep terrain. Due to the owner's ability to remove the land for usage, many small-scale farmers who have leased land that uses technology risk losing out on the returns on their investments.

2.9.11 Extension contact

According to NAERLS (2018), the nation's agricultural extension services are almost extinct. With the help of the World Bank, the agricultural development project (ADP) was implemented in the nation at the beginning of the 1970s as a platform for the efficient application of the training and visit (T & V) model. With the backing of the bank, extension people were hired, trained, and retrained, making the ADP project a resounding success. State governments took over as the main funder of the ADPs after the World Bank's assistance ended in the late 1980s. Due to retirement, resignation, and deaths, the ADPs have lost a large number of employees throughout the years. Although the state government was hiring new employees, the ADP system eventually fell dormant, which had very negative effects on production and revenue for small holder farmers, who make up more than 80% of the farming community.

According to a report from the Agricultural Performance Survey (APS) (2018), the number of village extension agents (VEAs) is woefully inadequate to provide farmers with extension services, despite the fact that the majority of states have not yet performed agricultural resource surveys, such village listing, agricultural diagnostic surveys, livestock censuses, farm family censuses, cultivated land areas, arable areas and other surveys of vital importance to the country have not been conducted by the state government over the years.

In light of this, the ratio of agricultural households in the nation is 1:5,000 as opposed to 1:800. ADP's capacity to effectively connect with all farm families can be gauged by the ratio of extension agents to farm households. The goal in Nigeria is to have one extension agent for every 1,000 farmers. The same poll revealed that the goal of having one extension agent for every 1,000 farmers is extremely far from being a reality, with reports from all the states indicating very high EAs/farmers ratios, this is according to ADP's report record. One EA to 18,429 farmers was the greatest ratio observed in River State, and one EA to 6,600 farmers was the lowest in Ondo state (NAERLS, 2018).

For the effective delivery of extension services, it is necessary to have enough qualified staff. Due to the potential use of an e-Extension model, the staffing requirements per farmer were higher ten years ago than they are today. In order for motivation to be effective, highly qualified employees with the required infrastructure (internet services, communication tools, social media platforms, and so on.) are required. A crucial area that has to be investigated is capacity development through training and retraining of farmers, processors, marketers, and up-takers. This will increase agricultural productivity without having to close the gap to get to the ratio of one EA to 1,000 farmers (NAERLS, 2018

2.10 Theoretical Framework

The Modernization and Diffusion Adoption theoretical approaches served as the foundation for this investigation. The reason for this is that e-farming in grain crops is focused on the transfer of science and technology to cereal crop farmers through e-agriculture information sources to boost their production and improve their livelihood. Since modernization is concerned with the development of science and technology, and adoption and diffusion is concern with accepting the innovation and spreading the new innovations invented by

science and technology, these theories will enlighten readers on what e-agriculture entail in the global world of technology in cereal crop farming and how it help increase the livelihood status of the cereal crop farmer

2.10.1 Modernization theory

Modernization is the process by which societies change from its primitive ways of life to technologically advanced and industrialized complex societies, where they will break out from religion to secular ideology, of the gloomy circle of unemployment, illiteracy, disease, and poverty (Held, 1980). Modernization is referred to be "the process of transition toward certain types of social, economic, and political systems" by Eisenstadt (1966). Colonial rulers frequently took the lead in modernization. For instance, the modernization process was seen to be self-generating and the outcome of internal changes that took place within these cultures. The structural functionalists' significant contribution to development studies can be seen in modernization theory.

Since modernization is frequently seen as a unique development strategy, it should be noted right away that many components of modernization theory can be found in the sociology of development. According to Held (1980), modernization was the emergence of Western-style phenomena like science, technology, industrialization, education, and a new type of man. Modernization is frequently viewed as a time of transition during which a culture loses its "traditional" traits and is overtaken by "Modern" Western institutions and behaviors (Moore, 1963). Traditional structures were not recognized as an essential component of national or international systems, but rather as a barrier to modern growth. Due to structural duality and the inability of centralized institutions to maintain control, there were demonstrations and a possible breakdown.

A perceived obstacle to China's modernization process was "a system of thought and bureaucratic procedure inimical to change' among other things. Thus, the delays encountered in the process of modernization were usually seen in terms of cultural obstacles, traditional structures and group disharmony, of the new nations themselves. Moore (1963) edited a collection of essays on modernization covering all aspects of society, ranging from national integration and urbanization to agriculture, value, and education. Modernization is viewed as a "complete process" with the creation of societies that resemble Western European societies as the end result.

According to Liz *et al*. (1993), the introduction of modern-day hypothesis of development after World War II was aided by three major historical factors. The emergence of the United States as a superpower came first. The United States emerged from World War II strengthened and rose to prominence as a global leader with the implementation of the Marshall Plan to rebuild war-torn Western Europe, whereas other Western nations like Great Britain, France, and Germany were left with diminished capacities. The growth of a global communist movement came in second. Along with China and Korea, the former Soviet Union had influence not only in Eastern Europe. Third, there was the breakup of European colonial powers in Asia, Africa, and Latin America, which resulted in the creation of numerous new Third World nation-states.

These emerging nation-states were looking for a development strategy to advance their economies and strengthen their political independence (Ramirez, 1993). Modern nations are more productive, children are better educated, and the needy receive more welfare, and claims the proponent of the modernization idea (Smelser, 1964). Smelser's analysis indicates that contemporary civilizations have the unique quality of social structural

differentiation, or a distinct definition of functions and political roles from national institutions.

Coleman focuses on three key characteristics of contemporary societies, which Smelser claims have boosted the functional capability of modern organizations but also created the difficulty of integration and of coordinating the actions of the numerous new institutions in a political sense; a) Differentiating political structures; b) Secularizing political culture with an emphasis on equality; and c) Increasing the effectiveness of a society's political system. The following essentially sums up the fundamental tenets of the modernization theory of development. Modernization is a phased process; for instance, Rostow's theory of economic development for a particular civilization has five phases.

We can say that modernization produces tendencies toward convergence among societies because it homogenizes those societies. For instance, Levy (1967) asserts that "as time goes on, they and we will increasingly resemble one another because the patterns of modernization are such that the more highly modernized societies become, the more they resemble one another." There is a complacent attitude toward Western Europe and the United States in the modernization literature. Modernization is a process of Europeanization or Americanization. These countries are thought to have unparalleled economic success and democratic stability (Tipps, 1976). Modernization is also an unstoppable process, once it has begun, it cannot be stopped. In other words, once third-world nations interact with the West, they will be powerless to withstand the pressure to modernize. Modernization is a gradual process that over time, becomes not only inevitable but also desired.

Coleman (2001) asserts that modernized political systems are better equipped than traditional political systems to handle the functions of national identity, legitimacy, penetration, participation and distribution. Modernization is also a drawn-out process, it is a gradual transformation rather than a revolutionary one. It will take years or maybe centuries to finish, and only time will be able to fully appreciate its immense impact. All of these presumptions are derived from evolutionary theory in Europe and America (Huntington, 1976). Another set of conventional presumptions that are more closely aligned with the functionalism-structuralism theory emphasizes the interdependence of social institutions, the significance of structural variables at the cultural level, and the inherent capacity for change through homeostasis equilibrium. These thoughts are primarily derived from Parsons' sociological theories. They are:

i) Modernization is a planned process; the characteristic of modernity is a cohesive totality that appears in a group rather than alone (Hermass, 1978).

ii) Modernization is a transformative process; for a society to enter the modern era, its traditional structures and values must be entirely replaced by a set of modern values; and

iii) Modernization is a process that is quickly approaching because of its systematic and transformative nature , which incorporates change into the social system.

Public policy decisions are one of the major areas where the modernization theory has been used. From this angle, it is generally known that the stages of development from Rostow's model serve as the foundation for the economic theory of modernization. These stages are in order, traditional society, prerequisite for take-off, take-off process, drive to maturity and high mass consumer society (Killing, 1984). This explanation claims that Rostow has

discovered a potential answer for the encouragement of Third World modernization. The giving of help to the nations in the form of money, technology, and knowledge is the answer if the issue facing Third World nations is their lack of productive investments (McClelland, 1964).

Several factors can be used to identify modernization theory's advantages. The foundation of the research focus can first be determined. Some writers have enlarged modern day theory to some fields, even with the fact that grass root modern studies were carried out by psychologists, social psychologists, political sociologists and sociologists of religion. Example; Bellah studied the impact of the Tokugawas believes on pajanes economic development in South-East Asia with effects on villages in Cambodia, Laos, and Burma; Lip set converse on the potential role of economic development in the democratization of Third World countries; and Inkeles examines the effects of modernization on people's attitudes and behaviour. The analytical framework is the modernization perspective's second distinguishing feature. The assumption among authors is that 3rd world war nations are traditional and Western nations are contemporary. These developing nations must absorb Western values in order to progress. Thirdly, the technique is founded on broad research, such as expositions on the value elements in the Third World and the distinction between unstable dictatorships and democracies. Contrarily, modernization theory was widely accepted in the 1950s but came under fire by the end of the 1960s (Ramirez, 1993).

2.10.2 Criticisms of the modernization theory

First of all, there are many pathway to progress, second, the modern ideas reflects a potential development paradigm. The growth pattern in the United States is the preferred illustration. However, in contrast to this situation, it can be noted that other countries, like

Taiwan and South Korea, have made development advancements. It must be acknowledged that their current development levels were attained by strong authoritarian regimes because of these traditional values is left behind as the subject of a second group of criticisms of the modernization theory (Killing, 1984). The traditional values of third-world nations are very diverse; there is no one consistent set of these values in these nations. Redfield (1965), for instance, makes a distinction between the great traditional values (values of the elites) and the minor traditional values (values of the masses) (Redfield, 1965). The fact that traditional and modern values do not always have to be in opposition to one another is a second area for criticism in this situation. For instance, despite its economic prosperity, China maintains traditional values, and it appears that Japan is in a similar predicament.

The consistency of the discovering is focus on the 3rd world war development, the analysis at the national level, the use of three main variables of internal factors, cultural values and social institutions are the key concepts of tradition and modernity, and the policy implications of modernization in that it is thought to be generally advantageous to society as a whole. Between the new studies of the modernization school and the classical studies, there are, nevertheless, also significant differences. For instance, whereas tradition is a hindrance to growth in the traditional strategy, it is a contributing component in the modern approach (Killing, 1984).

The new approach uses specific case studies that are presented in a historical context, whereas the traditional approach uses theoretical formulation with a high level of abstraction as its methodology. The new viewpoint prefers a multidirectional way of growth over the unidirectional approach used by the classical perspective, which tends toward the American and European models. Finally, the classical approach shows a relative neglect of

external elements and conflict, whereas the modern approach practices greater attention to external factors and conflicts (Seeso, 1986).

2.10.3 Relationship between modernization theory, e-agriculture and farmers' livelihood

Conclusively, modernization in agriculture is a transformational movement from the traditional means of production to modern ways of agricultural production through the application of science and technology. Agricultural modernization involves the use of e-agriculture information sources for agriculture extension services delivery, where farmers have access to information sources through the use of internet, modern transport system, use of agro-chemicals, irrigation, improved processing and marketing system, which help to replace or substitute use of human through biotechnology.

Modernization is also the development of policies for agricultural growth through the use of e-agriculture for improved access to productive assets, through extension services. This will lead to wide spread of diffusion of modern inputs to the cereal crop farmers, thereby creating efficient techniques of production. With modernization and e-agriculture, farmers of cereal crops will be encouraged to experiment with new crop varieties, production techniques, marketing techniques, hybrids, greenhouse technology, genetically modified food, artificial fertilizers, insecticides, tractors, and application of other scientific knowledge to replace the conventional ones, which will change their livelihood status and raise their standard of living.

2.10.4 Theory of diffusion and adoption

During the post-World War II era and until the 1970s, the diffusion of innovations hypothesis was the dominant theory in agricultural extension. It is still employed in agricultural extension today, especially where the acceptance of a certain technology is at

issue (that is, technology transfer approach to extension). The spread of innovation theory is credited with having been developed by Everett M. Rogers. In 1957, Rogers began work on a PhD (doctoral dissertation) that examined the spread of several agricultural advances in a rural Lowa community. Rogers was certain that innovations are adopted as part of a general process of societal transformation. It first appeared in communications to describe how, over time, an idea or product gathers steam and diffuses or spreads over a particular population or social system. The main component of the theory is the rate of diffusion. Rogers created adopter categories to gauge farmers' inventiveness and created a statistical model to display the distribution of the five adopter types across the average adoption period (Rogers, 2003). The theory of innovation diffusion aims to explain how, why, and at what rate an innovation is adopted to the point where it reaches a critical mass.

The categories of adopters are laggards, innovators, early majority, and late majority. One of the first social science hypotheses was the diffusion of innovation, which Rogers developed in 1962. It was first used in communication to describe how, over time, a concept or product gets traction before diffusing or spreading over a particular community or social structure. People accept a new concept, behaviour, or product as a result of diffusion when they are a member of a social system. Adoption is when someone does something different from what they had previously done, such as acquire and use a new behaviour, use a new product, and so on. The secret to adoption is that a person must understand that the idea, behaviour, or product (innovation) does not occur simultaneously in a social system, but rather that it is a process in which some people are more inclined to adopt the innovation than others.

According to research, those who adopt innovations sooner than those who acquire them later have different traits. Understanding the traits of the target demographic that will facilitate or impede acceptance of the invention is crucial when promoting it to that group. Awareness of the need for an invention, the decision of adopters to reject the innovation, the initial use of the innovation to test it, and ongoing use of the innovation are the processes by which a person adopts an innovation and wherefore dissemination is accomplished. The adoption of an innovation is influenced by five key elements, each of which is present in the five adopter categories to varying degrees.

i. Comparative Advantage. The degree to which a new innovation is thought to be superior to the concept, scheme, or thing it replaces.
ii. Compatibility. How consistent the innovation is with the values, experiences, and needs of the potential adopters.
iii. Complexity. How challenging it is to use or comprehend the innovation.
iv. Triability. The degree to which the idea can be tried out or tested out before being decided to embrace.
v. Observability. How much the innovation produces measurable outcome.

This approach has been successfully applied in a variety of industries, including marketing, agriculture, public health, criminal justice, and communication (Wayne and LaMorte, 2016). Adoption and diffusion of new technologies are among the key processes that drive agricultural development in developing countries. Hence, developing countries have invested considerable efforts to help farmers increase their diffusion and adoption of innovations. The studies on spatial distribution of technology have particularly examined the role of infrastructure and technology suppliers and innovators in the diffusion of

technologies. Technology adoption is the level of technological utilization in long-term equilibrium when the farmer is fully informed about the new technology and its possibilities. Diffusion is the process, which a new technology spreads from the early adopters to other potential users (Hall and Khan, 2002).

Adoption of innovation is considered to be a learning process. Adoption is founded on social-psychological conceptions of individual decision-making, but it is not viewed as a straightforward, single act, but rather as a complex pattern of mental processes and behaviours that form a continuum of mental development with regard to the innovation. A series of stages awareness, information, evaluation, trial, and adoption occurs during the process (Hall and Khan, 2002). Rogers (2003) identified five stages in the dissemination of innovation: Persuasion causes the agent to become increasingly interested in the innovation; trial causes the agent to test the innovation on a small scale; adoption causes the agent to actually decide to adopt; awareness causes the agent to become aware of the innovation's existence and to gain a general perception of what it entails. Consolidation, the agent either seeks confirmation of or rejects his choice.

The adoption theory takes into account the role that the community plays in the adoption process. These theories are based on how people behave and respond to new ideas and behaviours as a collective, as well as on the goals, desires, and wishes of specific individuals. Four more adoption/diffusion theories have recently been put out by Rogers (2003), including the innovation choice process theory, which states that as potential users of a technology advance through time, the diffusion process must go through five stages. Therefore, individuals must become knowledgeable about the innovation (knowledge), be convinced of its value (persuasion), decide to embrace it (choice), the innovation must then

be applied (implementation), and the decision must be confirmed or reversed (confirmation). According to the rate of adoption theory, innovation has a slow, progressive growth phase, followed by a dramatic and rapid growth phase, a gradual stabilization phase, and ultimately a decrease (Rogers, 2003). Diffusion is a goal-driven process that is typically evaluated only based on the anticipated result. The early images of invention dissemination can be combined to conceptualize the diffusion and adoption processes.

Simply put, the diffusion process can be considered as a step before adoption, however it does not always lead to it. Information flow between dyads or other units within a group of people is known as diffusion. The substance or essence of the information, the model used, and the process management by extension specialists will all have an impact on how the flow develops (Rogers, 2003). Diffusion starts with an innovation's real entry into a target system, which might be passive or active. The passive one typically takes the shape of harmless information interchange that results from people moving between systems, and the subsequent casual interaction that subtly impacts individual characters and influences the degree of modernization at the individual level (Rogers, 2003). Since active diffusion is intentionally done with a purpose, it requires a more technical approach. Communication techniques are frequently used because diffusion is comparable to communication in nature.

Adoption is the decision to fully utilize a technological advancement as the best course of action that is now possible (Rogers, 2003). A new idea, product, or approach that is perceived as novel by a person but may not always be the outcome of recent study is referred to as an innovation, according to Vandenban and Hawkins (1996). An innovation is adopted when a person or organization decides to use or implement it. When contemplating any new technology or innovation, most farmers are reported to go through a logical

problem-solving process known as the adoption process. It is understood that farmer decisions about whether or not to implement a recommended agricultural practice take place gradually over time rather than immediately (Vandenban and Hawkins, 1996).

After implementing an innovation, people frequently seek out extra information to make sure they made the proper choice. Explicit consideration of the prospect of the invention being rejected is now provided in these new sets of stages. This may have been a deliberate choice, but it's also likely that the farmer was unaware of the innovation until he learned more about it. It is not a matter of adopting an invention to move towards a more sustainable agriculture because it necessitates a gradual learning process and a transformation in mindset. A new concept, opinion, or product spreading throughout a society is known as diffusion. Adopters use diffusion to influence others who have not yet embraced a new idea to do so (Rogers, 2003).

2.10.5 Application of diffusion and adoption theory

The theory has been applied in anthropology, public health, general sociology, rural sociology, and agricultural extension, among other fields. It has been extensively utilized by extension program designers, assessors, and researchers in the agricultural sector to get a knowledge of the factors that influence the adoption or rejection of a specific new technique. Additionally, it gives a broad insight of the volume and quality of innovation uptake. Many governments in poor nations have shaped the conceptual framework and execution design of international rural development programs using the diffusion of innovation theory (Michael, 2015).

2.10.6 Critique of the diffusion and adoption theory

In the context of international development, public critiques of the Theory first surfaced in the 1970s (Rogers, 2003). The main complaint was that innovations were primarily intended for "innovators" and "early adopters." The more forward-thinking farmers with the hope that cutting-edge techniques would spread to the bulk of farmers. The theory's execution was actually perceived as a cause of inequity, alienating rural communities, and failing to help or benefit those who were most in need. This was especially apparent when the process of innovation diffusion increased the productivity of larger farmers while simultaneously lowering market prices and farm gate returns for all farmers in the region, including those who did not adopt the innovation (Vandenban and Hawkins, 1996).

2.10.7 Relationship between diffusion and adoption theory, e-agriculture and farmers' livelihoods

The theory of diffusion and adoption identifies the spread of information as an essential aspect of the diffusion process. This information is being diffused through the use of certain communication channels called e-agriculture information sources. Mass media is thought to be more effective at spreading initial information about innovations for adoption in cereal crop farming, whereas the adoption decision is influenced by interpersonal contacts. Likewise, earlier adopters are thought to obtain information from outside and pass information about an innovation to other farmers in their social system. The latter adopters will heavily rely on internal sources and will base their adoption decision on the opinions of their close peers. This relationship between adoption and diffusion of innovation through the use of e-agriculture information sources will greatly impacts the farmers who grow grain crops' ability to make a living.

The decision to change must only be influenced by other people. Information sharing with cereal crop farmers is greatly aided by other people's participation in the adoption of cereal crop production using e-agriculture. The sociological theories of adoption and diffusion are a useful place to start when developing a framework for the application of e-agriculture tools in the farming of cereal crops. Since e-agriculture is a modern innovation that facilitates information dissemination to cereal crop farmers globally in a timely manner as a result of technological advancement in nearly all facets of life, the modernization theory in this study will also help to provide insight to the research work.

2.11 Conceptual Frame Work

The conceptual model in figure 1 below, explains the framework of this study. The focus is on the conceptual model of this work which explained the intension of the researcher scope of work. Socio-economic characteristics and e-agriculture usage are the independent variables in this study, the socio-economic characteristics constitutes the following (socioeconomic factors, production factors and institutional factors) while the e-agriculture information sources includes (Telephone**,** Mobile phone**,** Computer and website**,** Internet and broadband**,** Broadcasting**,** Sensor networks**,** Satellite**,** Data storage and analytics**,** Geographical information Systems (GIS), Handheld personal computer**,** Global positioning system (GPS)**,** Television, Newspapers**,** Extension Agents**,** Short messages service system (SMS)**,** Interactive voice response (IVR) and Smartphone Integrated with social Media. The Intervening variables includes: Religious belief; Government Policies, Culture, Politics, and Bureaucracy, it is indicated by a small doted arrow. The dependent variable is the livelihood status of the cereal crop farmers.

The expected effects of this interaction is change in output, change in income, change in famers' livelihood status (standard of living), and change in economic growth and development as indicated in the model with a dotted arrow. The thick black arrow on the charts shows the directions of relationship between the given variables that is "the independent variables, intervening variables and the dependent variable" and how they correlate to influence each other (direct effect), to produce an effect on the cereal crop farmers' livelihood status. The small dotted arrow shows the intervening variables as it has indirect effect on the independent variables and the dependent variable to achieve effective changes on the cereal crop farmers' livelihood status as seen in the conceptual model.

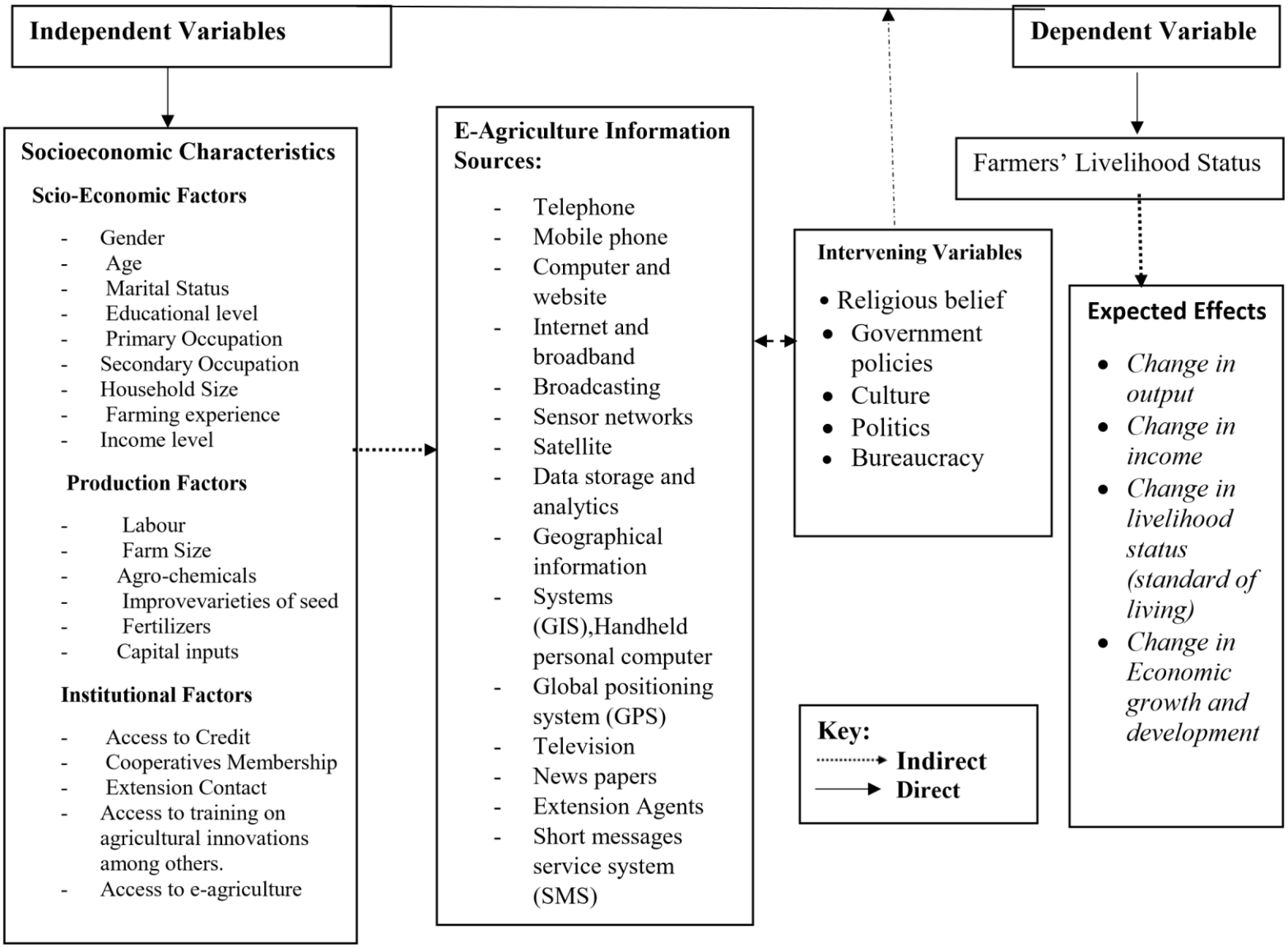

Figure 1: Conceptual Model of Effects of E-agriculture on Cereal Crop Farmers' Livelihoods in Borno and Kebbi States, Nigeria

Source: Narmailan, 2017

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 The Study Area

Borno State is one of the States in North Eastern Nigeria with Maiduguri as its capital. The North-Eastern State was separated into the State in 1976, creating the State. It included the Eastern part of the former Borno State, which is now Yobe State, until 1991. Borno State is divided into 27 Local Government Areas (LGAs). The State's physical environment resulted from a confluence of elements related to geography, geology, climate, and the extent of resource development in the region. Given the state's wide geographic range between Latitude 11°75' and 11°45'N and Longitude 13°18' and 13°11'E its physical environment is certain to be diverse. The Republic of Niger, the Chad Basin, Adamawa State, Yobe State, Gombe State, and the Chad Basin are the states that Borno State borders in the south, west, east, and north, respectively. The population density in Borno State is approximately 45 people per square kilometre (Babagana, 2017).

