Exploring potential use of e-agriculture platform for ease market access among smallholder vegetable farmers in Bojanala District

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DECLARATION

I hereby declare that this dissertation is my own original work and has not been previously submitted for a master's degree at another university. When other people's work has been used, it has been properly recognized in this text.

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DEDICATION

My dissertation is dedicated to my mother, relatives, and friends. I owe a special debt of gratitude to my devoted grandma, Ms S.S Ntwe, whose words of encouragement and resilience will live on in my heart forever. I also dedicate this thesis to myself for the effort I put in and the challenges I faced in completing it.

Abstract

E-agriculture is a worldwide community of practice where farmers/individuals from all over the globe share knowledge, ideas, and resources on using information and communication technology in order to reach sustainable agriculture and improve rural development. E-agriculture requires the use of ICT tools which are very essential for the effective operation use of e-agriculture as a platform. Little or no studies in South Africa have explored the use of e-agriculture as a platform to easing market access. Thus, the aim of the study was to identify the use of e-agriculture platform for ease markets access by smallholder vegetable farmers in Bojanala District, North WestNorthwest Province. Specifically, the objectives of the study were to determine: the socio-demographic characteristics of smallholder vegetable farmers; determine whether the smallholder farmers in the Bojanala district are aware of e-agriculture; investigated the willingness of farmers to adopt e-agriculture and determined the factors affecting market access of smallholder vegetable farmers in markets.

A structured questionnaire was used to collect data from a simple random selected sample of 92 farming households in Bojanala District. Descriptive statistics was used to analyse the socio-demographic characteristics and to assess the level awareness of e-agriculture by farmers. In addition, binary logistic regression model was used to establish the significance of factors which affect willingness to adopt e-agriculture at a significance level of 5%. Moreover, factor analysis (FA) was used to determine the factors affecting market access.

Descriptive results showed that 66.3% of farmers were female while only 33.70% of farmers were male. Pertaining to level of education, majority of farmers had no formal education (48.91%), 33.70% of the farmers only went to primary school, 17.39% of the farmer went secondary school and none have tertiary education. The descriptive results further revealed that, 29.35% of the farmers had no income besides farming, 46.74% of the farmers received grants from the government, 17.39% of the respondents are formally employed while 7.61% of the respondents have other forms of off-farm income. Moreover, Descriptive results showed that only 2.17% of the farmer's access information on television, 38.04% of the farmers rely on radio for agricultural information, 13.04% of the farmers acquire farming information from reading newspapers, 17.39% of the farmer's extract farming information from the internet and 29.35% of the farmers receive information from the extension agents.

Binary logistics regression results showed that the age, level of education, smartphone information search and preferred method of farming is statistically significant at 5 percent when ran against willingness to adopt e-agriculture using Binary logistic model. The binary logistic regression revealed that the probability of older people to become willing to adopt e-agriculture decreases by 0.0481. Additionally, the regression also showed that as the level of education increases so does the willingness to adopt e-agriculture by 0.05122. Furthermore, binary regression indicated that the probability of vegetable farmers to adopt innovative method of farming increases by 0.013 against willingness to adopt e-agriculture.

Factor analysis results revealed that, components 1, 2 and 3 termed as demographic traits, resource needed for marketing and affordability of ICT services respectively. From the study gender of respondents, age, educational level, years of farming experience, household size, access to funds and access to efficient land were found to have a significant relationship revealed by factor analysis. Lastly, do the farmers use the internet for information search, do the farmers have extension services and is there any ICT institution in their area had a significant relationship which was also revealed by factor analysis.

While the study illustrated the factors which influence farmers in accessing markets for their vegetables more needs to be done to achieve the use of e-agriculture as a platform to ease market access for smallholder vegetable farmers. Thus, the study recommends that the ICT infrastructure in the area should be improved. Also, it is recommended that extension services and training of extension agents about ICT and e-agriculture through government workshops should be increased. Finally, farmers should be encouraged to use smartphones in order to enhance e-agriculture.

Keywords: E-agriculture, market access, smallholder vegetable farmers, information communication technologies (ICTs)

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CHAPTER ONE