Borno State has a human population of 4,171,104, according to the 2006 population census estimate (National Population Commission) (NPC, 2006). The estimated human population of Borno in 2022 was 6,111,500 based on 2.4% annual growth rate of the population in the state (Thomas, 2022). The State has a density of 82.66 people per square kilometer and an estimated land area of 70, 898 km^2. The major tribes of the State include the Kanuri ethnic group, Buras, Baburs, Marghis, Bolewas, Kare-kares, Gudufs, Hausas, Ngizims and from latter migrations in the latter parts of the millennium, the Shuwa-Arabs and the Fulanis. Other important settlements in Borno include Biu, Bama, Kukawa, and Gwoza (Babagana, 2017).

From the hilly south to the northern sand dune terrain, Borno State's soils differ in colour, texture, structure, physico-chemical properties, and other important qualities. The depressions as well as the flat plains close to Lake Chad are dominated by vertisols. These are "thick, dark clay soils (firki), during the dry season, grow broad fractures." Regosols with shallow, poorly formed profiles grow on the dunes. Rock outcrops can be found on both gentle and steep slopes in the Volcanic and Basement complex zones, which contain good clayey loamy soils (GN Wikipedia, 2011). Borno State experiences three distinct seasons: the rainy season from July to September, the hot dry season from April to June, and the cold dry (harmattan) season from October to March. The hot season ranges between 39 and 40 degrees Celsius, and temperatures are high all year long.

The weather is often pleasant in the State's southern region. In the far north, the rainy season lasts less than 80 days, whereas in the far south, it can last up to 140 days. On the Biu Plateau, the annual rainfall average is around 800mm, whereas it is just 500mm or less in the far north, near Lake Chad. The state's relative humidity is typically low, varying from the driest months of February and March, where it is as low as 13 percent, to the wettest months of July and August, where it is at its highest levels of 80% (Britannica, 2016). Sahel savanna and sudan savanna are both types of vegetation found in Borno State. The vegetation is composed of Acacia seyal, Acacia nilotica, and Acacia Senegal. The latter two are the primary sources of gum-arabic and grow in semi-arid areas. Other plants in these areas include Despite the nonleguminous ziziphus and Balanitesa egyptiaca, the Acacia forest somewhat declined between 1975 and 1995.

The State receives down pour of rain water between June and July to September and from December to February, for a total of 613 millimetres of yearly precipitation. The dry harmattan season also occurs there, with an average temperature of 25.8^{o}C. The majority of the state falls under the semi-arid or arid categories. Potential Tourist sites also includes, Lake Alau, and Tilla, the tombs of the Shehu's at Kukawa, Elkanemi's tomb, Gwoza hills. The Mandara Mountains closed to the border with Cameroon is located in the State. The major fish found around the Lake Chad includes, Alestes, Tilapia and Clarias, while the soil of the Lake floor is extremely fertile and many farmers utilize the area to cultivate corn and coepeas.

Borno State also houses sizable number of savanna (Hiribarren, 2016). It is separated into two major relief areas, the hilly/mountainous area, which is typically over 600 meters the plains, which are generally less than 600 meters above sea level. Regions of the State in the South and South-East are dominated by the highlands, which make up nearly one-third of Borno's total geographic area. The Plains, which are typically located fewer than 600 meters above sea level, make up the remaining two-thirds of the total area (Britannica, 2016). Borno inhabitants engage in various activities of economic value including agriculture and trading. Sorghum, gum-arabic, wheat, mango, millet, onions, maize, sesame, indigo and cattle herding are major farm produce from the State. Fishing is also a significant occupation with other potentials in the utilization of various agricultural raw materials for industries (Hiribarren, 2016).

Kebbi State on the other hand is situated in Nigeria's North-Western agro-ecological zone. It is bordered by the Benin Republic to the west, Sokoto State to the north and east, and the states of Niger and Sokoto. The State is located between Latitude 12^{o} 27' and 57^{0} 88' N and Longitude 4^{0} 11' and 58^{0} 29' E. There are 21 Local Government Areas (LGAs) which make up

Kebbi State. The state, which has its administrative center in Birnin Kebbi, was formed in 1991 from the former Sokoto State. Kebbi State's population was 3,256,541 in 2006, according to the National Population Commission (NPC) (2006). However, based on the 3.4% annual rate of population increase, the estimated population of Kebbi in 2022 was 5,563,900 (Thomas, 2022). The State has a density of 66.32/km2 and a land area of 1,296 km2 (NPC, 2006). The main ethnic groups are the Bangawa, the Gungawa, the Dandawa, the Zarbarmawa, the Kabawa, the Dakarkaris, and the Kambaris. The Hausa and Fulani are another significant group, with regard to Hausa being widely spoken throughout the state, these ethnic groups speak a variety of languages and dialects (NPC, 2006).

Tropical maritime and tropical continental air masses, which come from the Atlantic Ocean and the Sahara Desert, respectively, have a significant influence on Kebbi State's tropical continental climate. "Wet" and "dry," the two most common seasons, are determined by these air masses. The balance of the year is characterized by the dry season, while the rainy season lasts from April to October in the South and from May to September in the North. The average annual rainfall in the north is 807mm, whereas it is 1000mm in the south. The average annual minimum temperature is roughly 28.4°C, which is high. However, the temperature can drop to around 21°C during the harmattan season (December to February) and rise to 40°C from April to June. Relative humidity at night is typically lower throughout the year, with the exception of the wet season when it averages 80% (Jammal, 2011).

Two pre-Cambrian basement complex strata dominate the geography of Kebbi State. Young sedimentary rocks are more prevalent in the south and southeast than they are in the north. Granites, schist, gneisses, quartizites, and migmatites are among the extremely old volcanic and metamorphic rocks that can be found, they make up the Basement complex region

(Rabia, 2016). Meta-sediments like phyllites and meta-conglomerates are another type of sediment. Rocks from the Gwandu, Illo, and Rima groups, with dates ranging from the Cretaceous to the Eocene, make up the sedimentary region. While the illo and Rima groups, respectively, are composed of pebbly grits, sandstones, and clays, mudstones, and siltstones, while the Gwandu group is composed of large clay grits interbedded with sandstone. In the State, minerals such as quartz, kaolin, piotolitic bauxite, clay, potassium, silica sand, and salt can be found (Dahiru, 2011).

The State is divided into three relief areas: the riverine lowland of the Niger and lower Rima valleys, the high plains in the south and southeast, and the plain landscape in the north. A Northern Guinea Savannah can be found in the state's south and southeast as its natural vegetation. Medium-sized trees like Parkia biglobosa (Parkia Clappertoniana), Bytyrosperrium (Shea Butter Tree) and Combretum species are what define them. The Sudan Savannah is open forest in the north with sporadic trees comprising porassus, dum palms, parkia clappertoniana, acacia aibida (gawo) (Zaki, 2017).

Kebbi State has a favourable agricultural climate due to its rich soil fertility. Huge farmlands and rivers with a healthy economy are protected by a pleasant tropical environment. Due to these factors, agriculture has continued to serve as the state's primary source of revenue in addition to serving as the base for the cultivation of millet, guinea corn, maize, cassava, potatoes, rice, beans, onions, and vegetables. Wheat, soy beans, ginger, sugar cane, groundnuts, and tobacco are among the cash crops grown in the state. In a similar vein, horticulture is used to produce fruits like mango, cashew, guava, and pawpaw. Clay, gypsum, limestone, and salt are some of the state's mineral resources (Schlenker and Lobell, 2010). Maps of the study area can be found in the Figures 3.1, 3.2 and 3.3 below.

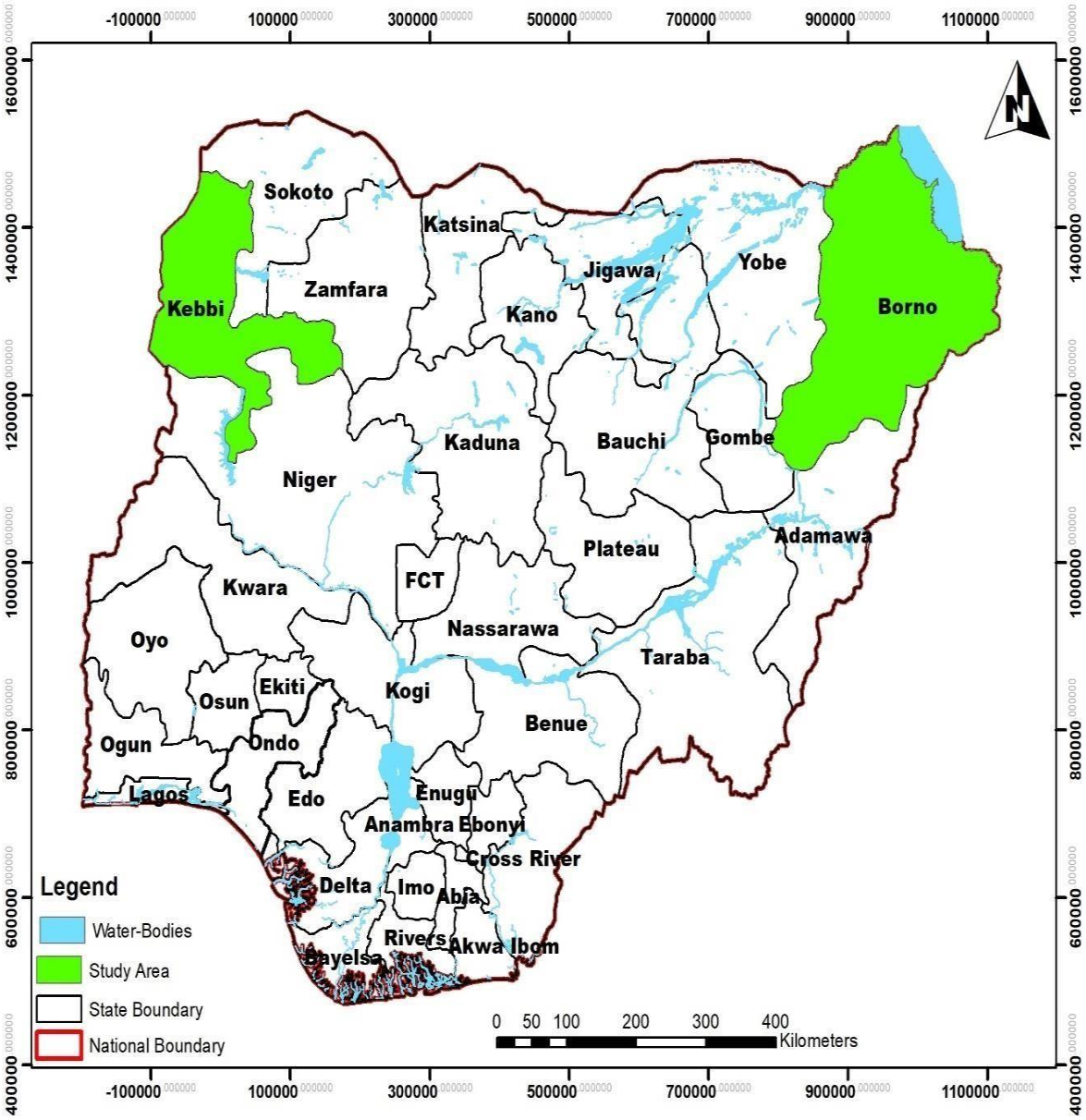

Figure: 3.1 Map of Nigeria showing Kebbi and Borno States

Source: Author's Design, 2019

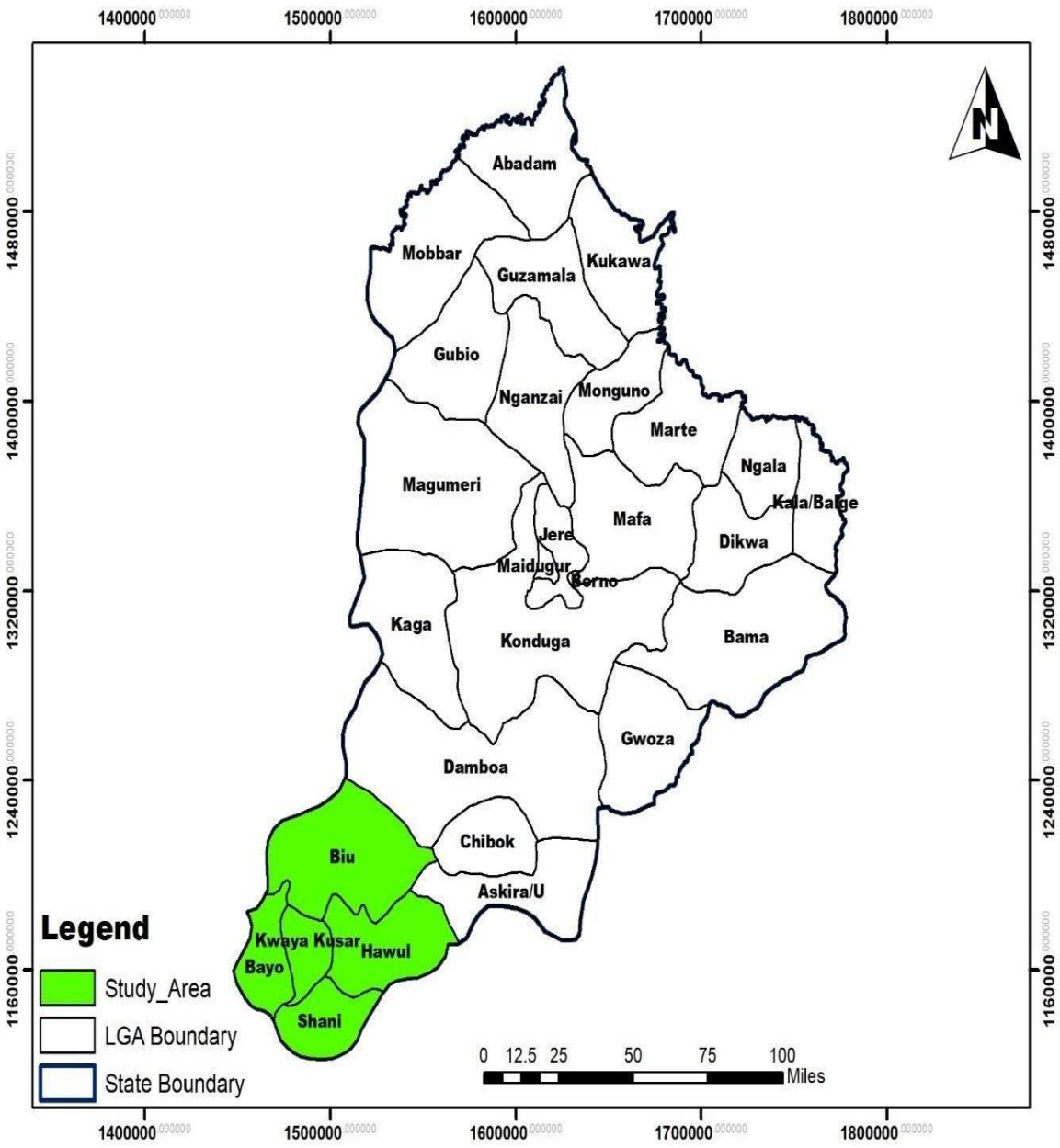

Figure 3.2: Map of Borno State showing the study Local Government Areas

Source: Author's Design, 2019

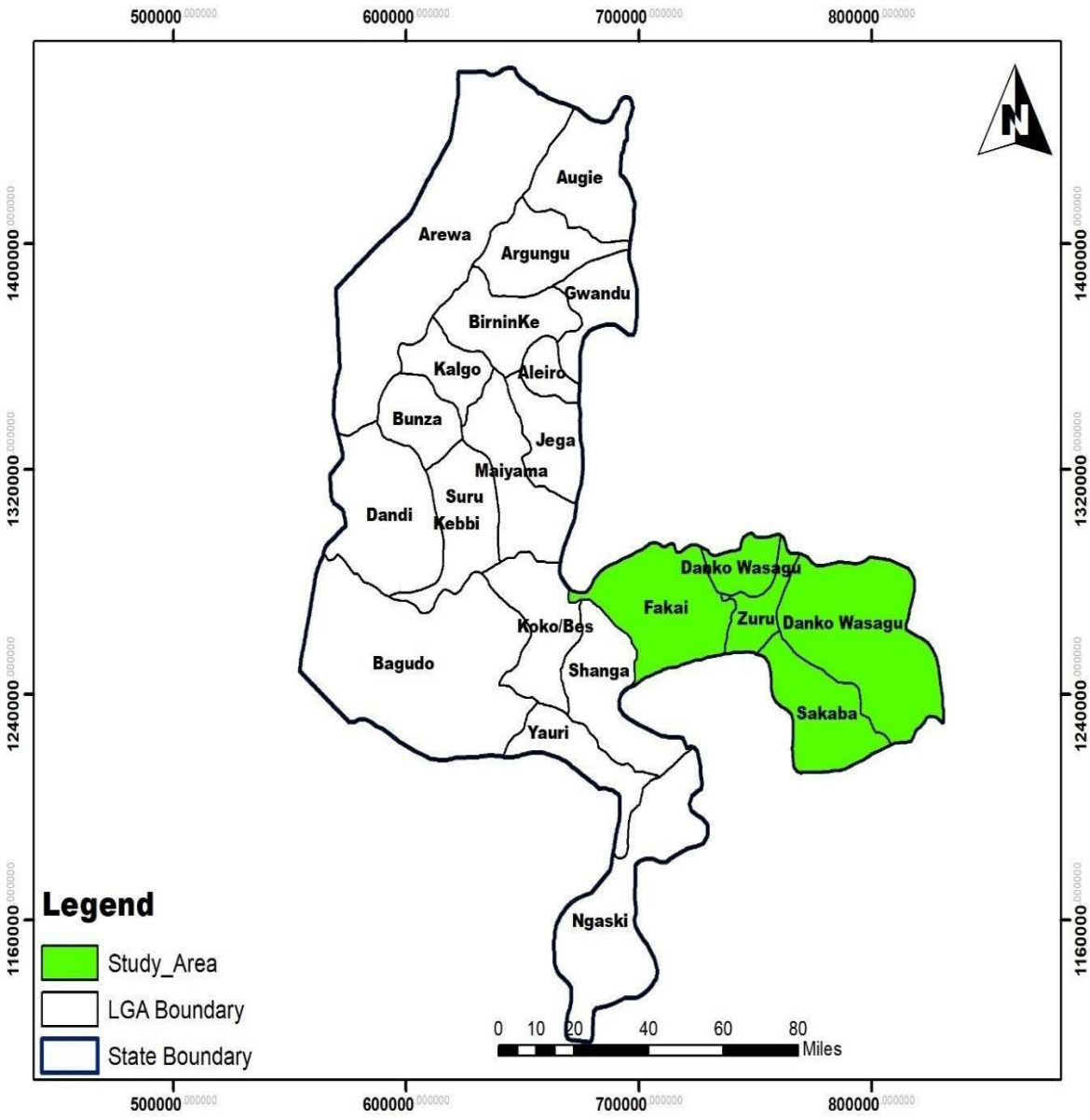

Figure 3.3: Map of Kebbi State showing the study Local Government Areas

Source: Author's Design, 2019

3.2 Sampling Procedure and Sample Size

The study was conducted in the Nigerian states of Borno and Kebbi. The study sample was collected using a three-stage sampling process. The first stage involved a purposive selection of five (5) LGAs from Borno State out of twenty-seven (27) and four (4) LGAs from Kebbi State out of twenty-one (21). To this end, nine (9) LGAs were selected from the two States. The reason for the purposive selection especially in Borno State, was because most of the villages were seriously affected by the insurgency, but the selected LGAs and villages for this study were less affected. Because of that, most of the people in the affected areas had migrated to others parts of the country including the less affected areas to settle down thereby shifting agricultural activities to the less affected areas. In addition, the 9 LGAs selected were predominantly cereal crops producing areas. The LGAs selected from Borno State are Biu, which has fifty-three (53) villages; Hawul, with eighty-two (82) villages; and Kwaya-kusar, with fifty (50) villages. Others are Bayo, with thirty-nine (39) villages and Shani, with twenty-six (26) villages. The LGAs selected from Kebbi State are Zuru, which has ninety-two (92) villages; Fakai, with twenty-eight (28) villages and Danko-wasagu, with thirty (30) villages, and the fourth LGA is Sakaba, with forty (40) villages

The second stage of the sampling procedure involved a proportionate selection of 10% of the villages for both States under study. Borno gave a total of twenty-five (25) villages, while Kebbi a total of nineteen (19) villages which gives an overall of forty-four (44) villages selected. Choosing the finalist was done in the third step sample size of farmers for the study. Pre-survey visit to the villages under study was conducted by the researcher to get the sample frame of the cereal crop farmers. The farmers' group from KARDA (2018), and Ministry of agriculture were used to obtain the sample frame in Borno and Kebbi States.

Using the Yamane Formula (1967) at 0.07 percent limit of tolerance error, the sample size was determined by the formula below:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

Where:

n = sample size

N = Population of Study (total population of the study area)

1 = Constant

e =Limit of tolerance error (0.07)

The sample frame for Borno State was 17,564 and that of Kebbi State was 5,637. Therefore, the sample sizes for Borno and Kebbi States were 203 and 197, respectively (Tables 3.1 and 3.2).

Table 3.1: Sampling distribution of the respondents in Borno State

State	LGAs	Sample Frame of Villages (SFV 10%)	Sample Size of Villages (10% of SFV)	Sample frame of farmers	Sample size of farmers
Borno	Biu	53 (5)	Gwaram	500	6
			Tabra	800	9
			Miringa	1000	12
			Ngrim	420	5
			Nassarawa	950	11
	Hawul	82(8)	Azare	1045	12
			Shaffa	1200	14
			Ngwa	500	6
			Yimirshika	900	10
			Sabon-gari	800	9
			Subwang	150	2
			Hyera	700	8
	Kwayakusar	50(5)	Marama	1200	14
			Gusi	1050	12
			Guwal	1000	12
			Kwayakusar	800	9
			Wandali	700	8
	Bayo	39(4)	Dayar	400	5
			Gaidam	800	9
			Maina Baba	700	8
			TashanItashe	280	3
	Shani	26(3)	Wuyo	150	2
			Pela	334	4
			Walama	900	10
			Kubo	285	3
Total	**5**	**250(25)**	**25**	**17564**	**203**

Source: Pre- Survey Information (2018)
Figures in parentheses are the sample size of villages (10% of sample frame of villages)

Table 3.2: Sampling distribution of the respondents in Kebbi State and sample size

State	LGAs	Sample Frame of Villages (SFV 10%)	Sample Size of Villages (10% SFV)	Sample frame of farmers	Sample size of farmers
Kebbi	Zuru	92(9)	Bedi	1250	44
			Dongo	150	5
			Amanawa	63	2
			Dongo	324	11
			Manga	265	10
			Dabai	350	12
			Senchi	435	15
			Rikoto	260	9
			Isgogo	174	6
	Fakai	28(3)	Mahuta	293	10
			Matseri	250	9
			Janhawa	125	4
	Danko-Wasagu	30(3)	Gwazawa	420	15
			Ranfin-Zuru	370	13
			Yarbuga	270	9
			Dirin Daji	183	7
	Sakaba	40(4)			
			Sakaba	246	9
			DankanKambari	120	4
			DirinGari	89	3
Total	**4**	**190(19)**	**(19)**	**5637**	**197**

Source: Pre- Survey Information (2018)
Figures in parentheses are the sample size of villages
(10% of sample frame of villages)

3.3 Data Gathering Techniques

Using both open-ended and closed-ended questions in a structured questionnaire, information used for this survey were collected from primary sources. Farmers who couldn't read or write were given an interview schedule with the assistance of skilled enumerators. The specified study objectives were covered by the data that was gathered. Among them are the farmers' socioeconomic traits, the sources of information on e-agriculture and the amount to which

they are used, and the financial situation of farmers who grow cereal crops in the research area. Additionally, information was gathered on the advantages that cereal crop farmers experienced from using e-agriculture information in their farming operations, the variables that affect how the farmers use e-agriculture information, how e-agriculture technologies and socioeconomic factors affect the farmers' ability to support themselves, the challenges the farmers faced in using e-agriculture information sources, and their perceived effectiveness.

3.3.1 The validity of the research tool

Exactly how much a research instrument carries out the intended measurement is known as validity. Thatcher (2010) defined validity as to whether or not the test measures what it claims to measure. The instruments (questionnaire schedule) that were used for data collection were subjected to both face-to-face and content validity test. Professionals relating to rural development and agricultural extension and the research supervisors helped and assisted the researcher to ascertain the validity of the instruments that were used. The face validity and content validity were used to evaluate the suitability of the interview schedule as one of the data collection instruments.

The researcher ensured that the instrument for content validity (questionnaires) were developed. The variables and study objectives were organized into themes that the respondents could understand. Some experts in the field of agriculture were hired to guarantee the accuracy of the instruments by distributing the instruments to other subject-matter authorities of research and methodology, agricultural extension and rural development, and agricultural economics who evaluated the research tools to verify the data and face validity.

3.3.2 Reliability of the research instrument

Reliability relates to the precision and accuracy of the instruments that was used. Thatcher (2010) defined reliability as the extent of consistency and precision of an instrument with which it measures what is expected to measure or is the extent which the test consistently yields the same results after time and item after item. It is also the ability of an instrument to consistently give the same result provided there is change in the characteristics. The research work on effects of e-agriculture information on cereal crop farmers' livelihood adopted the test and re-test method, this involved the random sampling of some few cereal crop farmers in the research area. The validity coefficient ranges from -1 to +1 however, the researcher made sure that the coefficient of the reliability test was near to 1. The test was done by randomly selecting 60 respondents (30 respondents from each State) as sample from another area different from the study area.

The test was conducted once more on the same respondents after a month. The socioeconomic characteristics-related items received scores, sources of e-agriculture information, extent of usage of e-agriculture sources, farmers livelihood status, farmers benefits derived by using e-agriculture information, factors influencing the usage of e-agriculture, perceived effects of the usage of e-agriculture information, effects of e-agriculture information usage on the livelihood status of the farmers, and each of the restrictions on using e-agriculture information that the producers of cereal crops face are given a scores. The total score for each of these variables were computed and subjected to statistical test analysis using Pearson products moment correlation (PPMC), both test has the correlation coefficient of 0.75. This was done to ensure the accuracy and validity of the data,

agricultural extension and rural development, and agricultural economics assess the study methods.

3.4 Measurement of Variables

3.4.1 Dependent variables

i. Livelihood status

Livelihood status was one of the dependent variables for this study. Livelihoods are 'the capabilities, assets (including natural assets, farm production/physical assets, human/ manpower assets, financial/economic assets and social assets) and activities required for making a living'. The specific items of the assets were measured in number. The livelihood situation of the farmers of cereal crops was ascertained using the Simpson Index of Diversity, where scores are between 0 – 1, ≤ 0. 33 = Low, 0.34 – 0.65 = moderate, 0.66 – 1 = high

ii. Extent of usage of e-agriculture information sources

The extent of usage of e-agriculture information sources was one of the dependent variables that was correlated along with the independent variables to determine the extent of usage of e-agriculture information sources used by farmers of cereal crops. Utilization of e-agriculture information sources was assessed using three (3) points Likert-type rating scale. Scores were assigned as highly used (HU3), fairly used (FU2) and not in use (NU1). Questions with options were provided for the farmers to indicate their sources of e-agriculture information, farmers were allowed to tick as many (multiple response) options as it is applied to their usage.

The farmers' responses were further arranged in order of frequencies and were ranked to achieve their extent of usage. The responses on each e-agriculture information sources were ranked and were further weighed and calculated by dividing the total number of farmers by mean score for each e-agriculture information sources used by the cereal crop farmers. The mean score was determined using (3+2+1)/3 = 2.00, from which decision was made as to the variation between highly used, fairly used and not in use. The decision is when it is 2.00 and above is highly in use and when it is below 2.00 is low in use by the cereal crop farmers. The values of the mean score were used to test the null hypothesis two ($H0_{2)}$ of this study.

3.4.2 Likert scale of measurement

A three (3) point Likert scale was used to assess objectives iv, vi and viii by assigning scores as very high (VH3), high (H2) and low (L1) for objective iv (benefits of the usage of e-agriculture information), objective vi (farmers' perceptions of the results of using e-agriculture information) scores were assigned as effective (E3), undecided (UD2) and not effective (NE1), while objective viii, scores for (perceived severity of the barriers respondents faced when using e-agriculture information) were given as very severe (VS3), severe (S2), and not severe (NS1).

Questions with options were provided and farmers were allowed to tick as many (multiple response) options as it is applied to them. The responses of the farmers were further arranged in order of frequencies and it was ranked to achieve the highest benefits, perceived effectiveness and severe constraints. The responses of the farmers were then ranked, and were further weighed and calculated by dividing the total number of farmers by mean score for each benefits obtained as perceived effectiveness and constraints faced by the cereal crop farmers. Decision was made as to the variation between high and low benefits, effective and

not effective and severe and not severe constraints. Mean score = (3+2+1)/3 = 2.00, the decision is that, when it is 2.00 and above is high benefit and when it is below 2.00 is low benefits, when it is 2.00 and above is effective and when it is below 2.00 is not effective. For the constraints when it is 2.00 and above is severe constraints and when it is below 2.00 is not severe constraints.

3.4.3 Independent variables

The socio-economic traits of the cereal crop growers serve as the study's independent variables and e-agriculture information sources. These variables were defined as follows:

Sex: Male (1) or female (0).

Age: measured in years.

Marital status: the farmer indicated (1) if married, (0) otherwise.

Educational level: measured in terms of numbers of years spent acquiring formal education.

Farming occupation: farmer indicated (a) yes, (b) otherwise.

Secondary occupation: was measured using categories of occupation (cereal crop farming, other farming activities, trading, fishing, and crafting).

Household size: measured in number of people in the house eating from the same pot.

Farming experience: measured in years.

Annual Income level: measured in naira (₦).

Labour: measured in a man-day.

Farm size: measured in hectares (Ha).

Fertilizer: measured in kilograms (kg).

Improved seeds varieties: measured in kilograms (kg).

Agrochemicals: measured in kg/litres.

Capital inputs: measured in naira (₦)

Sources of e-agricultural information: measured in number of sources used.

Access to credits: measured as amount accessed in naira (₦)

Access to financial services and insurance: assumed the dummy form of variables. Farmer indicated yes (1) if having access or no (0) otherwise.

Cooperative membership: measured by number of years of membership.

Extension contacts: measured by numbers of contact.

Access to training on agricultural innovations: measured on the number of trainings received by the farmer as at the time of this research.

Access to marketing information: measured in number of years of access to such information using e-agriculture.

Access to information on improved farming systems: measured in number of items having access to and it assumed multiple responses.

Access to information on weather condition: farmer responded yes (1) if having access and no (0) if not having access.

Access to information on crop cultivation and techniques: farmer indicated by choosing the number of items they have access to, this assumed multiple responses, and was measured in numbers.

Access to information on post-harvest technologies: farmer indicated the number of items they enjoy access to. This assumed multiple responses, and was measured in numbers.

3.5 Analytical techniques

Simple descriptive and inferential statistics were the analytical methods applied in this investigation. To group and describe the data and accomplish objectives i, ii, iv, vi, and viii, the descriptive statistical techniques employed include tables, frequency distribution, percentages and means.

3.6 Model Specification

3.6.1 Simpson index of diversity

The Simpson Index of Diversity (SID) is a diversity indicator that takes the quantity of available samples into account. The distribution of fundamental entities among the many sorts of samples that make up a data set or community is quantified by the diversity index. The values of *SID* ranges from zero (0) to one (1). Index 0 indicates no diversity, while index 1 denotes limitless diversity. The formula used to determine the diversity index is:

D =1-((n (n-1))/N (N-1) (2)

Where:

n = number of selected respondents

N = overall number of population of respondents (Mclaughlin, 2016).

Objective iii, was achieved using SID to differentiate between the livelihoods' status of the farmers. This is specified as:

$SID = 1 - \sum_{i=1}^{n} P_i^2$ (3)

Where:

S = Simpson

I = Index

D = Diversity

$\sum$ = Summation

P_i = proportion of i^{th} livelihood's status of the respondents where scores ranges between 0 – 1.

Thus, scores of:

≤ 0. 33 = Low livelihood's status

0.34 – 0.66 = Medium livelihood's status

0.67 – 1 = High livelihood's status

3.6.2 Model for ordered Probit regression I

The ordered probit regression model was used to achieve objective v. This was utilized to estimate the variables influencing the use of e-agriculture by the research area's farmers of cereal crops. It was as well used in estimating the influence of independent variables in order to establish the best variable that serve as the determinant of the factor that influence farmers growing cereal crops in the study area to use e-agriculture. Following are the model's specifications:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + ... + b_{12}X_{12} + U \quad (4)$$

Where;

Y = Use of e-agriculture (Very High =3, High =2 & Low =1);

$X_1 – X_{12}$ = Independent Variables;

X_1 = Age (years);

X_2 = Gender (1 male, 0 female);

X_3 = Marital Status (1 married, 0 otherwise);

X_4 = Educational (years);

X_5 = Household Size (number);

X_6 = Farming Experience (years);

X_7 = Farm Size (hectare);

X_8 = Extension Contact (number);

X_9 = Cooperatives Membership (years);

X_{10} = Access to Credit (naira);

X_{11} = Labour Usage (man-day);

X_{12} = Income (₦);

b_1 - b_{12} = Regression Coefficients;

a = Constant and

U = Error term.

3.6.3 Model for ordered Probit regression II

Using an ordered Probit regression model, objective vii was also accomplished. This was done to establish the significant effects of the usage of e-agriculture on the socio-economic factors of the cereal crop farmers and their livelihood status. The model is described as follows:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + ... + b_{17}X_{17} + U \quad (5)$$

Where:

Y = Farmers' Livelihood Status Index (SID) (high, moderate and low);

$X_1 – X_{17}$ = Independent Variables;

X_1 = Age (years);

X_2 = Marital status (1 married, 0 otherwise);

X_3 = Educational level (years);

X_4 = Household size (number);

X_5 = Farming Experience (years);

X_6 = Farm size (hectares);

X_7 = Income Level (naira);

X_8 = Extension Contact (number);

X_9 = Cooperative Membership (years);

X_{10} = Access to Credit (naira);

X_{11} = Labour usage (in man-day);

X_{12} = Sources of e-agriculture information (number);

X_{13} = E-agriculture information on marketing (1 yes, 0 otherwise);

X_{14} = E-agriculture information on training (number);

X_{15} = E- agriculture information on weather (1 yes, 0 otherwise);

X_{16} = E-agriculture information on farming system (1 yes, 0 otherwise);

X_{17} = E-agriculture information on post-harvest technology (1 yes, 0 otherwise);

b_1 - b_{17} = Regression coefficients

a = Constant and

U = Error term

3.7 Hypotheses Testing

3.7.1 Hypothesis one (HO_1)

HO_1 was tested using z-values obtained from the logit regression as expressed in equation (4).

3.7.2 Hypothesis two (HO_2)

Pearson Product Moment Correlation (PPMC)

The Pearson product moment correlation shows the degree of association between any two given variables, it also measures the strength, direction and probability of the linear association between two interval or ratio variables (Jennifer, 2015). This is usually

represented by symbol “r” and can only be applied if the two sets of scores are at interval level, that is, if both sets of scores are continuous. The Pearson “r” in this study was calculated using the below formula:

$$r = \frac{n\sum xy - (\sum x)(\sum y)}{\sqrt{\{n\sum x^2 - (\sum x)^2\}\ \{n\sum y^2 - (\sum y)^2\}}} \quad (6)$$

Where:

‘r’ = Correlation coefficient (ranges of ‘r’ = -1 to +1), which represents positive (+) correlation and negative (-) correlation.

n = Number of observations

$\sum$ = Summation

X = Independent variables

Y = Dependent variable

Therefore, the null hypothesis two (HO_2) was tested using the above PPMC model.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This section contains findings of the study analysis and was reviewed in relation to the study's goals, which were the socioeconomic traits of respondents in the research area; the sources of e-agriculture information and the extent of their use.; livelihood status of the respondents; benefits derived by the respondents from e-agriculture information usage; factors that influence the usage of e-agriculture information; effects of e-agriculture information usage on the respondent's livelihood status; limits that the respondents encountered when using e-agriculture resources and information, as well as the study's hypotheses.

4.1 Social and economic traits of farmers who grow cereal crops

In this research, socio-economic parameters such age, gender, and marital status, education, household size, and farm size were examined. Extension contacts, participation in a cooperative, and access to financing are institutional characteristics that were taken into consideration in this study, among other things, primary occupation, secondary occupation, farming experience, and annual farm income.

4.1.1 Age of the respondents

Table 4.1 showed that respondents in Borno and Kebbi States had mean ages of 46 and 44 years, respectively. The average mean age in Borno State is higher than that of Kebbi State, implying that respondents in Kebbi State were in their more youth-full productive age as compared to the respondents in Borno State. The responders had a mean age of 45 years, according to the combined results. This result suggests that the farmers were at a productive peak in their life cycle and can easily accept e-agriculture information that can improve their

cereal crop productivity and enhance their livelihood status. This result is consistent with that of Bedi (2009), who found that agricultural activities and rural development and intervention program are targeted at both men and women in their youthful mid age.

4.1.2 Respondents' gender

As seen in Table 4.1, male respondents made up the vast majority in the states of Borno (91.13%) and Kebbi (97.95%). By implication Kebbi State had the highest proportion of males engaged in cereal crop farming compared to Borno State. The combined findings showed that males made up 94.00% of the respondents in the research area. This shows that males were more engaged in cereal crop farming than their female counterparts as the use of e-agriculture requires people that are more exposed to information widely. Men in the study area are more exposed to information than women, because they have no restriction to movement, they can travel places because they have more freedom of interaction compared to their female counterparts. This result is in line with that of Johanson (2011), who stated that men were anticipated to be exposed to knowledge on cereal crop farming and other enterprises more than women.

4.1.3 Respondents' marital status

As revealed in Table 4.1, 92.61% of the respondents in Borno State and 84.26% in Kebbi State were married. This suggests that the majority of farmers in the study area who grew cereal crops were married. The pooled result revealed that 88.50% of the respondents were married. This implies that cereal crop farming is mostly carried out by married people in the study area. This might be as a result of married people who were faced with the responsibilities of taking care of their households. This pushed them into more farming to enable them provide food and sustainable income to meet the needs of their families. This

result agrees with that of Omotayo (2015), who revealed that married men were more involved in both cereal crop farming and off-farm activities.

Table 4.1: Respondent distribution based on socioeconomic traits (n = 400)

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled result
Age (Years)			
≥ 20	0 (0.00)	3 (1.52)	3 (0.75)
21 – 40	81 (39.90)	84 (42.64)	165 (41.25)
41 – 60	96 (47.29)	85 (43.15)	181 (45.25)
>60	26 (12.81)	25 (12.69)	51 (12.75)
Mean	**46**	**44**	**45**
Sex			
Male	185 (91.13)	191 (96.95)	376 (94.00)
Female	18 (8.87)	6 (3.05)	24 (6.00)
Marital status			
Single	15 (7.39)	25 (12.69)	40 (10.00)
Married	188 (92.61)	166 (84.26)	354 (88.50)
Widower	0 (0.00)	2 (1.02)	2 (0.50)
Widow	0 (0.00)	1 (0.51)	1 (0.25)
Separated	0 (0.00)	1 (0.51)	1 (0.25)
Divorced	0 (0.00)	2 (1.01)	2 (0.50)
Educational status			
Primary	44 (21.67)	38 (19.29)	82 (20.50)
Secondary	66 (32.51)	66 (33.50)	132 (33.00)
Tertiary	69 (34.00)	65 (33.00)	134 (33.50)
No formal	24 (11.82)	28 (14.21)	52 (13.00)
Method of land acquisition*			
Inheritance	154 (75.86)	174 (88.32)	328 (82.00)
Leased	2 (0.99)	7 (3.55)	9 (2.25)
Communal	5 (2.46)	3 (1.52)	8 (2.00)
Rented	33 (16.26)	14 (7.11)	47 (11.75)
Purchased	60 (29.56)	30 (15.23)	90 (22.50)
Farm size (in hectare)			
< 5	166 (81.77)	175 (88.83)	340 (85.00)
5 – 10	26 (12.81)	15 (7.61)	41 (10.25)
11 – 15	8 (3.94)	3 (1.52)	11 (2.75)
>15	3 (1.48)	4 (2.04)	8 (2.00)
Mean	**4**	**3**	**4**
Household size			
< 5	34 (16.75)	27 (13.71)	43 (10.75)
5 – 10	87 (42.86)	91 (46.19)	123 (30.75)
11 – 15	47 (23.15)	48 (24.37)	60 (15.00)
> 15	35 (17.24)	31 (15.73)	174 (43.50)
Mean	**11**	**11**	**11**

Source: Field Survey Data, 2019

***Multiple Responses**

Figures in parentheses are percentages

4.1.4 Respondents' level of education

In addition, Table 4.1 showed 33.99% of respondents in Borno State had tertiary education, 32.51% had secondary education and 21.67% only received a primary education, 33.00% of the respondents in Kebbi State received tertiary education, 33.50% had secondary and 19.29% had primary education. This implies that both States were having similar values for education, as respondents from both States had revealed to have enjoyed different levels of education. The pooled findings indicated that respondents had some type of education, with 33.50% holding a tertiary degree. This finding implies that there were reasonable levels of literacy among the respondents as most of them had one form of education or the other. This also implies that farmers of cereal crops in the study area have basic education that can enable them embrace the use of e-agriculture, as education helps to expose individual to new knowledge and ideas which could in turn help facilitate their acceptance of new innovation particularly the application of e-agriculture in the growing of cereal crops. This finding disagrees with that of Aderinoye-Abdulwahab *et al*. (2015), who reported that few respondents had formal education, hence the population in their study had comparatively low educational levels. And few were less educated and were left with no choices to cope with their livelihoods.

4.1.5 Method of land acquisition

According to Table 4.1, 75.86% of the respondents in Borno State and 88.32% in Kebbi State acquired their farmlands through inheritance. This suggests that farmers in the research area will spend less on buying land, thereby reducing their cost of production. The pooled result indicated that 82.00% of the respondents obtained their farmlands through inheritance. Consequently, it can be inferred that the study area's cereal crop farmers inherited their

farmlands from their fore-fathers and this usually led to farm land fragmentation among members of farm family making land for production scarce. However, farmers expand their farm land by purchasing and renting extra land to add to their inherited farm lands. This result is consistent with Stefania's (2016) conclusion that the majority of households have access to more than one farming plot in her study area. Some of the households purchased their farm lands and a few small-holder farmers rented their farmlands.

4.1.6 Respondents' farm size

According to Table 4.1, Borno State had an average farm size of 4.2 hectares with 81.77% of the respondents' owning farms with less than 5 hectares of land. Similarly, in Kebbi State, 88.83% of respondents had farms that were less than 5 hectares in size, with a mean of 3.3 hectares. Kebbi State had the highest proportion of respondents with less than 5 hectares of farmland compared to Borno State. Meanwhile the pooled result revealed that, 85.50% of the respondents, with an average farm size of 4 hectares, had less than 5 hectares of farmland. This implies that the cereal crop farmers were not into large scale. More so, the cereal crop farmers were small scale farmers, as such they mostly produce for their households' consumption and sell off little to generate income for household expenses. This finding is consistent with the findings of Abayneh and Beneberu (2014), who found that most farmers in their research area operated on a modest scale and produced mostly for their own consumption. Most agrarian societies were peasants that are characterized by small fragmented land holdings. Additionally, Stefania (2016) found majority of homes in her research area possessed an average farm size of 4 hectares, which is in agreement with this conclusion.

4.1.7 Respondents' household size

Tables 4.1 showed that respondents in both Borno and Kebbi States had mean household sizes of 11 people. Meanwhile, going by the pool result cumulatively (58%) of the respondents revealed to have 11-15 and above 15 people in the house. This could imply that a typical household size of the rural farmers in the area of research is larger than 11 people. Respondents in both States were having relatively same number of people in their households, as indicated by the mean household sizes. By implication, the cereal crop farmers had large household sizes, which could be used as reservoir for family labour, hence, help to reduce the costs of farm operation. Thus, more efforts must be put into farming and cultivation of cereal crops to meet up with the needs of such household sizes. This finding agrees with that of Aderinoye-Abdulwahab *et al.* (2015) who revealed that few of the respondents in their study area were within household sizes of 8 people and above.

4.1.8 Farming experience of the respondents

The result as indicated in Table 4.1 revealed that the mean farming experience of the respondents in Borno and Kebbi States were 24 and 19 years, respectively. This finding revealed that respondents from Borno State had higher farming experience than respondents from Kebbi State. The pooled result showed that the mean farming experience was 21 years. As a result of this discovery, it may be inferred that the majority of farmers have extensive experience in cereal crop farming, thus, experienced cereal crop farmers are endowed with more knowledge and skills that can facilitate their usage of e-agriculture information. This outcome supports Fisher's (2015) assertion that agricultural stakeholders will be used in conjunction with the knowledge and expertise of a wide range of local farmers who have

years of experience farming cereal crops to help improve cereal seed production and to promote and deliver maize varieties and hybrids widely.

4.1.9 Labour usage by the respondents

Table 4.2 revealed that, 57.14% of respondents in Borno State and 41.12% of respondents in Kebbi State reported that they have used both family and hired labour. According to this research, respondents in Kebbi State had employed fewer hired and family labour than respondents in Borno State. According to the pooled result, 49.25% of the respondents employed both hired and family labour. This suggests that both family and hired labour were utilized by the farmers of cereal crop in the research station. By implication, the farmers who used family labour may have done so because they were unable to secure loans from banks, friends, or relatives to enable them to pay for additional labour on top of the family labour. This might hinder their ability to use e-agriculture information sources for producing cereal crops. This result supports that of Abayneh and Beneberu (2014), who discovered in their research a straightforward and effective microcredit distribution method that helped farmers get loans to expand and develop their farming and economic activities.

4.1.10 Respondents' primary occupation

According to Table 4.2, the vast majority (88.17%) of the respondents in Borno State had cereal crop farming as their primary occupation. Similar to this, growing of cereal crops was the primary occupation of 48.73% of respondents in Kebbi State. This infers that the participants in the research area derived their livelihoods from cereal crop cultivation, with more in Borno State as primarily cereal crop farmers than their Kebbi State counterparts. The pooled result showed that majority (68.75) were active respondents in the research area in cereal crop farming as their primary occupation, with a few (19.00%) of them engaged in

other forms of occupations such as crafting, trading, non-cereal farming, fishing, and livestock farming. While 12.25% of them reported other forms of occupations; such as carpentry, driving, trading in herbal medicine, iron bending, mechanic, tailoring among others. This finding is in line with that of Omotayo (2015), who revealed the different primary activities farmers were engaged in in their study location that women were more engaged in post-harvest activities and dry season irrigation farming, while men were involved in off-farm activities and take the lead in rainy season farming.

4.1.11 Secondary occupation of the respondents

According to Table 4.2's findings, 40.89% of the respondents in Borno State indicated cereal crop farming as their secondary occupation while 52.28% of the respondents in Kebbi State had revealed their secondary occupation as cereal crop farming. This implies that respondents in Kebbi State were more into cereal crop farming as a secondary occupation than their Borno State counterparts. The pooled result revealed that 46.50% of those surveyed in the research area indicated cereal crop farming as secondary occupation, 22.50% indicated trading, while 17.25% indicated non-cereal farming. This suggests that the respondents have at least one type of secondary occupation or the other that assist them to generate more income for improved livelihoods. This finding corroborates that of Sharma (2000), who revealed that farmers in his study region were involve in milk collection centres as their secondary job and in cooperatives to measure butter fat and other milking activities in order obtain extra income.

Table 4.2: Distribution of the respondents' socio-economic characteristics continued (n = 400)

Variables*	Borno State (n = 203)	Kebbi State (n = 197)	Pooled result
Farm experience (Years)			
< 10	29 (14.29)	70 (35.53)	99 (24.75)
10 – 20	74 (36.45)	65 (33.00)	139 (34.75)
21 – 30	59 (29.06)	29 (14.72)	88 (22.00)
>30	41 (20.20)	33 (16.75)	74 (18.50)
Mean	**23.5**	**18.6**	**21**
Types of Labour used			
Family	50 (24.63)	58 (29.44)	108 (27.00)
Hired	27 (13.30)	46 (23.35)	73 (18.25)
Communal	6 (2.96)	12 (6.09)	18 (4.50)
Both family and hired	116 (57.14)	81 (41.12)	197 (49.25)
Mixed	4 (1.97)	0 (0.00)	4 (1.00)
Primary occupation			
Cereal crop farming	179 (88.18)	96 (48.73)	275 (68.75)
Crafting	7 (3.45)	0 (0.00)	7 (1.75)
Trading	7 (3.45)	23 (11.67)	30 (7.50)
Non cereal crop farming	2 (0.99)	3 (1.52)	5 (1.25)
Fishing	1 (0.48)	4 (2.03)	5 (1.25)
Livestock farming	2 (0.99)	27 (13.71)	29 (7.25)
Others	5 (2.46)	44 (22.34)	49 (12.25)
Secondary occupation			
Cereal farming	83 (40.89)	103 (52.28)	186 (46.50)
Crafting	11 (5.42)	1 (0.51)	12 (3.00)
Trading	51 (25.12)	39 (19.80)	90 (22.50)
Non cereal crop farming	39 (19.21)	30 (15.23)	69 (17.25)
Fishing	2 (0.99)	3 (1.52)	5 (1.25)
Livestock farming	15 (7.39)	18 (9.14)	33 (8.25)
Others	2 (0.98)	3 (1.52)	5 (1.25)
Types of farming systems*			
Sole cropping	60 (29.56)	50 (25.38)	110 (27.50)
Mixed cropping	192 (94.58)	171 (86.80)	363 (90.75)
Mixed farming	81 (39.90)	55 (27.92)	136 (34.00)
Crop rotation	130 (64.04)	89 (45.18)	219 (54.75)
Shifting cultivation	10 (4.93)	17 (8.63)	27 (6.75)
Continuous cropping	101 (49.75)	70 (35.53)	171 (42.75)
Reasons for cereal cultivation			
Income generation	2 (0.99)	16 (8.12)	18 (4.50)
Household consumption	4 (1.97)	29 (14.72)	33 (8.25)
For both	197 (97.04)	152 (77.16)	349 (87.25)
Type of cereal crop grown*			
Maize	203 (100.00)	173 (87.82)	376 (94.00)
Rice	164 (80.79)	150 (76.14)	314 (78.50)
Sorghum	158 (77.83)	156 (79.19)	314 (78.50)
Millet	63 (31.03)	88 (44.67)	151 (37.75)
Wheat	0 (0.00)	10 (5.08)	10 (2.50)

Source: Field Survey Data, 2019
***Multiple Responses**
Figures in parentheses are percentages

4.1.12 Farming systems practiced by the respondents

The research's findings showed that the majority (94.58%) of respondents in Borno State practiced mixed cropping, while 64.01% practiced crop rotation. Similarly, majority (86.80%) of the respondents in Kebbi State practiced mixed cropping, while 45.18% practiced crop rotation. This finding showed that respondents in Borno State were more in to mixed cropping and crop rotation than those in Kebbi State. The pooled result indicated that majority (90.75%) of the respondents practiced mixed cropping and 54.75% practiced crop rotation (Table 4.2). By implication mixed cropping with legumes gives very good yields of crops which is why majority of respondents in Borno State and Kebbi State were reported to have practiced mixed cropping, as legumes help to fix nitrogen and other nutrients into the soil that can be utilized by other crops especially cereal crops. Also, few of the respondents in the research region engaged in crop rotation, which is also very beneficial to cereal crop productivity. This is because cereal crops are deep rooted crops that deplete soils nutrients easily, unlike legumes that fix nitrogen into the soil. Therefore, rotating these crops annually will help re-boost the depleted nutrients needed by the cereal crops to thrive well.

Similar to this, 42.75% of the respondents in the research area indicated that they had used a continuous cropping system, which may have been because there was not enough land available to use another cropping scheme. This result is consistent with that of Kostandini (2015), who claimed that additional assistance is needed to strengthen cereal crop farming and empower them to utilizing integrated systems for managing agriculture and livestock production, soil fertility, and natural resource base management system, such as the use of livestock and cotton in crop rotation and the use of cotton in crop rotation for its residual phosphorus and nitrogen from legumes in cereal crop farming.

4.1.13 Reason for cereal crop cultivation by the respondents

On the reasons for cereal crop farming as presented in Table 4.2, showed that larger number of respondents in both Borno (97.01%) and Kebbi (77.16%) States cultivated cereal crops for both income generation and household consumption. However, the respondents in Borno State were more into cultivation of cereal crops for both income and household consumption to their Kebbi State counterparts. The pooled result revealed that 87.25% of the respondents cultivated cereal crops for both income generation and household consumption. By implication most of the cereal crop farmers did not only cultivate cereal crops for household consumption, but also for income generation.

4.1.14 Types of cereal crops grown by the respondents

Result on the types of cereal crops grown by the farmers is presented in Table 4.2. lt showed that all the entire (100.00%) respondents in Borno State cultivated maize, majority (80.79%) of them cultivated rice, 77.83% of them cultivated sorghum and a few (31.03%) of them cultivated millet while non-have reported to have cultivated wheat. Similarly, the result in Kebbi State revealed that majority (87.82%) of the respondents cultivated maize, 76.14% of them cultivated rice, 79.19% of them cultivated sorghum, while 44.67% of them cultivated millet and just a few (5.08%) of them cultivated wheat. This result implies that cereal crop farmers in Borno State were more into maize farming as compared to their counterparts in Kebbi State. More so, both States are involved in different types of cereal crops farming except for Borno State where none of the respondents cultivated wheat. The pooled result indicated that 94.00% of the farmers in the research region cultivated maize. Inferring maize to be a staple food in the study area and it is widely grown by the farmers and generally accepted by the people in the society not only for food but also for industrial uses like

production of confectionaries such as cornflakes and custard. This finding substantiates that of IITA (2008) that found maize to be the most frequently cultivated agricultural crop in Sub-Saharan Africa (SSA).

Additionally, it agrees with FAOSTAT's (2015) assessment that Maize is the main food source for more than 300 million people in SSA for their subsistence. Majority (78.50%) of the respondents cultivated sorghum, while 37.75% cultivated millet. Sorghum and millet have cultural and traditional values attached to their usage. Most peasant people prefer sorghum for their traditional values as food and medicine. It is also used in brewery, for beer production, pap and confectionaries. Millet is less recognized by majority of the people in the society thus, the need for it is less, but still valued among the fulanis, Hausas and Kanuris in the area of study. These results are consistent with those of FAOSTAT (2015), which ranked sorghum as the second-most significant cereal after maize and millet. This information is also in line with that provided by Klapwijk *et al.* (2014), who found that the main use for sorghum and millet in Africa, particularly in the dry plains, is for food.

More so, 78.50% of the respondents cultivated rice. Rice is a golden food desired by many not only in the study area or the nation but all over the African continent. It is a staple food for many societies of the nations on earth and is widely cultivated. With the ban on importation of foreign rice into Nigeria, farmers have been pushed into expanding their rice farmlands in order to satisfy the nation's increasing rice consumption. This result is in line with the observations made by Boius *et al.* (2011), who said that rice has elevated to the status of a very strategic and imperative good for food security in Africa. In comparison to other important basic foods on the continent, its consumption is increasing more quickly. In line with this, Seck *et al.* (2013) disclosed that between 2007 and 2008, food crises made the

continent to continue relying on importation of rice and other goods to meet up with the increasing demand for rice. However, the ban in rice importation by the President Buhari's administration has helped to enhance the local production to meet up with the local demand for rice and other agricultural commodities particularly in the study area.

4.1.15 Contact with extension agents

The outcome in Table 4.3 displayed the distribution of respondents based on their contact with extension agents. It revealed that only 22.66% of the respondents in Borno State had interactions with extension agents, while more than half (54.82%) of the respondents in Kebbi State experienced interactions and visits with extension agents. This finding implies that respondents in Kebbi State had more contact with extension agents compared to their Borno State counterparts. The pooled result revealed that 38.25% of the cereal crop farmers had extension contact/visit. By implication extension agents were not readily available in the study area, which could be the reason why most of the farmers lacked contact with them. This could have adverse impact on the acceptance of e-agriculture information by the farmers. This finding corroborates that of NAERLS (2018) that the number of village extension agents for providing extension services to farmers, (VEAs) is woefully insufficient. On the average, extension-farmer ratio in the country stands at 1:5,000, as against the required 1:800 (NAERLS, 2018).

4.1.16 Farmers' cooperative membership

In Borno State, Table 4.3 showed that 33.50 percent of respondents were members of cooperative societies. Similarly, 43.65% in Kebbi State had cooperative membership. This implies that respondents in Kebbi State had more cooperative membership than their Borno State counterpart. The pooled result revealed that 38.25% of the respondents had cooperative

membership. Cooperative membership is very crucial when it comes to accessing new information about cereal crops farming, especially the use of e-agriculture. It is evident in this finding that majority of the cereal crop farmers were not members of cooperative societies. This could pose a risk to effective usage of e-agriculture facilities due to poor exposure to expert advice that will encourage them to use e-agriculture information in their farming activities. This finding substantiates that of Cargill (2018) who reported that to improve farmers' livelihood, there is need to instruct and assist thousands of smallholder farmers in the finest agricultural methods establish cooperative groups that will increase their potential as a group and strengthen their communities.

4.1.17 Access to credit by the respondents

As revealed in Table 4.3, 16.75% of the respondents in Borno State had access to credit facilities, in a similar vein, 25.38% of the respondents in Kebbi State had access to credit facilities. This implies that respondents in Kebbi State had more access to credit than those in Borno State, this could be due to their cooperative membership as respondents in Kebbi State had more cooperative membership than their counterparts in Borno State and this could facilitate their access to credit facilities. The pooled result showed that 21.00% of the respondents had access to credit facilities. This implies that only few of the farmers who grew cereal had access to lending facilities. This might be as the result of the farmers' inability to obtain loan from financial institutions and or other sources which may require collateral before giving to farmers and most of these rural farmers have no tangible means of collateral.

4.1.18 Types of credit accessed by the respondents

Table 4.3 showed the types of loans accessed by the research area's farmers who grow cereal crops. Very few (5.42%) and (15.76%) of the respondents in Borno State accessed formal and informal credits, respectively to finance their cereal crop farming. Similarly, few (16.75%) and (9.14) of the respondents in Kebbi State had access to formal and informal credits, respectively, in their cereal crop farming. This implies that respondents in Kebbi State had more access to formal credit than those of their counterpart in Borno State; likewise, respondents in Borno State had more access to informal credit than those of Kebbi State.

The pooled indicated that 12.50% of those surveyed in the research area had accessed informal credit and 11.00% of them had accessed formal credit. Consequently, it can be inferred that the majority of respondents in the study area lacked access to credit meant to boost their cereal crops productivity aside their personal savings (that is, money saved for farming). Meanwhile, most of the informal types of credit come without interest rate attached to it. Here, agreement may involve farmers produce in exchange for money payment, or little interest to the money borrowed during repayment. This result supports the conclusions of Wulandari *et al*. (2017), who revealed that maintaining the production of agricultural goods depends on having access to money. These findings imply that farmers' productivity will likely increase with access to capital for agricultural companies, leading to higher farm incomes.

4.1.19 Income from cereal crop farming by the respondents

The result on income of the respondents from cereal crop production as presented in Most (75.37%) of respondents in Borno State reported incomes of at least < ₦500,000 per annum, and 18.23% of them had income of between ₦500,000 and ₦1,000,000 while majority (93.91%) of the respondents in Kebbi State had income of < ₦500,000 per annum and 5.08% of them had between ₦500, 000 and ₦1,000,000 per annum. This finding implies that respondents in Borno State had more income as compared to respondents in Kebbi State. The pooled result unveiled a higher percentage of respondents (84.50%) reported having an income of < ₦500,000, and 11.75% of them had income between ₦500,000 and 1,000,000 per annum. It is evident that the cereal crop farmers had benefited from cereal crop farming in monetary term. Most of the respondent's sale off their grains when in need of money to take care of their household needs, while they also consume part of their cereal produce thus, contributed to the upliftment of their livelihood status. This result is in conflicts with that of Adam (2020) who claimed that farm income might be a profit or a loss realized through the operation of a farm or agricultural companies or a summary of income and expenses incurred during a particular accounting period.

Table 4.3: Distribution of the respondents based on institutional variables (n = 400)

Variables	Borno State (n = 203)	Kebbi State (n = 197)	Pooled result
Extension contacts			
Yes	46 (22.66)	108 (54.82)	154 (38.50)
No	157 (77.34)	89 (45.18)	246 (61.50)
Membership of coop.			
Yes	67 (33.00)	86 (43.65)	152 (38.00)
No	136 (67.00)	111 (56.35)	248 (62.00)
Access to credit			
Yes	34 (16.75)	50(25.38)	84(21.00)
No	169 (83.25)	147 (74.62)	316 (79.00)
Other sources of income			
Yes	138 (67.98)	131 (66.50)	269 (67.25)
No	65 (32.02)	66 (33.50)	131 (32.75)
Types of credit accessed			
Formal credit	11 (5.42)	33 (16.75)	44 (11.00)
Informal credit	32 (15.76)	18 (9.14)	50 (12.50)
No credit	160 (78.82)	146 (74.11)	306 (76.50)
Other income sources			
Livestock	10 (4.93)	6 (3.05)	36 (9.00)
Civil servant	39 (19.21)	46 (23.35)	85 (21.25)
Trader	52 (25.62)	62 (31.47)	114 (28.50)
Carpentry	9 (4.43)	1 (0.51)	10 (2.50)
Artisan	20 (9.85)	3 (1.52)	24 (6.00)
Income (₦) /annum			
<500,000	153 (75.37)	185 (93.91)	338 (84.50)
500,000 – 1,000,000	37 (18.23)	10 (5.07)	47 (11.75)
1,000,001 – 1,500,000	7 (3.45)	1 (0.51)	8 (2.00)
1,500,001 – 2,000,000	2 (0.98)	0 (0.00)	2 (0.50)
>2,000,000	4 (1.97)	1 (0.51)	5 (1.25)
Employment status			
Self-employed	121 (59.61)	81 (41.11)	202 (50.50)
Unemployed	38 (18.72)	48 (24.37)	86 (21.50)
Government employed	44 (21.67)	68 (34.52)	112 (28.00)

Source: Field Survey Data, 2019

Figures in parentheses are percentages

4.2 Sources of E-agriculture and their Extent of Usage by the Respondents

The variables discussed include; the respondents' access to usage of e-agriculture information, frequency of access to e-agriculture information sources, sources of e-agriculture information, extent of usage of e-agriculture information sources and respondents' access to e-agriculture information.

4.2.1 Access to e-agriculture information

According to Table 4.4, the majority of respondents in the states of Borno (90.64%) and Kebbi (86.80%) have access to e-agriculture information. The combined data showed that the vast majority (88.75%) of participants in the study had access to e-agriculture information. Given that the majority of them reported using e-agriculture to get information on agriculture, it is implied that Farmers in the study area had access to e-agriculture information for farming of their cereal crops. This outcome is in agreement with those of Alemu and Negash (2015), who claimed that availability of ICTs, including the internet and mobile devices had greatly grown since the establishment of e-agriculture.

Respondents' frequency of access to e-agriculture information revealed that majority (70.94%) of them in Borno State used e-agriculture information often, while only 37.56% of them in Kebbi State used e-agriculture information often. The result implies that more crop farmers in Borno State used e-agriculture information often than those in Kebbi State. The pooled result demonstrated that the majority (54.50%) of the farmers used e-agriculture information often. This finding implies that larger number of the respondents often use e-agriculture information in cereal crop production which could help increase their productivity and improve their livelihood status. The finding is in line with that of Zhifei *et al.* (2018), who define livelihood strategies as the actions and decisions made in order to

attain one's means of subsistence. These actions and decisions include production activities, investment strategies and the use of e-agriculture.

Table 4.4: **Distribution of respondents according to their ability to access information using e-agriculture**

Variables	Borno State (n=203)	Kebbi State (n =197)	Pooled result (n=400)
Access			
Yes	184 (90.64)	171 (86.80)	355 (88.75)
No	19 (9.36)	26 (13.20)	45 (11.25)
Frequency			
Not often	58 (28.57)	118 (59.90)	36 (9.00)
Often	144 (70.94)	74 (37.56)	218 (54.50)
Very often	1 (0.49)	5 (2.54)	6 (1.50)

Source: Field Survey Data, 2019
Figures in parentheses are percentages

4.2.2 Area in which respondents used e-agriculture

Table 4. 5 showed the result on the areas of e-agriculture usage by the people who responded to the study. Farmers in Borno State had unveiled to have used e-agriculture to get information on agricultural marketing with mean score (Ms) of 11.79, improved farming practices (Ms = 8.62), crop cultivation techniques (Ms = 7.95), post-harvest techniques (Ms = 7.21) and training on e-agriculture innovation (Ms = 4.35). Furthermore, respondents in Kebbi State had also used e-agriculture to obtain information on e-agriculture marketing (Ms = 2.53), improved farming practices (Ms = 1.93), crop cultivation techniques (Ms = 2.00), post-harvest techniques (Ms = 1.51) and training on e-agriculture innovation (Ms = 1.00). By implication, the findings from the two States showed that respondents in Borno State used more e-agriculture to obtain information for their cereal crops farming than their Kebbi State counterparts.

The pooled result revealed that respondents used e-agriculture to obtain information on agricultural marketing (Ms = 6.92), improved farming practices (Ms = 4.99), crop cultivation techniques (Ms = 4.73), post-harvest techniques (Ms = 4.11) and training on e-agriculture innovation (Ms = 2.26). This implies that cereal crop farmers used e-agriculture to source for different types of agricultural information in order to improve on their cereal crop production as well as processing and handling of their cereal crop produce after harvest. This finding substantiates that of Abdulkareem (2016), who found that e-agriculture promotes access to crucial information that can help farmers whose livelihoods depend on agriculture to make the best decisions that will promote agriculture and rural development also, making the most efficient and sustainable use of the resources available.

Table 4.5: Distribution of the respondents based on area of e-agriculture usage

Variables*	**Borno State (n=203)**		**Kebbi State (n=197)**		**Pooled result (n = 400)**		
	WS	Mean	WS	Mean	WS	Mean	Rank
Marketing information	2394	11.79	374	2.53	2768	6.92	1st
Improved farming	1750	8.62	247	1.93	1997	4.99	2nd
Crop cultivation technique	1614	7.95	276	2.00	1890	4.73	3rd
Post-harvest technique	1464	7.21	183	1.51	1647	4.11	4th
Training on agric. innovation	884	4.35	20	1.00	904	2.26	5th

Source: Field Survey Data, 2019
***Multiple responses and WS = Weighted sum**

4.2.3 Sources of e-agriculture information by the respondents

Table 4.6 presents the e-agriculture information sources used by the respondents in their cereal crops farming in the research area. The outcome showed that respondents in Borno State used mobile phone (95.07%), radio (92.12%), television (76.85%), other farmers/friends (80.30%), extension agents (30.51%) and internet broadband (7.39%). Similarly, respondents in Kebbi State revealed to have used mobile phone (88.83%), radio

(84.77%), television (50.25%), other farmers/friends (16.75%), extension agents (46.70%) and internet broadband (9.64%).

The result clearly showed that larger proportion of respondents in Borno States used more of television and other farmers/friends than their counterparts in Kebbi State. Meanwhile the respondents in Kebbi State had more contact with extension agents than those of Borno State. This is evident on Table 4.6 with larger number (46.70%) of the respondents in Kebbi State revealing that their sources of e-agriculture information is from their contact with the extension agents. The pooled result showed that respondents used mobile phone (92.00%), radio (88.50%), television (63.75%), other farmers/friends (49.00%), extension agents (38.50%) and internet broadband (8.50%). This implies that several e-agriculture information sources were utilized by farmers who grow cereal crops in the study area.

However, according to the respondents, radio and mobile phones were the most popular e-agriculture information sources. This finding supports the claims made by Alemu and Negash (2015), who noted a considerable growth the use of mobile devices as informational tools for e-agriculture, and creation of market connections for farmers and business owners. In keeping with Mahanan (2016) findings, radio is one of the key e-agricultural instruments that gives farmers a voice, aids in the growth of agriculture, and serves as a channel for distributing knowledge and information, particularly to the rural people.

Table 4.6: Distribution of the respondents based on sources of e-agriculture (n=400)

Sources of E-agriculture*	Borno State (n = 203)	Kebbi State (n=197)	Pooled result
Mobile phone	193 (95.07)	175 (88.83)	368 (92.00)
Radio	187 (92.12)	167 (84.77)	354 (88.50)
Television	156 (76.85)	99 (50.25)	255 (63.75)
Other farmers (friends)	163 (80.30)	33 (16.75)	196 (49.00)
Extension agents	62 (30.54)	92 (46.70)	154 (38.50)
Newspapers	71 (35.00)	62 (31.47)	133 (33.25)
Short message service	74 (36.45)	53 (26.90)	127 (31.75)
Social media	58 (28.57)	58 (29.44)	116 (29.00)
Satellite	53 (26.11)	27 (13.71)	80 (20.00)
Computer website	17 (8.37)	21 (10.66)	38 (9.50)
Internet broadband	15 (7.39)	19 (9.64)	34 (8.50)
Telephone	4 (1.97)	26 (13.20)	30 (7.50)
Palmtop	7 (3.45)	12 (6.09)	19 (4.75)

Source: Field Survey Data, 2019
***Multiple Response**
Figures in parentheses are percentages

4.2.4 Extent of usage of e-agriculture information sources by respondents

Table 4.7 results showed the respondents' perceptions and extent to which they used e-agriculture information sources in their farming of cereal crops. The result indicated that in Borno State, mobile phone ranked 1st, radio ranked 2nd, other farmers/friends ranked 3rd, television ranked 4th and smart phone/social media ranked 5th among the devices/tools used to obtain information for cereal crop farming. The ranking signifies the strength of the extent of which each of the devices was used. More so, respondents in Kebbi State had reported the use of mobile phone (ranked 1st), radio (ranked 2nd), extension agents (ranked 3rd), television (ranked 4th) and other farmers/friends (ranked 5th). By implication, the result from the two States showed differences in the tools/devices used in extent of usage. Extension agents were more utilized by the respondents in Kebbi State than in Borno State. On the other hand, farmers/friends were more utilized by respondents in Borno State than in Kebbi State.

The pooled result showed that mobile phone (Ms = 2.70) ranked 1st among usage by the research region respondents who responded. This indicates that mobile phone was highly in use by the cereal crop farmers, because it can be easily accessed by the farmers as compared to other e-agriculture information sources. This outcome supports that of Alemu and Negash (2015) who found that growth in mobile phones has been explosive. Also, the finding substantiates that of Bertolini (2009) who reported that farmers short messaging services (SMS), is one of the most significant e-agriculture apps, and are a type of mobile phone application. Radio (Ms = 2.64) ranked 2nd in the extent of usage of e-agriculture information source by the respondents. This implies that radio was also highly used by cereal crop farmers which could be due to its capacity of reaching larger number of farmers in different locations as news travel faster through radio. Thus, information about new farming practices is delivered to farmers in diverse languages that they could understand easily. This result is consistent with Chataira's (2014) research, which claimed that community radio has the ability to give farmers a voice by airing local language programs that respect their local culture, customs, and interests. This would facilitate communication within the agricultural community.

E-agriculture information from other farmers/friends (Ms = 2.12) about new farming practices have been found to boost agricultural productivity, this is evident from the study as it ranked 3rd. This implies that e-agriculture information from other farmers/friends was utilized within the research region. E-agriculture has gone beyond technology to combination of different culture, knowledge and skills from different stakeholders in agriculture from across the globes. This result has confirmed that fact, farmers can serve as transmission agents in delivery new innovation to other farmers who are less privileged to have first-hand

information. This finding substantiates that of FAO and ITU (2017) that the idea of "e-agriculture" today encompasses information and culture as well as technology. Television (Ms = 1.99) ranked 4th, implies that television was fairly in used among the cereal crop farmers, however, extension agents (Ms = 1.61) showed low extent of usage.

Table 4.7: Distribution of the respondents based on extent of usage of e-agriculture

E-agriculture information sources *	Borno State (n=203)				Kebbi State (n=197)				Pooled Result (n=400)			
	WS	WM	R	D	WS	WM	R	D	WS	WM	R	D
Mobile phone	567	2.79	1st	HU	514	2.60	1st	HU	1081	2.70	1st	HU
Radio	556	2.73	2nd	HU	500	2.53	2nd	HU	1056	2.64	2nd	HU
Farmers to farmers	544	2.67	3rd	HU	305	1.54	5th	FU	849	2.12	3rd	HU
Television	464	2.28	4th	HU	332	1.68	4th	FU	796	1.99	4th	HU
Extension agents	271	1.33	9th	FU	374	1.89	3rd	FU	645	1.61	5th	FU
Smart/social media	325	1.60	5th	FU	280	1.42	6th	FU	605	1.51	6th	FU
Newspapers	300	1.47	7th	FU	276	1.40	7th	FU	576	1.44	7th	FU
Short message service	319	1.57	6th	FU	254	1.28	8th	FU	573	1.43	8th	FU
Satellite	286	1.40	8th	FU	243	1.23	10th	FU	529	1.32	9th	FU
Internet broadband	236	1.16	10th	FU	227	1.15	12th	FU	463	1.16	10th	FU
Telephone	213	1.04	13th	FU	246	1.24	9th	FU	459	1.15	11th	FU
Computer/website	228	1.12	11th	FU	233	1.18	11th	FU	461	1.15	11th	FU
Palmtop PC	220	1.08	12th	FU	210	1.06	13th	FU	430	1.08	13th	FU

Source: Field Survey Data, 2019
***Multiple responses**
Note: •WS = Weighted Sum, WM = Weighted Mean, R = Rank and D = Decision
•HU = Highly used and FU = Fairly used

4.3 Livelihood Status of the Respondents

4.3.1 Respondents access to social assets/facilities in the study area

The result in Table 4.8 showed that respondents in Borno State had access to school (98.52%), village market (89.66%), GSM network (96.55%), hospital (93.10), radio (93.60%) and internet (48.28%). Similarly, respondents in Kebbi State had access to school (94.42%), village market (98.98%), GSM network (89.85%), hospital (88.83), radio

(89.34%) and internet (48.73%). By implication majority of the respondents in Borno State had access to more hospital/health care facilities as compared to their counterparts in Kebbi State, even though the overall number of respondents for this study is higher in Borno State than Kebbi State, it is still clear that the State enjoyed these facilities more. Meanwhile, the finding also indicated that 70.93% and 15.76% of the respondents in Borno State had more access to funeral aid group and pipe borne water, respectively. On the other hand, (39.09%) and (8.12%) of the respondents in Kebbi State had more access to funeral aid group and pipe borne water, respectively. Recreational centres were accessed more by the respondents (5.08%) in Kebbi State than the respondents (1.48%) in Borno State. The result is in line with that of Yan *et al*. (2009), who claimed social assets offer farmers external support and assistance while they are struggling to produce and survive, and that possessing various social assets has a favourable impact on how farm households allocate their assets for a living.

The pooled result showed that majority (96.50%) of the respondents had accessed schools and this ranked 1st as one of the social assets enjoyed by them. This implies that having formal education is very vital as it assists farmers in understanding what e-agriculture is in their production activities. This is evident as most of the respondents had indicated school as one of their social assets available in their locality. More so, 94.25% of them had access to market places ranked 2nd, implying that market is very vital to farmers as cereal crop produce move from the farm and or moves from home to markets for sales. Majority (93.25%) of the respondents accessed GSM network ranked 3rd, implying that communicating through mobile phones and internet was not a problem in the study area. Since GSM network was readily available therefore access to e-agriculture information sources by the cereal crop

farmers through mobile phones and smart phones were made easily accessible to the respondents. The discovering corroborates with FAO (2007) that providing GSM among the most important players, networks for the exchange of new procedures and methods in agriculture community is very relevant in digital information exchange and learning. Meanwhile, 91.50% of the respondents indicated access to hospital and this ranked 4th. It implies that social asset is one of the keys to wellbeing of farmers in the study area, because is difficult to enjoy life without the basic social facilities. More so, 91.00% had access to radio facilities, which came in fifth among the respondents.

Radio helps transmit information to the cereal crop farmers about their farm produce, market prices and other vital information they need for their farming activities. The result is in accordance to that of Charalampos (2013) who stated that the chance to expand mobile connection availability in offering information services to those involved in agriculture is phenomenal, since access to the appropriate information at the appropriate time aids in making educated judgments. However, all other social assets accessed by the respondents as mentioned in this study are very vital in making the cereal crop farmers' livelihood better off. This outcome supports that of Zhifei *et al*. (2018), who found that social assets are social resources that family households require in order to implement various livelihood strategies. Owning various social assets, in particular, has a favourable impact on how agricultural households divide up the resources necessary for their subsistence.

Table 4.8: Distribution of the respondents based on their access to social assets/facilities

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled Result (n=400)	Rank
School	200 (98.52)	186 (94.42)	386 (96.50)	1st
Village market	182 (89.66)	195 (98.98)	377 (94.25)	2nd
GSM network	196 (96.55)	177 (89.85)	373 (93.25)	3rd
Radio	190 (93.60)	176 (89.34)	366 (91.50)	4th
Hospital	189 (93.10)	175 (88.83)	364 (91.00)	5th
Relatives	169 (83.25)	187 (94.92)	356 (89.00)	6th
Urban market	172 (84.73)	181 (91.88)	353 (88.25)	7th
Motorable road	175 (86.21)	158 (80.20)	333 (83.25)	8th
Electricity	162 (79.80)	128 (64.97)	290 (72.50)	9th
Good medical service	181 (89.16)	104 (52.79)	285 (71.25)	10th
Transportation services	139 (68.47)	141 (71.57)	280 (70.00)	11th
Television	146 (71.92)	128 (64.97)	274 (68.50)	12th
Member of Political party	135 (66.50)	117 (59.39)	252 (63.00)	13th
Good road network	112 (55.17)	128 (64.97)	240 (60.00)	14th
Funeral group aid	144 (70.93)	77 (39.09)	221 (55.25)	15th
Health care facilities	92 (45.32)	121 (61.42)	213 (53.25)	16th
Internet	98 (48.28)	96 (48.73)	194 (48.50)	17th
Non-governmental organization	83 (40.89)	79 (40.10)	162 (40.50)	18th
Farmers organization	74 (36.45)	78 (39.39)	152 (38.00)	19th
Labour exchange group	80 (39.40)	68 (34.52)	148 (37.00)	20th
Village/town hall	62 (30.54)	64 (32.49)	126 (31.50)	21th
Non-farm cooperative	61 (30.05)	54 (27.41)	115 (28.75)	22th
Good toilet (water system)	38 (18.72)	35 (17.77)	73 (18.25)	23st
Library	37 (18.23)	30 (15.23)	67 (16.75)	24st
Pipe borne water	32 (15.76)	16 (8.12)	48 (12.00)	25rd
Recreational centers	3 (1.48)	10 (5.08)	13 (3.25)	26th

Source: Field Survey Data, 2019
***Multiple responses**
Figures in parentheses are percentages

4.3.2 Respondents types of financial/economic assets owned

Table 4.9 showed that respondents in Borno State had farm income (96.06%), available cash (60.09%), other occupations' earnings (67.98%) and liquid assets (71.92%) as financial/economic assets. Similarly, respondents in Kebbi State had revenue from a farm (98.98%), available cash (82.74%), other occupations' earnings (74.11%) and liquid assets (26.90%) as financial/economic assets. By implication this finding revealed that less

respondents in Borno State had cash at hand as compared to their counterparts in Kebbi State. Few respondents in Kebbi State had liquid assets as compared to the respondents in Borno State. More so, more respondents in Kebbi State were keeping their money in the bank as savings, while few of the respondents in Borno State had money in the bank as savings. When it comes to remittances, respondents in Kebbi State were found to have more remittances as compared to their counterparts in Borno State, and more of these financial assets were of privileges to respondents in Kebbi State as to respondents in Borno State.

The pooled result showed that larger number (97.50%) of the respondents' financial/economic assets were income from farm produce after sales (ranked 1st). This implies that the respondents cultivated cereal crops not only for house-hold consumption but also for income generation. This result agrees with that of Hao *et al*. (2010) who stated that majority of their respondents earned their income from farming. Similarly, 71.25% of the respondents indicated cash at hand which ranked 2nd as their financial/economic assets. This implies that the cereal crop farmers normally keep their money at home for their immediate cash need. Thus, home savings is mostly preferred by the farmers (as cash at home or at hand) than bank savings.

More so, 71.00% of the respondents indicated that their financial/economic assets were obtained through investment in non-agricultural jobs like carpentry, trading, fishing, mechanic, iron bender, civil servant ranked 3rd, which is an act of diversification. This finding corroborates that of Shi *et al.* (2014), who reported that having a diverse range of endeavours and resources could allow one to thrive and raise living standards of rural households. Furthermore, 49.75% of the respondents indicated liquid assets inform of unsold

agricultural produce, farm household assets, and other items ranked 4th as their financial/economic assets. They can be sold to generate money to meet household needs. Meanwhile, 4.25% of the respondents rely on grants and this ranked 10th as their financial/economic assets. Governments usually give out grants and other incentives/assistance like agricultural inputs to farmers to carry out their farming activities, such grants were normally non-repayable funds or inputs given to the farmers by the government, non-profit entity, e-educational institution, business or well to do individuals. This finding substantiates that of Zhifei *et al*. (2018) who found financial assets to be one significant aspect impacting farm households' decision to engage in livelihood strategies. Lastly, 3.00% of the respondents had Jewelleries as their assets to get financial help ranked 12th, this was to be part of the liquid assets, but because jewelleries are more precious and attracts better financial value, it was considered as a financial/economic asset on its own. Jewelleries can be kept with the money lenders in place of money collected to be returned to the owner after repayment of the money borrowed.

Table 4.9: Distribution of respondents' financial/economic assets owned in the study area

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled result (n=400)	Rank
Income from farm	195 (96.06)	195 (98.98)	390 (97.50)	1st
Cash at hand	122 (60.09)	163 (82.74)	285 (71.25)	2nd
Income from other jobs	138 (67.98)	146 (74.11)	284 (71.00)	3rd
Liquid assets	146 (71.92)	53 (26.90)	199 (49.75)	4th
Savings in bank	58 (28.57)	112 (56.85)	170 (42.50)	5th
Income from relatives	22 (10.84)	84 (42.64)	106 (26.50)	6th
Wages (salaries)	42 (20.69)	44 (22.34)	86 (21.50)	7th
Pension	12 (5.91)	26 (13.20)	38 (9.50)	8th
Remittances	4 (1.97)	28 (14.21)	32 (8.00)	9th
Grants	2 (0.99)	15 (7.61)	17 (4.25)	10th
Insurances	0 (0.00)	16 (8.12)	16 (4.00)	11th
Jewelleries	6 (2.96)	6 (3.04)	12 (3.00)	12th

Source: Field Survey Data, 2019
***Multiple Responses**
Figures in parentheses are percentages

4.3.3 Respondents access to natural assets

Table 4.10 shows the results, which indicated that respondents in Borno State had access to natural assets such as family farmland (86.21%), fire wood (75.37%), water bodies (62.56%) and community land (13.30%). In a similar vein, respondents in Kebbi State had access to the natural assets in their locality including family farmland (92.39%), fire wood (85.78%), water bodies (63.45%) and community land (28.93%). This finding implies that respondents in Kebbi State had more access to economic trees, waste assimilation and disposal (44.67%) and community farm land compared to their counterparts in Borno State. This is evident with few of the respondents in Borno State indicated to have access to these natural assets.

The pooled had it that majority (89.25%) of farmers in the study region had family farmland, ranked 1st as their natural assets, also 80.50% of the respondents indicated gathering of firewood ranked 2nd as their natural assets. This implies that gathering of fire wood is termed very essential by the cereal crop farmers in the study area, as the wood were naturally accessed from their localities. The farmers only need to cut the woods down dry and gather them for use as fuel in cooking their daily meals and 67.75% of the respondents indicated access to economy trees which ranked 3rd these include mango, guava, pawpaw and cashew as their natural assets. This implies that regardless of the fact that economic trees can be grown by an individual, some of them are found in the wild (bushes) and are termed non-timber products exploited by the farmers to use at home or sell-off at the market places. More so, 63.00% of the respondents had access to water bodies ranked 4th, which they revealed as their natural assets. Water is very essential commodity both for human consumption and plant growth. Water bodies like lakes, rivers, ponds, dams, reservoirs and wells are natural assets accessed by the communities for daily usage.

In a similar vein, 32.00% of the respondents accessed wastes disposals and hunting of wildlife ranked 6th as their natural assets respectively. This implies that hunting of wildlife animals was a hobby for some of the farmers as the wildlife animals are naturally found in the bushes as provided by nature. The farmer gets these wildlife animals only when they venture into hunting as only domestic animals are found in the community. Waste disposals like animal wastes are very important and essential sources of nutrients for plant growth and development, the respondents can access the waste naturally. Furthermore, 21.00% of the respondents had access to community land ranked 8th as their natural asset accessed. This finding implies that the cereal crop farmers were endowed with natural assets that helped make their lives easier though, settlements by our forefathers has brought about fragmentation (title) to lands which can only be acquired nowadays through inheritance or purchase. This finding corroborates the study by Zhifei *et al.* (2018), who found that rural farm households are more likely to have access to natural resources when they have more of those resources engage in agricultural and non-agricultural occupations. The study further pointed out that the most important natural asset for farm households is land.

Table 4.10: Distribution of respondents based on their access to natural assets in the study area

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled result (n=400)	Rank
Family farm land	175 (86.21)	182 (92.39)	357 (89.25)	1st
Gathering fire wood	153 (75.37)	169 (85.78)	322 (80.50)	2nd
Economic trees	119 (58.62)	152 (77.16)	271 (67.75)	3rd
Water bodies	127 (62.56)	125 (63.45)	252 (63.00)	4th
Gathering non-timber products	92 (45.32)	77 (39.09)	169 (42.25)	5th
Waste assimilation & disposal	40 (19.70)	88 (44.67)	128 (32.00)	6th
Hunting of wildlife	61 (30.05)	67 (34.01)	128 (32.00)	6th
Community land	27 (13.30)	57 (28.93)	84 (21.00)	8th

Source: Field Survey Data, 2019
***Multiple Responses**
Figures in parentheses are percentages

4.3.4 Farm production/physical assets owned by respondents

Table 4.11 showed that respondents in Borno State had indicated their farm production/physical assets as landed property (farms) (74.38%), draught animal(s) (25.62%), machete(s) (91.13%), rake(s) (88.18%), hoe(s) (97.04%), cutlass (es) (56.65%), sickle(s) (90.15%) and tractor (0.49%). While respondents in Kebbi State had reported to have owned the following farm production assets; landed property (farms) (40.10%), draught animal(s) (38.07%), machete(s) (47.72%), rake(s) (56.85%), hoe(s) (96.95%), cutlass(es) (71.07%), sickle(s) (88.32%) and tractor (1.02%). By implication respondents in Borno State used more of hoes as compared to their counterpart in Kebbi State while, respondents in Kebbi State have used more of machetes as compared to their counterparts in Borno State, also respondents in Kebbi State owned more of farm lands as compared to that of respondents in Borno State. More so, most of the respondents in Borno State used sickles in harvesting their cereal crops than their counterpart in Kebbi State. This implies that there are differences that exist between the two states when it comes to farm production physical assets and implements for farm operation as they have differences in soil texture.

The pooled result revealed that the cereal crop farmers had the following as their farm production/physical assets; landed properties (farms) (57.50%), draught animal(s) (31.75%), farm house(s) (13.00%) and water (well and borehole) (18.50%). These were owned by few of the cereal crop farmers as majority of them do not have some of these assets. The result also revealed that hoe(s) (97.00%), sickle(s) (89.25%), cutlass (es) (63.75%), machete(s) (69.75%), rake(s) (72.75%) and tractor (0.75%) were also part of the cereal crop farmers' farm production/ physical assets. Consequently, it can be inferred that the research area's respondents had some ownership of physical assets or farm production. This outcome agrees

with that of Liu *et al*. (2018), who discovered that agricultural household material assets constitute essential forms of infrastructure and means of production. They are the unavoidable precondition for agricultural output, and the more sophisticated tools for the industry that farm households own and how easily accessible the infrastructure is, the more inclined farm families are to choose agriculture as a livelihood.

Table 4.11: Distribution of the respondents' farm production/physical assets owned

Variables*	Borno State (n = 203)	Kebbi State (n = 197)	Pooled Result (n = 400)
Water (well & borehole)(s)	34 (16.75)	40 (20.30)	74 (18.50)
Landed property (farm)	151 (74.38)	79 (40.10)	230 (57.50)
Farm house(s)	20 (9.85)	32 (16.24)	52 (13.00)
Draught animal(s)	52 (25.62)	75 (38.07)	127 (31.75)
Tractor(s)	1 (0.49)	2 (1.02)	3 (0.75)
Irrigation gadget(s)	3 (1.48)	6 (3.05)	9 (2.24)
Machete(s)	185 (91.13)	94 (47.72)	279 (69.75)
Rake(s)	179 (88.18)	112 (56.85)	291 (72.75)
Hoes(s)	197 (97.04)	191 (96.95)	388 (97.00)
Shovel(s)	55 (27.09)	67 (34.01)	122 (30.50)
Watering can(s)	14 (6.89)	17 (8.63)	31 (7.75)
Spade(s)	36 (17.73)	29 (14.72)	65 (16.25)
Cutlass(es)	115 (56.65)	140 (71.07)	255 (63.75)
Sickle(s)	183 (90.15)	174 (88.32)	357 (89.25)

Source; Field Survey Data, 2019
***Multiple Response**
Figures in parentheses are percentages

4.3.5 Household/material assets owned by respondents in the study area

According to Table 4.12, farmers in Borno State owned the following as household/material assets, these include radio (90.15%), television (68.47%), residential house (72.41%), personally owned land (64.03%), furniture (71.92%) and handsets (89.16%). Likewise, the respondents in Kebbi State had revealed to own the same kind of assets. This includes the following; radio (80.20%), television (52.28%), residential house (56.85%), personally owned lands (36.55%), furniture (55.78%) and handsets (64.47%). It can be inferred from

this study that cereal farmers were not only owning other form of assets related to farm production and implements but also had household material assets as seen above and this were enjoyed by the respondents from both States. These household material assets may serve as collateral in terms of loans in financial institutions to boost their cereal crop productivity and also it will help them have a better livelihood while enjoying these facilities.

The pooled result revealed that the cereal crop farmers owned reasonable number of household material assets such as radio (85.25%), television (60.50%), residential house (64.75%), personally owned land (farms) (50.50%), furniture (62.00%), handsets (77.00%), computer (7.75%), shops (15.75%), cars (10.75%) and motor bike (37.00%). This finding implies that the cereal crop farmers had access and owned most of the basic household assets, this will enable them to have a good living standards/livelihood. Though, reasonable number of them do not own most of these household assets especially cars, tricycles, gas cookers, electric cookers and generators. This might be because of the remoteness of some of these villages and differences in their livelihood status which made it difficult for the farmers to access some of these valuables. This finding substantiates that of Zhao *et al*. (2011), they found showed farming households were more likely to choose options for their livelihood that involved agricultural production the more material assets they had.

Table 4.12: Distribution of respondents' household/material assets owned

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled Result (n=400)
Radio	183 (90.15)	158 (80.20)	341 (85.25)
Television	139 (68.47)	103 (52.28)	242 (60.50)
Computer	15 (7.39)	16 (8.12)	31 (7.75)
Car	20 (9.85)	23 (11.68)	43 (10.75)
Tricycle	12 (5.91)	1 (0.51)	13 (3.25)
Residential house	147 (72.41)	112 (56.85)	259 (64.75)
Shop/business(es)	41 (20.19)	22 (11.17)	63 (15.75)
Personally owned land	130 (64.03)	72 (36.55)	202 (50.50)
Refrigerator	54 (26.60)	25 (12.69)	79 (19.75)
Dinning sets	9 (4.43)	15 (7.61)	24 (6.00)
Charcoal stove	101 (49.75)	24 (12.18)	125 (31.25)
Kerosene stove	51 (25.12)	37 (18.78)	88 (22.00)
Fire wood cooker	135 (66.50)	140 (71.07)	275 (68.75)
Gas cooker	2 (0.98)	13 (6.59)	15 (3.75)
Electric cooker	9 (4.43)	2 (1.02)	11 (2.75)
Micro wave oven	1 (0.49)	3 (1.52)	4 (1.00)
Furniture (beds, cushions)	146 (71.92)	102 (55.78)	248 (62.00)
Wall clock	150 (73.89)	56 (28.43)	206 (51.50)
Fans	107 (52.71)	59 (29.95)	166 (41.50)
Motor bike	66 (32.51)	82 (41.62)	148 (37.00)
Bicycle	68 (33.50)	50 (25.38)	118 (29.50)
Handset/smartphone	181 (89.16)	127 (64.47)	308 (77.00)
Generator	52 (25.62)	62 (31.47)	114 (28.50)
House electronics	58 (28.57)	23 (11.68)	81 (20.25)

Source: Field Survey Data, 2019
***Multiple Response**
Figures in parentheses are percentages

4.3.6 Man power/human assets used by cereal farmers

Table 4.13 showed that respondents in Borno State had used people as man power/human assets in the following farming operation; land clearing (99.51%), seed bed preparation (96.06%), sowing (100.00%), weeding (100.00%), harvesting (100.00%) and processing (96.55%). Meanwhile, respondents in Kebbi State had revealed to have used human assets in their cereal crop farming operation in land clearing (98.48%), seedbed preparation (92.89%),

sowing (98.98%), weeding (96.95%), harvesting (98.98%) and processing (91.88%). This finding implies that the respondents from both States had enjoyed adequate labour using human assets in their cereal crop farming which helped boost their cereal crop productivity thereby enhances their livelihoods status.

The pooled result revealed cereal crop farmers to have used human assets as labour on their land clearing (99.00%), seed bed preparation (94.50%), sowing (99.50%), weeding (98.50%), fertilizer application (97.75%), harvesting (99.50%) and processing (94.25%). This implies that the cereal crop farmers do use adequate human /manpower assets as labour to achieve their productivity in cereal crop farming. This result is at contradicts that of Hao *et al.* (2010), who discovered that a lack of labour resources is the principal barriers preventing rural households from working in agriculture. It is also in agreement with the findings of Zhifei *et al.* (2018) who discovered that high-quality labourers typically choose non-agricultural activities while a relatively low-quality labour force tends to engage in agricultural production.

Table 4.13: Distribution of the respondents' man power/human assets used

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled Result (n=400)
Land clearing	202 (99.51)	194 (98.48)	396 (99.00)
Seed bed preparation	195 (96.06)	183 (92.89)	378 (94.50)
Sowing	203(100.00)	195 (98.98)	398 (99.50)
Weeding	203(100.00)	191 (96.95)	394 (98.50)
Thinning	113 (55.67)	128 (64.97)	241 (60.25)
Fertilizer application	203(100.00)	188 (95.43)	391 (97.75)
Harvesting	203(100.00)	195 (98.98)	398 (99.50)
Processing	196 (96.55)	181 (91.88)	377 (94.25)
Packaging	187 (92.12)	189 (95.94)	376 (94.00)

Source: Field Survey Data, 2019
***Multiple Response**
Figures in parentheses are percentages

4.3.7 Respondents' types of food consumed and how often they consumed them

Table 4.14 showed that 93.59%, 100.00% and 98.03% of the respondents in Borno State had consumed the following food items; poultry products (eggs and meat), vegetables and bananas respectively. Similarly, 88.32%, 96.95% and 72.58% of the respondents in Kebbi State had consumed poultry products (eggs and meat), vegetables and bananas. This finding implies that more of the respondents in Borno State consumes more of this food items as compared to the respondents in Kebbi State. The pooled result shows that majority (98.50%) of the respondents consumed vegetables and this ranked 1st, 91.00% of them consumed poultry products (eggs and meat) which ranked 2nd and 85.50% of them consumed bananas ranked 3rd. This finding implies that most of the cereal crop farmers had access to different types of food items. Consumption of different varieties of food are very necessary than consuming cereal crops alone which is not healthy to the body. These food items are necessary to balance the diet needed for proper functioning of the body systems. This finding is in agreement with that of Matt (2019) who found that farmers produce more and more different types of food, for their consumption.

The result on the frequency of consumption of this food items revealed that, 88.18% of the respondents in Borno State consumes this food daily, 81.28% of them consumes it twice a week, while 89.16% of them consumes it weekly and 81.28% of them consumes it monthly. Respondents in Kebbi State have also revealed the frequency of their consumption of this food items thus, 93.90% of them consumes it daily, 80.71% of them consumes it twice a week, 90.35% of them consumes it weekly and 71.06% of them consumes it monthly. By implication respondents from both States had equal consumption of almost all the food items indicated in Table 4.14.

The pooled result revealed that majority (91.00%) of the respondents consumed these foods daily and this ranked 1st, 81.00% of them consumed them twice a week which ranked 3rd, meanwhile 89.75% of the respondents consumed the food items weekly which ranked 2nd and 76.25% of the respondents consumed the food items once in a month (monthly) and this ranked 4th. This finding implies that most of the cereal crop farmers consumed the food items identified daily. The respondents could attain daily food consumption by selling some of their cereal produce, while few of the respondents that had other jobs aside cereal crop farming can easily afford these food items on a daily basis, and few of them cultivate these food items for their use. However, few of the respondents could not afford to consume the identified food items daily due to differences in income and livelihood status. This finding is consistent with Vermeulen *et al.* (2012), who reported that access to food required having the financial means to purchase it from markets. It also accords with Nord (2014), who reported that having insufficient food for consumption is a public health concern because it makes people more susceptible to a variety of physical, mental, and social health issues.

Table 4.14: Distribution of respondents' food types consumed & how often they consumed them

Variables*	Borno State (n=203)	Kebbi State (n=197)	Pooled result (n=400)	Rank
Food type consumed				
Vegetables	203 (100.00)	191 (96.95)	394 (98.50)	1st
Poultry products	190 (93.59)	174 (88.32)	364 (91.00)	2nd
Banana	199 (98.03)	143 (72.58)	342 (85.50)	3rd
Grape fruits	182 (89.66)	141 (71.57)	323 (80.75)	4th
Water melon	27 (13.30)	13 (6.59)	40 (10.00)	5th
Frequency of consumption				
Daily	179 (88.18)	185 (93.90)	364 (91.00)	1st
Weekly	181 (89.16)	178 (90.35)	359 (89.75)	2nd
Twice a week	165 (81.28)	159 (80.71)	324 (81.00)	3rd
Monthly	165 (81.28)	140 (71.06)	305 (76.25)	4th

Source: Field Survey Data, 2019
***Multiple Responses**
Figures in parentheses are percentages

4.3.8 Respondents livelihood status in the study area

Table 4.15 present the livelihood status of the respondents in Borno and Kebbi States and the pooled result in the study area. This was achieved using Simpson Index of Diversity where scores are between 0 - 1. Majority (89.66%) of the respondents in Borno State had moderate livelihood status, 5.91% of them had low livelihood status and only 4.43% of them had high livelihood status. Meanwhile larger number (80.71%) of the respondents in Kebbi State had moderate livelihood status, 6.60% of them had low livelihood status and 12.69% of them had high livelihood status. This finding implies that, respondents in both States had moderate livelihood status, furthermore, more of the respondents in Kebbi State had revealed to have high livelihood status as compared to their counterparts in Borno State.

The pooled result discloses that majority (85.25%) of the research area's respondents were found to have had moderate livelihood status, while 8.50% of them had high livelihood status and 6.25% of the respondents had low livelihood status. This outcome suggests that the vast majority of the cereal crop producers in the research area had a moderate level of livelihood, which corresponds to a decent standard of living. The producers of cereal crops were neither extremely poor nor extremely wealthy, but their revenue from farming cereal crops enables them to meet the demands of their households. This observation is consistent with Zhifei *et al* (2018) assertion that people must hold various forms of livelihood assets to obtain positive livelihood status.

Table 4:15: Distribution of the respondents' based on their livelihood's status

Livelihood status	Borno State (n=203)	Kebbi State (n=197)	Pooled result (n=400)
Low	12 (5.91)	13 (6.60)	25 (6.25)
Moderate	182 (89.66)	159 (80.71)	341 (85.25)
High	9 (4.43)	25 (12.69)	34 (8.50)

Source: Field Survey Data, 2019
Figures in parentheses are percentages
Note: ≤ 0.33 = Low, 0.34 – 0.65 = Medium and 0.66 – 1 = High

4.4 Benefits of E-agriculture Information Used by Respondents in the Study Area

4.4.1 Respondents benefits of the usage of e-agriculture information

Table 4.16 showed that respondents in Borno State had benefited from the use of e-agriculture information on the following; provides food security (Ms = 2.44), increased yield of crops (Ms = 2.40), increased income (Ms = 2.29), alleviate rural poverty (Ms = 2.31), increased knowledge of agricultural practices (Ms = 2.28) and uplifting farmers livelihoods (Ms = 2.25). While respondents in Kebbi State had benefited from the following; increased income (Ms = 2.53), provision of timely market information (Ms = 2.52), increased yield of crops (Ms = 2.49), increased knowledge of agricultural practices (Ms = 2.45), access to improved seed varieties (Ms = 2.42), timely warning on pest and disease (Ms = 2.40), provides food security (Ms = 2.37) and access to education and training (Ms = 2.37). This implies that respondents in Borno and Kebbi States had differences in benefits obtained, this could be on the account of differences in geographical region of both States and the taste of individual respondents in ascertaining their benefits. The results in both States have shown high benefits with almost all the variables with the exception of five (5) variables in Borno State which had low benefits and two (2) variables in Kebbi State which also had low benefits.

The pooled results revealed that among the advantages cereal crop producers got from using e-agriculture information, an increase in crop yields (Ms = 2.44) was ranked first. This suggests that producers of cereal crops used e-agriculture information to increase yields. Thus, as farmers yield increases, income rises, thereby improving their standard of living. This result supports a report by Moshe (2017) who found that using e-agriculture increases the number of cereal crops produced per acre and improves produce quality. Furthermore, among the advantages the farmers of cereal crops attained, higher income (Ms = 2.41) came in second place. This implies that the majority of respondents believed that using e-agriculture information in their growing of cereal crops had given them the necessary information to achieve a better standard of living.

Among the several advantages the farmers experienced, food security (Ms = 2.40) was ranked third. This result suggests that farmers of cereal crop benefited greatly from the use of e-agriculture since it aimed to increase agricultural productivity to attain greater food security and improve incomes. This result supports Mittal (2012) report, which claimed that making use of e-agriculture information will increase food security, support rural livelihoods, and also help to eliminate poverty. The outcome indicates that timely market information and marketing transparency (Ms = 2.38 and placed fourth), which suggests that farmers in the research area who grow cereal crops utilize e-agriculture to learn about how to market their agricultural products. Additionally, the majority of respondents (Ms = 2.37) placed fifth said they used e-agriculture material to learn more about farming. This outcome is in agreement with those of Narmilan (2017) who claimed that e-agriculture has the ability to provide widespread agricultural information availability that enhance decision-making and knowledge exchange.

Furthermore, nearly all the farmers in the survey area benefitted from the use of e-agriculture since it provides them with increase access to improved seed varieties (Ms = 2.33) ranked 6th. This finding corroborates that of Zahedi and Morteza (2012) who reported that the crop variety selection system of e-agriculture advices the users depending on the unique characteristics of the farm and the user's needs, users are informed about the best variety for farmers' plantations. Timely warning on pests and diseases attack of crop is also another information benefitted through the use of e-agriculture by the cereal crop farmers in the research area (Ms = 2.28) ranked 7th. This result is consistent with that published and found by Latha *et al*. (2014) who developed a method using e-agriculture to recognize plant leaf diseases and categorization. Following illness classification, the number of infected leaves is used to grade the severity of disease.

In addition, majority of this farmers had high benefits using e-agriculture information which enhances their productivity (Ms = 2.26) ranked 8th. This finding is in line with that of FAOSTAT (2015) who found e-agriculture and automation to trigger volumetric approach in water applications which in turn enables expansion of irrigation region, more food output in the affected area, as well as higher farm earnings. Also, the finding is substantiated by that of Mittal (2012) who reported that due to the development and adoption of mobile e-agriculture in rural dwellings, e-agriculture has increased productivity. When agricultural productivity is enhanced, agricultural growth will be achieved because it is through enhanced productivity that agricultural growth is attained. Most of the respondents indicated to have benefited from the use of e-agriculture information sources to achieved agricultural growth. This is evident (Ms = 2.21) ranked 10th among the high benefits of using e-agriculture information.

There were also high benefits of the usage of e-agriculture to provide access to education and training (Ms = 2.20) ranked 11th. This implies that with the help of e-agriculture cereal crop farmers had access to education and training on new agricultural practices especially in their cereal crop farming that helped increased their knowledge and skills which in turn boost their productivity. The finding supports the work of Mittal (2012) who reported that e-agriculture provide access to innovation using technological media that aids in training and education. Furthermore, high benefits of e-agriculture information usage provide access to post harvest information about cereal crop farming to the farmers (Ms = 2.18) ranked 12th. Postharvest information is mainly centered on information that will enable farmers gain access to good storage facilities and safer chemicals that will be used to preserve grains in storage. This kind of information is very vital to cereal farmers as some of their produces were sometimes reserved for sell during the off-season demand.

Similarly, e-agriculture information sources provide farmers with proper awareness and understanding about crop seeds, fertilizers, market prices of produce and other related information (Ms = 2.18) ranked 12th. Understanding the contents of every information shared is important, farmers might be aware of a particular practice but without proper understanding of what this new innovation is all about and how they work and the outcome from them, the farmer might likely not accept the practice or innovation. However, through e-agriculture tools and devices accessible to farmers can make the content of the information clearer possibly through demonstrations, pictures and posters. This finding is in agreement with that of Ali *et al. (*2012) who in their findings unveiled that image processing software helps detect maize leaf variety and also fertilizer system software helps gives fertilizer schedule that covers fertilizer types, fertilizer quality, fertilizer name and application time.

Large number of the cereal crop farmers have revealed that e-agriculture provides reduction in transaction costs (Ms = 2.07) ranked 14th. Transaction costs is sometimes associated with transportation to places where farmers can purchase inputs or sale off their produce. E-agriculture make it easier for farmers to enquire prices of inputs and produce instead of transporting themselves to the place which may incurred more costs. This finding depicts that of Mittal (2012) who found the use of e-agriculture in farming to have helped reduce transaction costs in tracking the consumer needs.

More so, e-agriculture help provide access to agriculture-related local and federal policies (Ms = 1.96) ranked 16th was considered low benefits by the cereal crop farmers. A system of legislation governing domestic agriculture and the importation of agricultural products from other countries is commonly referred to as an agricultural policy. Government agencies in agriculture are stakeholders and partner to farmers in the course of agricultural production, especially in crop production sub-sector. Federal government policies on agriculture industry may be significantly impacted by the national economy, international events, and trade initiatives influenced by e-agriculture information network among stakeholders of agriculture and rural development. This result is consistent with that of Xiaolan and Shaheen (2012) who claimed that e-agriculture plays a significant role in government policies since it aids farmers in receiving the information, they need to complete their work.

The respondents also claimed that access to natural resources in agriculture was only marginally improved by e-agricultural (Ms = 1.94, ranking 17th). The bulk of rural poor people lacked the land and other natural resources they would have required to expand their agricultural production, which hampered their ability to rely on agriculture and related activities for a living. Secured access to land makes it possible for greater agricultural

productivity and food security that brings about economic growth in the rural areas, increase family income and opportunities. Using e-agriculture by cereal farmers in the research region have brought about availability of land, reservoir and dam for irrigation and pumping machines to boost their cereal crop farming over the years.

Table 4.16: Distribution of respondents' according to benefits derived from the use of e-agriculture

Benefits	Borno State (n = 203)		Kebbi State (n = 197)		Pooled Result (n = 400)			
	WS	WM	WS	WM	WS	WM	R	D
Increased yield of crop	488	2.40	491	2.49	978	2.44	1st	H
Increased income	466	2.29	500	2.53	966	2.41	2nd	H
Provides food security	496	2.44	467	2.37	961	2.40	3rd	H
Timely market information	456	2.24	498	2.52	954	2.38	4th	H
Increased knowledge	464	2.28	484	2.45	948	2.37	5th	H
Access to improved seed var.	458	2.25	477	2.42	933	2.33	6th	H
Warning on pests &dis.	439	2.16	474	2.40	913	2.28	7th	H
Helps alleviate poverty	469	2.31	454	2.30	912	2.28	7th	H
Uplifting livelihoods	457	2.25	447	2.26	904	2.26	9th	H
Enhance productivity	451	2.22	455	2.30	905	2.26	9th	H
Empowers rural develop	451	2.22	461	2.34	905	2.26	9th	H
Adoption of new practices	423	2.08	467	2.37	890	2.22	12th	H
Achieves agricultural growth	444	2.18	450	2.28	886	2.21	13th	H
Increased development	422	2.07	461	2.34	883	2.20	14th	H
Access to education & tr	414	2.03	468	2.37	882	2.20	14th	H
Awareness of inputs	433	2.13	439	2.22	872	2.18	16th	H
Access to post-harvest Info	414	2.03	460	2.33	873	2.18	16th	H
Reduce transaction costs	400	1.97	428	2.17	828	2.07	18th	H
Business opportunities	418	2.05	440	2.23	836	2.09	19th	H
Access to farm inputs	395	1.94	414	2.10	809	2.02	20th	H
Access to policies on agric.	395	1.94	390	1.97	785	1.96	21st	L
Access to natural resources	388	1.91	390	1.97	778	1.94	22nd	L
Access to financial banking	360	1.77	409	2.07	769	1.92	23rd	L

Source: Field Survey Data, 2019

***Multiple responses**

Note: WS = Weighted sum, WM = Weighted mean, R = Rank, D = Decision, H = High and L = Low

4.5 Factors Influencing Use of E-agriculture Information by the Respondents

4.5.1 Factors influencing use of e-agriculture information

The findings of ordered probit regression estimate of the variables affecting how producers of cereal crop use e-agriculture information were shown in Table 4.17. With a pseudo R^2 value of 0.6401, the respondents' ordered Probit regression estimate in Borno State indicates that 64% of the variation in the dependent variables (Y = use of e-agriculture) can be accounted for by the independent variables ($X_1 – X_{12}$) in the model. The remaining (36%) of the variation can be explained by other variables outside this model. While the pseudo R^2 value **(**0.4713) of Kebbi State is lower compared to that of Borno State. This implies that there is 47% variation in the dependent variables (Y = use of e-agriculture) which is explained by the independent variables ($X_1……X_{12}$) included in the model. The remaining (53%) of the variation can be explained by other variables outside the model.

The finding from Borno State revealed that the coefficient of age (2.91) and use of e-agriculture in Kebbi State (2.34) were significant at 1% level of probability and had positive influence with the use of e-agriculture information. This implies that as respondents' advances in age their use of e-agriculture information will increase. The result the result of the coefficient of marital status (1.94) from Kebbi State indicated positive influence with e-agriculture usage and was significant at 5% probability level. This suggests that as respondents' marital status increases, so will their usage of e-agriculture information, implying that married persons are more likely to use this information in their cultivation of cereal crops.

Also, from Borno State, the results of household size (1.69) and educational level (2.10) had beneficial effects on the usage of e-agriculture and were significant at 5% and 10% levels of probability, respectively. E-agriculture usage by cereal farmers is therefore predicted to expand as these variables increase. The result of farming experience (2.78) from Borno State and (3.13) from Kebbi State had positive influence with the usage of e-agriculture and significant at a 1% level of likelihood. Implying that the more the cereal crop farmers acquire experience in cereal crop farming the more likely they are influenced to use e-agriculture information. The result of farm size (-1.99), extension contact (-1.76) and labour usage from Kebbi State were significant at 5%, 10% and 5% levels of probability respectively but had inverse influence on the usage of e-agriculture. This means that increasing these variables will reduce the respondents' likelihood of using e-agriculture information in their growing of cereal crops. Membership of cooperative (2.90) from Kebbi State was relevant at 1% level of likelihood with usage of e-agriculture information and had positive influence on the usage of e-agriculture. By implication, respondents' access to membership of cooperative society will influence their usage of e-agriculture information in their farming activities.

Meanwhile, the result from Borno State showed that extension contact (2.10) and income level (2.12) had positive influence with the use of e-agriculture information and relevant at 5% extent of likelihood. Inferentially, when respondents' extension contacts and income level increases their chances of using e-agriculture information also increase. This finding substantiates that of Wulandari *et al.* (2017) who discovered that availability to credit is necessary for maintaining agricultural productivity, increasing income, and enabling cereal crop farmers to use e-agriculture information to gain access to savings accounts, find reasonably priced insurances, and find tools to better manage risks in their farming

operations. The pooled result has pseudo R^2 0.4910 suggesting 49% differences of dependent data (Y = use of e-agriculture) can be explained by independent data (X_1……X_{12}) found in the model. Fifty one percent (51%) of the remaining data can be explained by other variables outside this model, this could be due to error in the estimation "the error terms". TheChi^2value is significant (Prob > Chi^2 = 0.0000) at 1%, 5% and 10% levels of probability. This indicated that the explanatory data contained in the model perfectly informed the dependent data. Log likelihood of this model is = -270.32195, which indicates that the model is fit. It was also used in the estimation of the likelihood ratio (LR) which is the Chi^2 (12) = 63.38 test of whether all predictors variables regression coefficients are simultaneously zero.

The pooled result revealed that age (2.34) had positive influence on the usage of e-agriculture information and is relevant at 5% likelihood levels. Inferentially, age is important in the usage of information sources gotten by e-agriculture, therefore, the older a farmer become the more their usage of e-agriculture. Farm size (-3.81), membership of cooperative (-4.38) and labour usage (-1.73) were relevant at 1%, 1%, and 10% likelihood levels but had inverse influence on the respondents' usage of e-agriculture information. Inferentially, a rise in any of these factors will result in fewer farmers in the research area using e-agriculture information. More so, extension contact (4.64) had positive influence on the use of e-agriculture and not relevant at a 1% level of likelihood. This suggests that improved access to extension contact by the respondents will increase their usage of e-agriculture information. This result supports that of Mwombe *et al*. (2014), who discovered age, gender, income and hectare of land of cereal crop planted to have influence on the extent of usage of e-agriculture tools as a source of agriculture information for smallholder cereal crop farmers.

Table 4.17: Ordered probit regression estimates of factors influencing the use of e-agriculture

Variables	Borno State (n = 203)			Kebbi State (n = 197)			Pooled Result (n = 400)		
	Coef.	Std. Err	Z-value	Coef.	Std. Err	Z-value	Coef.	Std. Err	Z-value
Age	0.0591	0.0203	2.91***	0.0352	0.0150	2.34***	0.0244	0.0108	2.26**
Gender	-0.1553	0.3062	-0.51	0.2817	0.5680	0.50	0.0743	0.2444	0.30
Marital status	-0.3073	0.4010	-0.77	0.3944	0.2033	1.94**	0.2324	0.1703	1.36
Educational level	0.0431	0.0206	2.10**	0.0261	0.0216	1.21	0.0054	0.0156	0.35
Household size	0.0424	0.0251	1.69*	-0.0069	0.0110	-0.62	-0.0112	0.0100	-1.12
Farming experience	0.0326	0.0117	2.78***	0.0375	0.0119	3.13***	0.0005	0.0073	0.07
Farm size	-0.0392	0.0340	-1.15	-0.0897	0.0451	-1.99**	-0.1581	0.0415	-3.81***
Extension contact	0.4489	0.2134	2.10**	-0.3750	0.2135	-1.76*	0.1826	0.0393	4.64***
Membership of cooperative	-1.0507	2.1307	-0.49	0.5710	0.1966	2.90***	-0.5934	0.1356	-4.38***
Access to credit facilities	2.7307	7.3507	0.37	-1.2107	2.1906	-0.06	5.7208	5.8907	0.10
Labour usage	-0.0274	0.0782	-0.35	-0.1723	0.0767	-2.25**	-0.0894	0.0517	-1.73*
Income level	0.4483	0.2117	2.12**	-1.8807	2.8807	-0.65	-9.4608	1.5707	-0.60
• LR Chi^2 (12) = 63.38									
• Log likelihood = -270.32195									
• Prob > Chi^2 = 0.0000*** and									
• Pseudo R^2 = 0.4910 (pooled)									

Source: Field Survey Data, 2019

Key: *: significant at 10%, **: significant at 5%, *: significant at 1%,**

4.5.2 Marginal effects of the factors influencing the use of e-agriculture information

Table 4.18 showed the marginal effects of the ordered probit regression estimates of the factors influencing the use of e-agriculture by the respondents in the study area. This refers to the degree/magnitude of change in the dependent variable as it is affected by the independent variables as shown by the coefficient of the regression. The result from Borno State revealed that the coefficient of age (0.0081) and household size (0.0424) were positive and had significant influence on the usage of e-agriculture at 10% level of probability. This implies that increase in age and household size will influence the respondents' usage of e-agriculture information by 0.81% and 4.24% respectively.

Meanwhile, the result of the coefficient of age (0.0352), farming experience (0.0375) and membership of cooperative (0.5710) from Kebbi State had positive influence on the use of e-agriculture and significant at 1% level of probability. This implies that increase in these variables will influence the usage of e-agriculture information at 3.52%, 3.75% and 57.10% respectively. While, the coefficient of marital status (0.3944) from Kebbi State showed positive influence with the usage of e-agriculture information and significant at 5% level of probability, implying that increase in marital status of the cereal crop farmers will influence their usage of e-agriculture information by 39.44%.

The coefficient of educational level (0.0168), extension contact (0.4489) and income level (0.1284) from Borno State had positive influence with the usage of e-agriculture and significant at 5% of probability. This implies that increase in these variables will increase the respondents' usage of e-agriculture information by 1.68%, 44.89% and 12.84% respectively. While, the result on farming experience (-0.0096) from Borno State had inverse influence with the use of e-agriculture information but significant at 1% level of probability. This

implies that increase in the cereal crop farmers farming experience will decrease their usage of e-agriculture information by -0.96%. The result of farm size (-0.0897) from Kebbi State and labour usage (-0.1723) had inverse influence with the use of e-agriculture but significant at 5% level of probability. This implies that increase in farm size and labour will decrease the cereal crop farmers' usage of e-agriculture by -8.97% and -17.23%, while, extension contact (-0.3750*) from Kebbi State had inverse influence with the use of e-agriculture but significant at 10% level of probability, implying that increase in extension contact by the cereal crop farmers in the study area will decrease their usage of e-agriculture information by -37.50%.

The pooled result revealed that the coefficient of age (0.0244) and extension contact (0.1826) had positive influence with the use of e-agriculture and significant at 5% and 1% levels of probability respectively. This finding implies that increase in age and extension contact will increase the cereal crop farmers' usage of e-agriculture by 2.44% and 18.26%. Meanwhile, the coefficient of farm size (-0.1581), membership of cooperative (-0.5934) and labour usage (-0.0894) had inverse influence with use of e-agriculture but significant at 1%, 1% and 10% levels of probability respectively. This implies that increase in these variables will decrease the cereal crop farmers' usage of e-agriculture by -15.81%, -59.34% and -8.94% respectively.

Table 4.18: Marginal effects of the ordered probit regression estimate of factors influencing the use of e-agriculture in the study area

Variables	Borno State (n=203) dy/dx	Kebbi State (n=197) dy/dx	Pooled Result (n=400) dy/dx
Age	0.0081*	0.0352***	0.0244**
Educational level	0.0168**		
Marital status		0.3944**	
Household size	0.0424*		
Farming experience	-0.0096***	0.0375***	
Farm size		-0.0897**	-0.1581***
Extension contact	0.4489**	-0.3750*	0.1826***
Membership of cooperative		0.5710***	-0.5934***
Labour usage		-0.1723**	-0.0894*
Income level	0.1284**		

Source: Field Survey Data, 2019

Key: *: significant at 10%, **: significant at 5%, *: significant at 1%**

4.6 Perceived Effectiveness of the Usage of E-agriculture Information Sources by Respondents in the Study Area

4.6.1 Respondents' perceived effectiveness of the usage of e-agriculture information sources

Table 4.19 showed that respondents in Borno State perceived the use of mobile phone (Ms = 2.88), radio (Ms = 2.73), other farmers (friends) (Ms = 2.67), television (Ms = 2.57), newspaper (Ms = 2.18), smartphone/social media (Ms = 2.13), short message services (SMS) (Ms = 2.07) and satellite (Ms = 2.02) as effective sources of e-agriculture information for their cereal crop farming. While, respondents from Kebbi State perceived the use of mobile phone (Ms = 2.85), radio (Ms = 2.75), other famers (friends) (Ms = 2.27), television (2.16), extension agents (Ms = 2.15) and smartphone/social media (Ms = 2.01) as effective e-agriculture information sources used by them in their cereal crop farming. Other sources indicated in Table 4.19 are not effective sources of e-agriculture information to the

respondents in both States. By implication, respondents from both States had perceived the same sources as effective in their cereal crop farming with the exception of few (newspaper, satellite and extension agents) which are not common to both States.

The pooled result revealed mobile phone (Ms = 2.87) ranked 1st in effectiveness of usage by the respondents, this implies that possession of mobile phone was an effective e-agriculture information sources used by the cereal crop farmers. This result concurs with that of FAO (2017), which found that networking, banking, and advisory sales are frequently conducted on mobile devices. In a similar vein, Alemu and Negash (2015) found that mobile phones helped farmers and business owners connect to markets, cut transaction costs, expanded trade networks, and facilitated job searches.

Radio (Ms = 2.74) ranked 2nd, implying that the use of radio as e-agriculture information sources was effective in delivering information to the cereal crop farmers. This could be due to the fact that the cereal crop farmers had easy access to radio where they get information faster about their cereal crop farming activities. This finding substantiates that of Mahanan (2016) who revealed that radio is an important mechanism for dissemination of knowledge and information in different languages, especially to the rural poor farmer. Other farmers (friends) (Ms = 2.48) ranked 3rd, implies that friends/other farmers are considered stakeholders with regards to e-agriculture information sources, this is because they get their agricultural information from other stakeholders with modern technologies that help facilitate the understanding of their cereal crop farming. This finding substantiates that of FAO and ITU (2017), who referred to e-agriculture as a concept that moves even beyond technology to the combination of knowledge and culture with primary focus on the

improvement of communication and the process of learning among different stakeholders of agricultural sector who are engaged at different levels.

Television (Ms = 2.37) ranked 4th, implying that usage of television was effective as indicated by the cereal crop farmers in the study area, which could be due to the fact that through television practical things are shown about cereal crop farming to farmers to learn and put into use. This result is consistent with that of Lohento *et al*. (2013), who claimed that e-agriculture utilized both cutting edge and more seasoned internet-based technology. Social media integration on a smart phone (Ms = 2.07), which was ranked fifth, demonstrated to farmers of cereal crops the effectiveness of e-agriculture. Farmers in the study area revealed to have gained experiences like spacing of their cereal crops from social media using smartphone. This finding is in line with that of FAO (2017), who reported that the overall aim of e-agriculture using internet is to enable farmers to exchange idea related to agriculture and to ensure that the knowledge created is effectively shared and used worldwide.

Also, extension service (Ms = 2.06) ranked 6th implies that, extension services proved to be effective e-agriculture information sources. This finding disagrees with that of NAERLS (2018) who reported that the number of village extension agents (VEAs) is grossly inadequate to deliver extension services to farmers. Internet/broadband (Ms = 1.74) ranked 10th, thus perceived not effective e-agriculture information sources by the respondents in the study area. Broadband connection can boost agricultural productivity because of high level of internet usage has spread. Internet applications requiring high transmission speeds have become an integral part of information in agriculture. Therefore, the cereal crop farmer's needs broadband connections to advertise their produce, because it helps access new market around the world that will enable them increase cereal crop production, particularly in the

study area. This finding agrees with that of FAO and ITU (2017), who posited that e-agriculture is aimed at the intersection of agricultural informatics, agricultural development and entrepreneurship, focusing on agricultural services, technology dissemination and information delivered through the internet.

Computer (Ms = 1.73) ranked 11th implies that computer was rarely in use by the cereal crop farmers as access to this device could be difficult to them, because most of the cereal crop farmers were not computer literate and lives in rural areas. However, those that had access to the use of computer revealed that it helped them gain access to market information and advertised their farm produce for sells online. This finding corroborates that of FAO (2017) who reported that computer is a device used in agricultural information and marketing. Telephone (Ms = 1.45) ranked 12th, implying that it is not effective e-agriculture information sources of the cereal crop farmers. Telephones were used for interactive voice response, but the use of mobile phone have outweighed the use of telephone in the study area, with very few respondents revealed effective usage of telephone. This finding disagrees with that of Bertolini (2009) who unveiled that most farmers in Africa solely utilize telephone as their primary form of e-agriculture. One of the most significant e-agriculture applications, according to some farmers, is mobile phone software like SMS.

Table 4.19: Distribution of respondents' perceived effectiveness of the usage of e-agriculture information sources on their livelihood status in the study area

Sources of e-agriculture information	Borno State (n=203)		Kebbi State (n=197)		Pooled Result (n=400)		R	D
	WS	WM	WS	WM	WS	WM		
Mobile Phone	586	2.88	563	2.85	1149	2.87	1st	E
Radio	556	2.73	543	2.75	1099	2.74	2nd	E
Other farmers/friends	543	2.67	449	2.27	992	2.48	3rd	E
Television	522	2.57	426	2.16	948	2.37	4th	E
Newspapers	443	2.18	387	1.96	830	2.07	5th	E
Smartphone/social md	433	2.13	396	2.01	829	2.07	5th	E
Extension Agents	400	1.97	425	2.15	825	2.06	7th	E
Short messages/SMS	422	2.07	383	1.97	805	2.01	8th	E
Satellite	411	2.02	378	1.91	789	1.97	9th	NE
Internet/Broadband	348	1.71	348	1.76	696	1.74	10th	NE
Computer/website	357	1.75	338	1.71	695	1.73	11th	NE
Palmtop PC	347	1.70	342	1.73	689	1.72	12th	NE
Telephone	249	1.22	331	1.68	580	1.45	13th	NE

Source: Field Survey Data, 2019

Note: WS = Weighted Sum, WM = Weighted Mean, R = Rank, D = Decision, E = Effective and NE = Not effective

4.7 Effects of E-agriculture Information Usage on the Livelihood Status of the Respondents

4.7.1 Effects of e-agriculture information usage on respondents' livelihood status

Table 4.20 revealed that the ordered regression estimate on the effects of e-agriculture on the livelihood's status of cereal crop farmers in Borno State has a pseudo R^2 value of = 0.5051, meaning that the independent variables ($X_1 – X_{17}$) in the model account for 50% of the variation in the dependent variables (Y = farmers' livelihood Status index). Other variables not taken into account by this model can account for the remaining (50%) of the variation. Although respondents in Kebbi State had higher pseudo R^2 values than respondents in Borno State (both of which were 0.6338), this indicates that 63% of the variation in the dependent variables (Y = farmers' livelihood Status index) is explained by the independent variables

(X_1 X_{17}) included in the model. Other variables not included in this model can account for the remaining variation (37%) in the data.

The result for Borno State revealed that the coefficient of age (3.62), educational level (3.13), extension contact (4.11) and e-agriculture information on farming system (3.52) were significant and had positive effect on the respondents' livelihood status at 1% level of probability respectively. Similarly, result for Kebbi State revealed that farm size (4.37), extension contact (3.72), sources of e-agriculture information (3.73), access to e-agriculture training (3.32), and e-agriculture information on farming system (3.32) were significant and had positive effect on the respondents' livelihood status at 1% level of probability respectively. This implies that, increase in access to these variables will increase the usage of e-agriculture information by the respondents thereby improving their livelihood status.

The coefficient of household size (-1.72) for Borno State is significant at 10% level of probability but has an inverse effect on the respondents' livelihood status. This implies that increase in household size will decrease the usage of e-agriculture information thereby reducing the livelihood status of the cereal crop farmers. The coefficient of access to e-agriculture information on marketing (1.98) was significant and had positive effect on the respondents' livelihood status in Borno State at 10% level of probability. This implies that the more the cereal crop farmers access information on marketing using e-agriculture the more likely their usage of e-agriculture information on farming which could have positive influence on their livelihood status and enhance their living standard.

The result for Kebbi State showed that access to credit (2.21) and access to e-agriculture information on marketing (2.06) were statistically significant and had positive effect on the respondents' livelihood status at 5% level of probability respectively. This implies that, the more the cereal crop farmers' access credit facilities and information on marketing using e-agriculture the more likely their usage of eagriculture information on farming which could have positive influence on their livelihood status and enhances their living standard. E-agriculture information on post-harvest technology (-1.83) in Kebbi State was significant but had an inverse effect on the respondents' livelihood status at 10% levels of probability. That is to say, a rise in the use of e-agriculture information on this variable will imply a decline in the standard of living for farmers of cereal crops in the research area.

The combined result has a pseudo R2 value of = 0.4210, indicating that the independent variables in the model ($X_1 – X_{17}$) account for 42% of the variation in the dependent variables (Y = farmers' livelihood Status index). Other variables outside the scope of this model can explain the remainder (58%) of the variation, this could be due to error in the estimation "the error terms". TheChi^2value is significant (Prob > Chi^2 = 0.0000) at 1%, 5% and 10% level of probability. This proves that the model's explanatory factors effectively explained the dependent variables. It was also used to calculate the likelihood ratio (LR), which is the Chi2 (17) = 174.77 test of whether all predictor variables regression coefficients are concurrently zero. The log likelihood of this model is = -120.16213, indicating that the model is fit.

The findings indicated that, at a 1% level of probability, the coefficient of age (3.28) was significant and had a positive effect on the respondents' level of livelihood. This suggests that when respondents' ages increase, they would utilize e-agriculture information tools more frequently, which will improve the livelihood situation for farmers of cereal crops. At a 1%

level of probability, access to training (2.85) was significant and had a positive effect on the respondents' livelihood status. This suggests that the more cereal crop farmers have access to e-agriculture training, the more probable it is that they will use the information available to them, which could improve their ability to make a living. This result conflicts with that of Zhifei *et al.* (2018), who found that access to training had a negative and significant effect on the livelihood strategies chosen by farm households.

Marital status (-1.66) and household size (-1.90) were significant but with inverse effect with the respondents' livelihood status at 10% level of probability. By implication, having more married farmers and larger household size will decrease the use of e-agriculture information and thereby reducing the cereal crop farmers' livelihood status. Meanwhile, e-agriculture information on weather (1.79) was significant and had positive effect on the respondents' livelihood status at 10% level of probability. This implies that the more the respondents access information on weather, the more their usage of e-agriculture and thereby enhancing their livelihood status.

The coefficient of educational level (2.09), access to credit (2.27) and e-agriculture information on marketing (2.70) were significant and had positive effects on the respondents' livelihood status at 5% level of probability. This finding implies that the more the respondents' educational status increases, the more they access credit and the more they access information on marketing using e-agriculture information sources, the more their livelihood status increases. Farm size (4.20), extension contact (6.00), sources of e-agriculture information (2.56) and e-agriculture information on farming system (4.12) were significant and had positive effect on the respondents' livelihood status on a 1% level of probability. By increasing these variables, it is implied that cereal crop producers will use e-

agriculture more frequently, improving their ability to support themselves in the research area. This result supports that of Liu et al. (2018), who discovered that financial resources and human capital significantly influenced how farm households chose their mode of subsistence.

Table 4. 20: Ordered probit regression estimates of the effects of e-agriculture usage on respondents' livelihood status

Variables	Borno State (n = 203)			Kebbi State (n = 197)			Pooled Result (n = 400)		
	Coef.	Std. Er	Z-value	Coef.	Std. Er	Z-value	Coef.	Std. Er	Z-value
Age	0.1732	0.0479	3.62***	0.0609	0.0637	0.96	0.0931	0.0284	3.28***
Marital status	-0.9513	1.0192	-0.93	-1.3954	0.9487	-1.47	-0.8606	0.5199	-1.66*
Educational level	0.2808	0.0897	3.13***	-0.0302	0.0575	-0.52	0.0747	0.0358	2.09**
Household size	-0.3328	0.1931	-1.72*	-0.1693	0.2351	-0.72	-0.2238	0.1179	-1.90*
Farming experience	-0.0015	0.0385	-0.04	0.0201	0.0319	0.63	-0.0006	0.0213	-0.03
Farm size	0.1460	0.1106	1.32	1.2157	0.2779	4.37***	0.3311	0.0789	4.20***
Income level	5.3107	8.0607	0.66	6.5607	5.4907	1.19	-3.6807	3.8907	-0.95
Extension contact	0.3919	0.0954	4.11***	0.3457	0.0929	3.72***	0.3222	0.0537	6.00***
Membership of cooperative	-0.0216	0.0596	-0.36	-0.0300	0.0758	-0.40	-0.0179	0.0341	-0.53
Access to credit	1.8706	1.4406	1.30	0.0000	4.7306	2.21**	2.2906	1.0106	2.27**
Labour usage	0.5079	0.8905	0.57	0.0954	0.6629	0.14	0.4382	0.4227	1.04
Sources of e-agriculture	-0.2051	0.1632	-1.26	0.6678	0.1789	3.73***	0.2127	0.0830	2.56***
E-agric.info on marketing	1.5928	0.8053	1.98*	2.0632	1.0021	2.06**	1.3481	0.4998	2.70**
Access to training	0.5728	0.7479	0.77	2.8785	0.8569	3.32***	1.1341	0.3982	2.85***
E-agric.info on weather	0.9595	0.6939	1.38	0.7404	0.8405	0.88	0.7701	0.4304	1.79*
E-agriculture info on farming	3.4067	0.9681	3.52***	3.7282	1.1242	3.32***	2.3708	0.5759	4.12***
E-agric. in on post harvest tec	-0.6111	0.7629	-0.80	-2.1691	1.1842	-1.83*	-0.4798	0.4915	-0.98
• LR Chi^2 (17) = 82.69***									
• Prob > Chi^2 = 0.0000									
• Log likelihood = -40.513097									
Pseudo = R^2 = 0.5051 (Pooled)									

Source: Field Survey Data, 2019.

Key: *: significant at 10%, **: significant at 5% and *: significant at 1%**

4.7.2 Marginal effects of e-agriculture information usage on respondents' livelihood status

Table 4.21 showed the marginal effects of the effect of e-agriculture usage on the respondents' livelihood status, which refers to the degree/magnitude of change in the dependent variable as it is affected by the independent variables as shown by the coefficient of the regression. The result in Borno State revealed the coefficients of age (-0.0004), (-0.0001), and (0.0005), educational level (-0.0006), (-0.0002) and (0.0008), household size (0.0008), (0.0002) and (0.0009) among respondents with low, moderate and high livelihood status to have positive effect on the respondents livelihood status since e-agriculture information is used, it follows that an increase in these variables in proportion to their coefficients will improve the respondents' standard of living in the research area. Contrary to that from Kebbi State which showed no positive effect with the usage of e-agriculture on the respondents' livelihood status.

Meanwhile, results of extension contact (-0.0009) low, (-0.0003) moderate and (0.0012) high from Borno State and Kebbi State (-0.0003) low, (-0.0005) moderate and (0.0009) high, e-agriculture information on marketing (-0.0060) low, (0.0025) moderate and (0.0056) high from Borno State and from Kebbi State (-0.0041) low, (-0.0004) moderate and (0.0037) high and e-agriculture information on farming system from Borno State (-0.0366) low, (0.0315) moderate and (0.0051) high and from Kebbi State (-0.0160) low, (0.0099) moderate and (0.0061) high livelihood status of the respondents had positive effect on the respondents livelihood status with the usage of e-agriculture information, this implies that, increase in this variables in proportion to their coefficient will increase the livelihood status of the cereal crop farmers in the study area.

Other variables from Kebbi State (farm size -0.0012 low, -0.0019 moderate, and 0.0031 high), (access to credit -1.0408 low -1.6208 moderate and 2.6608 high), (sources of e-agriculture -0.0007 low, -0.0010 moderate and 0.0017 high), (access to e-agriculture training 0.0041low, 0.0054 moderate and -0.0096 high) and (e-agriculture information on post-harvest technology 0.0015 low, 0.0099 moderate and -0.0114 high) had positive effects with the usage of e-agriculture information on the respondents livelihood status. This implies that increase in these variables will result in rise in the respondents' usage of e-agriculture and an improvement in their standard of living.

The pooled result of the low livelihood status revealed that coefficient of age (-0.0006), farm size (-0.0022) and e-agriculture information on farming system (-0.0391) were significant but had negative effects on livelihood status of the cereal crop farmers at 5% level of probability. This finding implies that an increase in age and farm size will decrease the cereal crop farmers' usage of e-agriculture information and thereby reduces their livelihood status by -0.6% and 0.22%. Meanwhile, as they access more information on farming system using e-agriculture their livelihood status will reduce by -3.91. This finding is in line with that of Liu *et al*. (2018), who noted that farm household livelihood status values within their study area were generally low, indicating low-level living standards and limited livelihood asset resource. Educational level (-0.0085) and e-agriculture information sources (-0.0014) were significant but had negative effect on the livelihood status of the respondent at 10% level of probability. This implies that an increase in the cereal crop farmers' educational status will reduce their livelihood status by -0.85. More so, as they access more information on their cereal crop farming using e-agriculture information sources it will reduce their livelihood status by -0.14%.

While access to e-agriculture training (0.0076) had positive effect on the respondents' livelihood status and significant at 10% level of probability. This implies that, when the cereal crop farmers with low livelihood status accesses more training on e-agriculture related activities it will increase their usage of e-agriculture information which will in turn enhance their livelihood status by 0.76%. However, the results on extension contact (-0.0022) showed negative effect on the respondents' livelihood status and is significant at 1% level of probability. Inferentially, a 0.22 percent decline in the farmers' ability to make a living from their cereal crops will result from increased access to extension contacts. This result is consistent with that of Hua (2014), who observed that a farm household's decision regarding its livelihood strategy is influenced by changes in the amount and structure of its livelihood status. In other words, changes in livelihood assets determine changes in livelihood status. The result on farm size (-0.0022) and extension contacts (-0.0056) among respondents with moderate livelihood status had negative effect on the respondents' livelihood status but significant at 10% levels of probability respectively. This implies that increase in farm sizes and extension contact will reduce the cereal crop farmers' livelihood status by -0.22% and -0.56% respectively.

Furthermore, age (0.0012), sources of e-agriculture information (0.0029), e-agriculture information on marketing (0.0139) and e-agriculture information on farming system (0.0198) among respondents with high livelihood status were significant and had positive effect on the cereal crop farmers' livelihood status at 5% levels of probability respectively. By implication, increase in the age of the respondents will increase their usage of e-agriculture information and enhance their livelihood status by 0.12%. Meanwhile, increase in access to sources of e-agriculture information, e-agriculture information on marketing and

e-agriculture information on farming system among respondents with high livelihood status will increase their livelihood status by 0.029%, 1.39 and 1.98% respectively. Meanwhile, access to e-agriculture training (-0.0152) had negative effect on the respondents' livelihood status but significant at 5% level of probability, implying that an increase in access to e-agriculture training will reduce the livelihood status of cereal crop farmers by -1.52%. Educational level (0.0010), access to credit (3.0708) and e-agriculture information on weather (0.0097) were significant and had positive effect on the cereal crop farmers' livelihood status at 10% levels of probability. This implies that an increase in each of these variables will increase the livelihood status among the cereal crop farmer with high livelihood status by 0.1, 307.08% and 0.97% respectively. Household size (-0.0030) was significant but had negative effect on the respondents' livelihood status at 10% level probability. This implies that as household size increases, the use of e-agriculture information decreases, thereby reducing the livelihood status of the respondents by -0.30%.

At a 1% level of probability, the farm size (0.0044) and extension contact (0.0043) variables were significant had positive effects with the livelihood of cereal crop farmers. This implies that a rise in these variables will increase the use of e-agriculture information by farmers of cereal crops, raising the standard of living of farmers with high livelihood status by 0.44% and 0.43% respectively. The study supports the findings of Liu *et al.* (2018), who found that the adoption of livelihood strategies is significantly influenced by the livelihood situation of farm households. The results concur with those of Zhifei *et al.* (2018), who claimed that personnel assets significantly influenced the choice of livelihood strategy for farm households.

Tables 4.21: Marginal effects of the ordered probit estimate on the effect of e-agriculture usage on respondents' livelihood status

	Dy/Dx								
	Borno State (n = 203)			Kebbi State (n = 197)			Pooled result (n = 400)		
Variables	**L (0)**	**M (1)**	**H (2)**	**L (0)**	**M (1)**	**H (2)**	**L (0)**	**M (1)**	**H (2)**
Age	-0.0004	-0.0001	0.0005				-0.0006**	-0.0006	0.0012**
Educational level	-0.0006	-0.0002	0.0008				-0.0005*	-0.0005	0.0010*
Household size	0.0008	0.0002	-0.0009				0.0015	0.0015	-0.0030*
Farm size				-0.0012	-0.0019	0.0031	-0.0022**	-0.0022*	0.0044***
Extension contacts	-0.0009	-0.0003	0.0012	-0.0003	-0.0005	0.0009	-0.0022***	-0.0021*	0.0043***
Access to credit				-1.0408	-1.6208	2.6608	-1.5508	-1.5208	3.0708*
Sources of e-agriculture				-0.0007	-0.0010	0.0017	-0.0014*	-0.0014	0.0029**
E-agric. info on marketing	-0.0060	0.0025	0.0056	-0.0041	-0.0004	0.0037	-0.0137	-0.0002	0.0139**
Access to e-agric. training				0.0041	0.0054	-0.0096	0.0076*	0.0075	-0.0152**
E-agric. info on weather							-0.0058	-0.0039	0.0097*
E-agric. info on farm system	-0.0366	0.0315	0.0051	-0.0160	0.0099	0.0061	-0.0391**	0.0192	0.0198**
E-agric. info on post-harvest tech				0.0015	0.0099	-0.0114			

Source: Field survey data, 2019.

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

Key: Low (0) = low livelihood status, Moderate (1) = moderate livelihood status and High (2) = high livelihood status

4.8 Perceived Severity of Constraints faced by the Respondents in the Study Area

4.8.1 Perception of the severity of the constraints faced by the cereal crop farmers

Table 4.22 showed that constraints that are severe as identified by the respondents had a weighted (Ms = 2.00 and above, while not severe constraints had a weighted mean score value below 2.00. The result for Borno State had revealed their severe constraints to include inadequate training in e-agriculture related activities (Ms = 2.39) ranked 1st, policy inconsistency by the government (Ms = 2.28) ranked 2nd, high cost of telephone service (Ms = 2.21) ranked 3rd, poorly developed e-agriculture tools (Ms = 2.18) ranked 4th, inadequate extension agents (Ms = 2.18) ranked 4th, content complicity (Ms = 2.12) ranked 6th, inadequate skills to use devices (Ms = 2.08) ranked 7th and low access to e-agriculture tools (Ms = 2.06) ranked 8th.

Meanwhile, the respondents in Kebbi State identified their severe constraints as inadequate training in e-agriculture related activities (Ms = 2.47) ranked 1st, policy inconsistency by the government (Ms = 2.42) ranked 2nd, inadequate skills to use devices (Ms = 2.32) ranked 3rd, poorly developed e-agriculture tools (Ms = 2.29) ranked 4th, content complicity (Ms = 2.25) ranked 5th, inadequate power supply and connectivity (Ms = 2.23) ranked 6th, incompatibility of the technology with the existing culture (Ms = 2.20) ranked 7th and low access to eagriculture tools (Ms = 2.18) ranked 8th. By implication, Kebbi State had the highest number of constraints faced as compared to their counterpart in Borno State. The result also revealed that respondents in Borno State identified inadequate time (Ms = 1.16) ranked 20th as not severe constraint, and same result (Ms = 1.16) ranked 20th was obtained from Kebbi State as not severe constraints. This implies that respondents in both States do not have problem with time in their cereal crop farming. This could be because majority of them were

primarily farmers, hence time is not a limiting factor to their usage of e-agriculture information in their cereal crop farming.

A majority of the respondents do not have access to training on e-agriculture-related activities, according to the pooled result, which indicated that inadequate training and involvement by farmers in associated activities (Ms = 2.44) revealed to have very severe constraints and is ranked first. Government policy inconsistency, which was evaluated as the second-most severe constraint (Ms = 2.36), suggests that changes in policies frequently have an impact on the adoption of innovative agricultural methods, particularly the usage of e-agriculture. This result supports that of Arokoyo (2011), who claimed that inconsistent policy has stymied agricultural development. Poorly developed e-agriculture tool (Ms = 2.23) ranked 3rd, implying that cereal crop farmers in the study area considered e-agriculture tools to be poorly developed and therefore posed a serious problem to using it. This study is in line with that of Arokoyo (2011) who revealed that very poorly developed ICT infrastructural facilities are as a result of poor and limited number of telephone lines.

The fourth-ranked very serious constraint faced by farmers of cereal crops was a lack of skill (Ms = 2.21). This conclusion is consistent with research by Bouis *et al*. (2011), who found that older and illiterate farmers are typically less likely to adopt e-agriculture because they typically have less developed digital skills. High cost of telephone service (Ms = 2.19) ranked 5th as severe constraints the cereal crop farmers faced, Content complicity (Ms = 2.18) ranked 6th, implies that the cereal crop farmers had problems in understanding the contents of e-agriculture information sources coupled with the high costs of telephone services that makes it difficult for them to access the content of e-agriculture information. This finding is in line with that reported by WSIS (2015) who found that if the material does

not satisfy farmers' need for relevant information, its transmission may be restricted. E-agriculture provides a lot of information but does not guarantee its effective usage. Poor extension agents (Ms = 2.14) placed seventh, indicating that there were few extension agents in the research area. This study shows that because so few farmers of cereal crops interact with extension agents. This result is consistent with the findings of NAERLS (2018), which stated that many extension staff left the ADPs' employ after the World Bank's financial support for them dried up in the late 1980s. The number of field extension agents across the country significantly decreased as a result of some leaving due to retirement, resignation, and death.

Low access to e-agriculture tools (Ms = 2.13) ranked 8th, implies that not all cereal crop farmers do have access to e-agriculture tools since majority of the respondents revealed their problem of accessing e-agriculture tool to be very severe. This finding corroborates that of AfDB (2010) who reported that access to e-agriculture tools is not yet equitable due to increase in digital divide between male farmers and female farmers despite the growing number of internet users. More so, inadequate power supply and connectivity (Ms = 2.09) and incompatibility of the technology with their existing culture (Ms = 2.09) ranked 9th implies that the farmers were not connecting to social media or internet often to get information on e-agriculture. The respondents revealed that accepting new agricultural practices through e-agriculture affects their cultural beliefs hence, e-agriculture information is a severe problem with their existing culture as they were not compatible and not easy to drop their existing culture to adopt new practices. This finding is agreement with that of Singh et al. (2015) and that reported by WSIS (2015) who in their findings reported that identifying the right mix and technologies that are suitable to local needs and contexts is

often a challenge, that these technologies should be suited to local contents and needs, and that their selection should be taken into account the influence of e-agriculture on gender and social dynamics.

Geographical location (Ms = 1.91) is another barrier that has been found to prevent cereal crop producers from using e-agriculture tools and information; it was placed as the 14th least severe barrier. This implies that geographical location, is of the utmost importance when educating rural farmers about new practices because locations have an impact on how well these new efforts, particularly e-agriculture information tools and sources, are adopted. This result is consistent with that of Hassan (2009) who found that the placement of an e-agriculture center should be socially convenient for all users, including women and older people.

Tools for e-agriculture are expensive, and capacity development is lacking (Ms = 2.03). This indicates that the farmers have trouble getting e-agriculture information because of the high expenses and low-capacity development, ranking 11th as a serious limitation the cereal crop farmers encountered. This result supports Swanson's (2010) who claim that access to e-agriculture information sources in rural areas is hampered by high technology prices and a lack of infrastructure, which makes computer education either prohibitively expensive or inaccessible. This finding is also in line with that of Akpabio *et al*. (2007), who found that socio-economic factors had been cited as major determinants of the use of e-agriculture and that poor e-agriculture infrastructural development, high costs for broadcast equipment, high fees for radio, television presentations, high costs for access and internet connectivity, and electricity power issues were among the barriers preventing cereal crop farmers from using e-agriculture.

Another challenge the cereal crop farmers in the study area encounter is inadequate funding, which is placed 17th (Ms = 1.79). This result showed that the use of e-agriculture information sources by cereal crops farmers was not significantly impacted by their financial situation. The outcome here differs from that of Franz and Robey (2011), who in their research revealed that access to training has also been linked to financial limitations, distance from home, lack of time, cultural restraints, and stereotypical attitudes of the cereal crop producers.

Table 4.22: Distribution of the respondents' severity of the constraints faced in the study area

	Borno State (n=203)		Kebbi State (n=197)		Pooled Result (n=400)			
Constraints	**WS**	**WM**	**WS**	**WM**	**WS**	**WM**	**R**	**D**
Inadequate training in e-agriculture activities	487	2.39	487	2.47	974	2.44	1st	SC
Policy inconsistency by Government	464	2.28	478	2.42	942	2.36	2nd	SC
Poorly developed e-agriculture tools	443	2.18	453	2.29	892	2.23	3rd	SC
Inadequate skills to use devices	424	2.08	459	2.32	883	2.21	4th	SC
Content complicity	430	2.12	445	2.25	875	2.19	5th	SC
High cost of telephone service	450	2.21	423	2.14	873	2.18	6th	SC
Inadequate extension Agents	443	2.18	414	2.10	857	2.14	7th	SC
Low access to e-agriculture tools	420	2.06	431	2.18	851	2.13	8th	SC
Inadequate power supply and connectivity	395	1.94	441	2.23	836	2.09	9th	SC
Incompatibility of tech. with existing culture	401	1.97	435	2.20	836	2.09	9th	SC
High level of rural poverty	401	1.97	401	1.97	827	2.06	11th	SC
High cost of e-agriculture tools	403	1.98	412	2.09	815	2.03	12th	SC
Low-capacity development	410	2.02	402	2.04	812	2.03	12th	SC
Geographical location of farmer	382	1.88	383	1.94	765	1.91	14th	NSC
Fear of uncertainty	367	1.80	378	1.91	745	1.86	15th	NSC
Inadequate understanding of e-agriculture tools	375	1.84	365	1.85	740	1.85	16th	NSC
Inadequate finances	387	1.91	329	1.67	716	1.79	17th	NSC
Issues of gender and diversity	356	1.75	350	1.77	706	1.76	18th	NSC
High level illiteracy	335	1.65	340	1.72	675	1.68	19th	NSC
Inadequate time	327	1.61	318	1.61	645	1.61	20th	NSC

Source: Field Survey Data, 2019

***Multiple responses**

Note: WS = Weighted Sum, WM = Weighted Mean, R = Rank, D = Decision, SC = Severe Constraints, NSC = Not Severe Constraints

4.9 Test of Hypotheses

Hypothesis 1

4.9.1 Selected socio-economic variables and usage of e-agriculture information

The t-values of the ordered probit regression estimates of selected socioeconomic characteristics and e-agriculture information utilization in the research area are shown in Table 4.23. Age results from Borno State (2.91) and Kebbi State (2.34) were significant and had a positive relationship with cereal crop farmers' usage of e-agriculture information sources at the 1% level of probability.

Result on marital status (1.94) from Kebbi State was significant and had positive relationship with the usage of e-agriculture at 5% level of probability, educational level (2.10) and household size (1.69) from Borno State were significance and had positive relationship with e-agriculture information usage at 5% and 10% levels of probability respectively. Farming experience (2.78) from Borno State and Kebbi State (3.13) showed positive and significant relationship with their usage of e-agriculture information both at 1% level of probability. The results of farm size (-1.99), extension contact (-1.76) and labour usage (-2.25) from Kebbi State showed significant but with inverse relationship with the usage of e-agriculture information at 5%, 10% and 5% levels of probability respectively and membership of cooperative (2.90) was significant and had positive relationship with the usage of e-agriculture information at 1% level of probability.

At a 5% level of probability, the extension contacts result (2.10) and income level (2.12), both from Borno State, had a positive and significant relationship with the use of e-agriculture information. This results in the study stated null hypothesis (1) being rejected. The study's null hypothesis (1), which stated that "there is no significant relationship between the selected socio-economic characteristics of the respondents and their usage of

e-agriculture information is accepted," was accepted for other variables that are not significantly correlated with the use of e-agriculture information.

The pooled result revealed that age (2.26) showed significant and had positive relationship with the usage of e-agriculture information at 5% level of probability. Farm size (-3.81), membership of cooperative (-4.38) and labour usage (-1.73) were negative but had significant relationship with the usage of e-agriculture information at 1%, 1% and 10% levels of probability respectively. While extension contact (4.64) showed significant and had positive relationship with the usage of e-agriculture information at 1% level of probability. Since five (5) of the socio-economic variables had shown significant and positive relationships with the usage of e-agriculture information, the null hypothesis (1) of the study is 'therefore rejected' and alternative hypothesis 'accepted". While, with the variables that showed no significant relationship with the usage of e-agriculture information the "null hypothesis (1) is accepted".

Table 4.23: Ordered probit regression estimates of the z-values of selected socio-economic characteristics and usage of e-agriculture information

	Borno State (n=203)	**Kebbi State (n=197)**	**Pooled Result (n=400)**
Variable	**Z-value**	**Z-value**	**Z-value**
Age	2.91***	2.34***	2.26**
Gender	-0.51	0.50	0.30
Marital status	-0.77	1.94**	1.36
Educational level	2.10**	1.21	0.35
Household size	1.69*	-0.62	-1.12
Farming experience	2.78***	3.13***	0.07
Farm size	-1.15	-1.99**	-381***
Extension contact	2.10**	-1.76	4.64***
Membership of coop.	-0.49	2.90***	-4.38***
Access to credit	0.37	-0.06	0.10
Labour usage	-0.35	-2.25**	-1.73
Income level	2.12**	-0.65	-0.60

Source: Field Survey Data, 2019
Key Note: *: significant at 10%, **: significant at 5%, *: significant at 1%.**

Hypothesis 2

4.9.2 Relationship between extents of usage of e-agriculture information sources and livelihood status of the respondents in the study area

The result of the correlation analysis on Table 4.24 of the respondents in Borno State revealed a direct and positive relationship between livelihood status and computer websites CW(X_3) (0.2389) at ($P< 0.05$) level of probability. This implies that, as the respondents' livelihood status increases it increases their extent of usage of computer/website. Meanwhile, other farmers/friends OFF(X_{13}) (-0.2392) showed an inverse correlation between the extent of usage of e-agriculture information sources and the livelihood status of the cereal crop farmers at ($P < 0.05$) level of probability. This implies that, increase in the cereal crop farmers' livelihood status will decrease the usage of other farmers/friends, meaning that when the livelihood status of the cereal crop farmers increases, their taste changes thereby leading them to use e-agriculture information sources that are more professionally based than using other farmers/friends to solve their cereal crop farming problems. While the result of the respondents from Kebbi State had revealed a direct and positive correlation between livelihood status and radio R(X_5) (0.1795) at ($P < 0.05$) level of probability. This implies that, as the respondents' livelihood status increases their extent of usage of radio.

Result on extension agents EA(X_9) (0.1517) from Kebbi State had positive correlation between the extent of usage of e-agriculture information sources and the livelihood status of the cereal crop farmers at 0.05% level of probability. This implies that, increase in the cereal crop farmers' livelihood status will increase their usage of extension agents for information. Furthermore, the correlation result between the livelihoods status of the respondents from Kebbi State and satellite SAT(X_{12}) (0.2173) had a positive correlation at ($P < 0.05$) level of probability, implying that respondents having more access to

agricultural information on satellite will in no doubt improve their knowledge of cereal crop farming and enhances their usage of satellite thereby improving their livelihood status and raise their standard of living.

The pooled result revealed a direct and positive correlation between livelihood status and computer websites CW (X_3) (0.1389) at ($P < 0.05$) level of probability. This implies that as the cereal crop farmers' livelihood status increases, the extent of computer website usage also increases. Also, extension agents EA(X_9) (0.1389) and livelihood status on the extent of usage of e-agriculture information sources showed significant correlation with increase in livelihood status of the cereal crop farmers at ($P < 0.05$) level of probability. This implies that, increase in extension contact will increase the chances of the cereal crop farmers' usage of extension agents and in turn improve their livelihood status.

Similarly, extent of usage of satellite SAT(X_{12}) (0.1542) and livelihood status was significant at ($P < 0.05$) level of probability. This implies that, more access to e-agriculture information on satellite will increase the knowledge base of the cereal crop farmers on their farming activities thereby enhancing their productivity which will in turn improve their livelihood status. While other farmers/friends OFF (X_{13}) (-0.1206) showed an inverse correlation between the extent of usage of e-agriculture information sources and the livelihood status of the cereal crop farmers at ($P < 0.05$) level of probability. This implies that, increase in the cereal crop farmers' livelihood status will decrease the usage of other farmers/friends. By implication, when the livelihood status of the cereal crop farmers increases their taste changes, thereby leading to use of e-agriculture information sources that are more professionally based than using other farmers/friends to solve their cereal crop farming problems. Since five (5) of the variables from both States and four (4) variables from the pooled results has shown direct and inverse correlation with the

extent of usage of e-agriculture information sources The null hypothesis (2), which claimed there was no significant correlation between the degree of use of e-agriculture information sources and the livelihood situation of cereal crop farmers in the study area, was "rejected" at (P 0.05) levels, while the alternative hypothesis was "accepted."

Table 4.24: Correlation analysis showing the relationship between extents of usage of e agriculture information sources and livelihood status of the respondents

Borno State (n = 203)		**Kebbi State (n = 197)**		**Pooled Result (n = 400)**	
Lh S (Y)	Coef.	Lh S (Y)	Coef.	Lh S (Y)	Coef.
Lh S (Y)	1.0000	Lh S (Y)	1.0000	Lh S (Y)	1.0000
Tel.(x_1)	0.0445	Tel.(x_1)	- 0.0185	Tel.(x_1)	0.0216
MP.(X_2)	0.0391	MP.(X_2)	0.1307	MP.(X_2)	0.0803
CW(X_3)	0.2389*	CW(X_3)	0.0668	CW(X_3)	0.1389*
IB(X_4)	0.0804	IB(X_4)	0.0285	IB(X_4)	0.0490
R(X_5)	- 0.0192	R(X_5)	0.1795*	R(X_5)	0.0865
PPC(X_6)	0.0503	PPC(X_6)	0.0085	PPC(X_6)	0.0255
TV(X_7)	0.1020	TV(X_7)	0.1011	TV(X_7)	0.0595
NP(X_8)	- 0.0348	NP(X_8)	0.1219	NP(X_8)	0.0476
EA(X_9)	0.0492	EA(X_9)	0.1517*	EA(X_9)	0.1428*
SMS(X_{10})	0.0588	SMS(X_{10})	0.0493	SMS(X_{10})	0.0302
SSM(X_{11})	0.0334	SSM(X_{11})	0.1115	SSM(X_{11})	0.0614
SAT(X_{12})	0.1291	SAT(X_{12})	0.2173*	SAT(X_{12})	0.1542*
OFF(X_{13})	-0.2392*	OFF(X_{13})	0.0187	OFF(X_{13})	-0.1206*

Source: Field survey data, 2019.

Key note: * Correlation is significant at 0.05 level (2-tailed) 0.01 - 0.49 = weak correlation relationship and Lh S = Livelihood status

Tel = telephone, MP = mobile phone, CW = computer/website, IB = internet broadband, R = radio, PPC = palmtop PC, TV = television, NP = newspaper, EA = extension agent, SMS = short message services, SSM = smartphone/social media, SAT = satellite, OFF = other farmer/friends.

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

According to the study's findings, the majority of the farmers who grew cereal crops were men, and their average age was 45 in both States, which indicates that they were in their prime age of active productivity. The majority of the farmland was inherited with an average farm size of 4.0 hectares. Farmers who grew grain crops also had substantially large number of household size from both states, with most of them having above three decades of farming experience and majorly use both family and hired labour. They were primarily full-time farmers and maize was the stable cereal crop cultivated by them, which were for both income generation and household consumption. Mobile phone, radio, other farmers/friends, television, newspaper, smart phone/social media, extension agents and short message services were found to be very effective e-agriculture information sources used by the farmers in the research area by farmers who grow cereal crops.

The effects of e-agriculture usage on cereal crop farmers' livelihood status were found to be positive and significant with their age, educational level, farm size, farming experience, extension contact, access to credit, sources of e-agriculture information, e-agriculture information on marketing, e-agriculture information on weather and e-agriculture information on farming system. Lastly, types of assets the respondents had access to and the ones they owned as household assets were revealed and majority of the respondents had access to schools, markets and hospitals.

5.2 Recommendations

In an effort to improve the livelihood condition of the cereal crop farmers in Borno and Kebbi States, the following recommendations were made based on the findings of this study.

1. Extension contacts had positive influence with usage of e-agriculture on the cereal crop farmers' livelihood status. With the unabated banditry and security concerns in both States, relevant bodies in agricultural extension and rural development, government agencies, and other stalk holders in agriculture should endeavour to deploy the use of e-agriculture for easy contact with farmers in the study area. Additionally, technology should be appropriate for regional needs and content, and their selection should take into account how e-agriculture may affect rural farmers' gender and social dynamics.
2. Internet broadband, satellite and computer website proved to be not effective e-agriculture information sources to the cereal crop farmers in the study area. Therefore, farmers are encouraged to explore these devices as they harbour more information on agriculture and farming activities. This will widen their knowledge of agriculture and thereby enhances their livelihoods.
3. Membership of cooperative society had positive influence with the usage of e-agriculture information on the respondents' livelihood status. Therefore, farmers should endeavour to join cooperative society related to agriculture to enable them access loans and other agricultural inputs that will enable them boost their productivity and realize high yields of their cereal crops.
4. Inadequate training was ranked 1stand inadequate skills to use e-agriculture tools ranked as very severe constraints, while the marginal effect of e-agriculture usage on respondents' livelihood status had positive effect. Consequently, gaining

knowledge of contemporary technologies opens up new opportunities, including networking and organizing, this calls for immediate attention of agricultural stakeholders and relevant bodies/institutions concern to engage the farmers in e-agriculture training activities on relevant subject matter for them to gain the knowledge and abilities they'll need to use e-agriculture information to boost their cereal crop farming, thereby enhancing their livelihood status.

5. The usage of smart phone/social media proved to have no correlation with the extent of usage of e-agriculture information sources and the livelihood status of the cereal crop farmers. This calls for the farmers to intensify the use of smart phone/social media as the usage will enable them get more information on cereal crop farming from other farmers/friends from all over the globes.
6. Policy inconsistency by the government on agricultural related matters ranked 2nd as very severe constraints. There is therefore, need for government to be consistent with the implementation of polices that concerns agriculture to avoid the wavering of the promises made by the government to agricultural sector in order to achieve the full delivery of technological packages related to agricultural production to farmers concerned.

5.3 Suggestions for further study

1. Factors affecting the use of e-agriculture information on sorghum farmers' livelihood status. Author should take into consideration the objectives of 'before and after usage of e- agriculture information'.

2. Factors influencing the use of e-agriculture information by rice farmers

3. Impact of the usage of e-agriculture information on maize farmers' yields

5.4 Contributions to knowledge

The elements that affect respondents' livelihood situations and their adoption of e-agriculture had shown positive influences and had significant relationships with majority of the variables identified. This implies that, an increase in the usage of e-agriculture information by the cereal crop farmers, will increase their livelihood status, thereby enhances their usage of e-agriculture information in the study area. The result of the marginal effects of usage of e-agriculture information and the Livelihood status of the cereal crop farmers had significant and positive effects with majority of the variables among farmers with high livelihood status. This implies that, these variables had positive effects with the usage of e-agriculture information as having more access to them by the cereal crop farmers will have a higher positive effect on their livelihood status, thereby improving their living standards.

Finally, increase in age and extension contact will influence the cereal crop farmers' usage of e-agriculture, also increase in farm size, extension contact and increase in access to sources of e-agriculture information, e-agriculture information on marketing and e-agriculture information on farming system will increase the cereal crop farmers usage of e-agriculture and enhances their livelihood status.

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APPENDIX I

PhD RESEARCH AND STUDIES WORK PLAN

	2018												2019												2020											
Activities	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Course Work																																				
Constitution of Supervisory committee																																				
First semester examination																																				
Research proposal write ups																																				
Literature Review																																				
Departmental proposal seminar																																				
ASSU STRIKE																																				
School proposal seminar																																				
Thesis Corrections																																				
Data collection																																				
Data coding																																				
Data cleaning																																				
Data analysis																																				
Writing of thesis																																				
Departmental exit seminar																																				
School Exit Seminar																																				
Writing and publication of articles																																				
Examination																																				

APPENDIX II

Department of Agricultural Extension and Rural Development

School of Agriculture and Agricultural Technology

Federal University of Technology Minna, Niger State,

Nigeria

Dear respondent,

I am a Post-Graduate Student (PhD) of the above-named institution and Department. I am taking a research work entitled (**Evaluation of the Effects of E-agriculture on the Cereal Crop Farmers Livelihood in Borno and Kebbi state, Nigeria**). The research work is strictly for academic purpose and any information that is elicited from you will be used to improve your livelihood status and change your living standards. Therefore you may find attached to this letter a "questionnaire" soliciting for your kind cooperation to provide truthful answers to the questions, as information given by you will be kept confidential and only for the purpose of this research.

Thank you sincerely for your anticipated cooperation.

Yours faithfully

JAMES Rejoice Mshelizah
(PhD/SAAT/2017/1005)

SURVEY QUESTIONNAIRE, 2019

INSTRUCTIONS: - Please Tick the Options that Best Expresses Your Opinion and Fill-in the Blank-Spaces

Questionnaire Number: _____
Interview Date: _____
State of Study_____
Local Government Area_____
Village:_____
Name of Association: _____
Name of Farmer (Optional): _____
Phone Number: _____

SECTION A: Socio-Economic Characteristics of the Cereal Crop Farmers.

1. Age _____
2. Gender
   a. Male ( )
   b. Female ( )
3. Marital status
   a. Single ( )
   b. Married ( )
   c. Separated ( )
   d. Divorce ( )
   e. Widow (er) ( )
4. Number of years spent in formal education _____
5. What is your level of education?
   a. Primary ( )
   b. Secondary ( )
   c. Tertiary ( )
6. What is your ownership structure of house?
   a. Owned the house ( )
   b. Rented house ( )
7. If owned the house, what is the method of acquisition?
   a. Purchased ( )
   b. Inherited ( )
   c. Family house ( )
8. What is your household size?
   a. Male adult _____
   b. Female adult _____
   c. Male child _____
   d. Female child _____
9. For how long (years) have you being in cereal crop farming activities? _____

10. What is the size of your farm land (hectare) for cereal crop farming? _____

11. What is the method of your farm acquisition?
a. Inheritance ( )
b. Leased ( )
c. Community land ( )
d. Rent ( )
e. Purchased ( )
f. Others (please) specify _____
11d. If rented, how much (₦)? _____
11e. If purchased, how much (₦)? _____
11b. If Leased, what is the collateral?
11b1 Money, how much (₦)? _____
11b2 Farm produce, what is the quantity (kg) _____
11c. If community land, how much (₦) _____
12. What is the farming system you practice?
a. Sole cropping ( )
b. Mixed cropping ( )
c. Mixed farming ( )
d. Crop rotation ( )
e. Continuous cropping ( )
f. Compound farming ( )
13. What type of cereal crop do you cultivate?
a. Maize ( )
b. Rice ( )
c. Sorghum ( )
d. Millet ( )
e. Wheat ( )
f. Others (please) specify _____
14. Why do you cultivate the cereal Crop you indicated in 10 above?
a. For income generation ( )
b. Household consumption ( )
c. For both household consumption and income generation ( )
d. Others (please) specify _____
15. Did you have any other source of income apart from farm income?
a. Yes ( )
b. No ( )
16. Please indicate the other source of income? _____
17. Did you have any extension contact?
a. Yes ( )
b. No ( )
18. Please, indicate number of contact with extension agent for the last growing season_____

19. Are you a member of a cooperative society?
    a. Yes ( )
    b. No ( )

19a. If yes, how many cooperative society do you belong to? _____

19b. If No, state reason why? _____

20. How long (years) have you being a member of cooperative society? _____

21. Did you have access to credit?
    a. Yes ( )
    b. No ( )

22. Please indicate the type of credit you have access too
    a. Formal credit ( )
    b. Informal ( )

23. How much did you receive as a credit? _____

24. What is the interest rate on the Credit you receive? _____

25. What type of labour do you use in your cereal crop farming?
    a. Family labour ( )
    b. Hired labour ( )
    c. Communal labour ( )
    d. Both family and hired labour ( )
    e. Others (please) specify _____

26. What is your primary occupation?
    a. Cereal crop farming ( )
    b. Trading ( )
    c. Fishing ( )
    d. Crafting ( )
    e. Non cereal crop farming ( )
    f. Livestock farming ( )
    g. Others (please) specify _____

27. What is your secondary occupation?
    a. Cereal crop farming ( )
    b. Trading ( )
    c. Fishing ( )
    d. Crafting ( )
    e. Non cereal crop farming ( )
    f. Livestock farming ( )
    g. Others (please) specify _____

28. What is your employment status?
    a. Self-employed ( )
    b. Unemployed ( )
    c. Government employed ( )

29. What is your Income (in naira) in cereal crop farming? _____

Section B: Sources of E-Agriculture Information and Extent of Usage

30. Did you use e-agriculture information sources in your cereal crop farming?
    a. Yes ( )
    b. No ( )

31. Please indicate in the Table below sources of e-agriculture information used by you:

Sources of e-agriculture information	**Usage**
Telephone	
Mobile phone	
Computer/website	
Internet/broadband	
Radio	
Palmtop PC	
Television	
News papers	
Extension agents	
Short messages services	
Smartphone and social media	
Satellite	
Other farmers (friends)	

32. Please tick from the Table below the extent of your usage of e-agriculture information sources:

E-Agriculture Information Sources	**Extent of Usage**		
	Highly used	**Fairly used**	**Poorly used**
Telephone			
Mobile phone			
Computer /website			
Internet /broadband			
Radio			
Palmtop PC			
Television			
News papers			
Extension agents			
Short messages services			
Smartphone and social media			
Satellite			
Other farmers (friends)			

33. How often did you have access to e-agriculture information sources?
    a. Very often ( )
    b. Not often ( )
34. How many time(s) (number) in the last five (5) years did you use e-agriculture information sources to access marketing information? _____
35. How many time(s) (number) do you access training on agricultural innovations using eagriculture sources? _____
36. How many time (number) in the last 5 years did you use e-agriculture to access information on improve farming system? _____
37. Did you use e-agriculture information sources to access information on weather condition?
    a. Yes ( )
    b. No ( )
38. How many time(s) (number) in the last 5 years did you use e-agriculture information sources to access information on crop cultivation and techniques? _____
39. How many times(s) (number) in the last 5 years did you use e-agriculture information sources to access information on post-harvest technologies? _____

SECTION C: Livelihood Status of the Cereal Crop Farmers

48. Choose from the options below the types of social assets your household have access to.
    a. Relatives (Cousins, Aunties, Uncles and so on) ( )
    b. Access to market ( )
    c. Access to school ( )
    d. Access to hospital ( )
    e. Access to non-governmental organization ( )
    f. Access to motorable roads ( )
    g. Access to farmers organizations ( )
    h. Access to labour exchange group ( )
    i. Member of political party ( )
    j. Member of non-farm cooperatives ( )
    k. Member of funeral aid group ( )
    l. Others, please specify ----------
49. Choose from the options below the types of financial/economic assets owned by your household.
    a. Income from farm ( )
    b. Cash at hand ( )
    c. Income from other jobs ( )
    d. Remittances ( )
    e. Savings in bank ( )
    f. Jewelries ( )
    g. Liquid assets ( )
    h. Insurances ( )
    i. Pension ( )
    j. Grants ( )

k. Wages (salaries) ( )

50. Choose from the options below the types of natural assets your household have access to. a. Gathering of fire wood ( )
    b. Economic trees ( )
    c. Family farm land ( )
    d. Water bodies (reservoir (s), river (s), well (s) and so on) ( )
    e. Land owned by the community ( )
    f. Waste assimilation and disposals ( )
    g. Hunting of wildlife ( )
    h. Gathering of non-timber products ( )
    i. Others, pls. specify.....

51. Please indicate from the Table below, other inputs for cereal crop production used by you:

Inputs	**Quantity used/kg/litre**	**Cost of unit (₦)**	**Total**
Improved cereal varieties			
Herbicide			
Fertilizer			
Organic Manure			
Insecticide			

52. Please from the Table below, provide the following information on the farm production/physical assets used and owned in your cereal crop farming:

Farm crude implements	**Numbers**	**Unit cost**	**Expected life span**	**Total cost**
Machete (s)				
Rake (s)				
Hoe(s)				
Shovel (s)				
Watering CAN (s)				
Spade (s)				
Cutlass(es)				
Sickle(s) for harvest				
Others (please) specify				

53. Please indicate the Household/material assets owned by you, from the options on the Table below:

Household Assets		**Quantity (Units)**	**Costs/Unit (₦)**
Radio			
Television			
Computer			
Car			

Tricycle			
Residential house			
Shops/ business (es)			
Personal owned land			
Refrigerator			
Dinning set			
Charcoal stove			
Kerosene stove			
Firewood cooker			
Gas cooker			
Electric cooker			
Microwave oven (s)			
Furniture (beds and cushions)			
Water dispenser			
Air conditioner			
Wall clock (s)			
Fans			
Motor Bike			
Bicycle			
Hand set/smart phones			
Generator			
House electronics			
Well, borehole, tapwater			
Others, specify them			

54. Please list out your farm production assets as indicated in the Table below:

Farm production Assets	**Quantity (Units)**	**Costs/Unit (₦)**
Water (well and borehole)		
Landed Properties (farms)		
Farm House(es)		
Draught animals		
Tractors		
Irrigation gadgets		
Others (please) specify		

55. Do you have access to other food items apart from cereal crop?
    a. Yes ( )
    b. No ( )
56. Choose from the options below other foods and vegetables you consume.
    a. Poultry products ( )
    b. Vegetable fruits ( )
    c. Grape fruits ( )
    d. Babanas ( )
    e. Others (please) specify _____
57. How often do you consume these food/vegetable?
    a. Daily ( )
    b. Every two days ( )
    c. Weekly ( )
    d. Monthly ( )
58 Do you have access to modern facilities?
    a. Yes ( )
    b. No ( )
59. Please indicate the types of social facilities you have from the options below a. Electricity ( )
    b. Good toilet facilities ( )
    c. Pipe borne water ( )
    d. Television ( )
    e. Radio ( )
    f. GSM network ( )
    g. Internet ( )
    h. Good road network ( )
    i. Market ( )
    j. Public medical service ( )
    k. Good hospital facilities ( )
    l. Recreational centres ( )
    m. Village town halls ( )
    n. Motorable roads ( )
    o. Library ( )
    p. Others (please) specify ( )
60. Does cereal Crop Farming provides you with the opportunity to good housing facilities?
    a. Yes ( )
    b. No ( )
60a. Please indicate from the options below your type of residential house
    a. Bungalow ( )
    b. Duplex ( )
    c. Town house ( )
    d. Terraced house ( )
    e. Stairs building ( )

f. Traditional house (mud with thatch roof) ( )
g. Traditional house (mud with zinc roof) ( )

SECTION D: Benefits of Using E-Agriculture by the Cereal Crop Farmers

61. Indicate the benefits you derived from the use of e-agriculture information sources:

Benefits	**Response**		
	Very high	**High**	**Low**
Provision of timely market information and transparency			
Increased access to improve seed varieties			
Increased Income			
Increased yield of crop			
Increased access to financial banking			
Reduction in transaction costs			
Timely warning (on pest and diseases of crop)			
Increased knowledge of Farming			
Facilitate adoption of new agricultural practices			
Grant easy access to farm inputs			
Grant access to post harvest information			
Uplifting farmers' livelihoods			
Provides food security			
Help alleviating poverty			
Creation of new business opportunities			
Increasing economic, social and institutional development			
Provide access to education and training			
Provide proper awareness and understanding about crops, seeds, fertilizers, marketing and other related information			
Provides better access to natural resources			

Provides access to local and national policies related to agriculture			
Enhance productivity			
Achieve agricultural growth			
Empowers rural employment			

Section E: Perceived Effects of E-Agriculture Usage on Cereal Crop Farmers' Livelihood

62. Please rate below how you perceive the effects of usage of e-agriculture information sources on your livelihood:

Sources of e-agriculture information	**Perceived effectiveness**		
	Effective	**Undecided**	**Not effective**
Telephone			
Mobile Phone			
Computer /Website			
Internet /Broadband			
Radio			
Satellite			
Palmtop PC			
Television			
News papers			
Extension Agents			
Short messages service (SMS)			
Smartphone /social Media			
Other Farmers (friends)			

Section F: Constraints Faced by Farmers in the Use of E-Agriculture Information Sources

63. Please tick the constraints you face in the use of e-agriculture information sources and indicate their severity.

Constraints	**Severity**		
	Not severe	**Severe**	**Very severe**
Inadequate finances			
High level Illiteracy			
Inadequate understanding and awareness of E-agriculture tools			
High level of rural Poverty			
Low access to E-agric.tools			
High cost of E-agriculture tools			
Fear of uncertainty			
Inadequate time			
Geographical location of farmers			
Inadequate extension agents			
Content complicity			
Inadequate skills to use devices			
Incompatibility of the technology with existing culture			
High cost of telephone service			
Poorly developed E-agric-tools			
Low capacity development			
Issues of gender and diversity			
Inadequate training and participation by farmers in Eagriculture related activities			
Policy inconsistency by the government			
Others (please) specify			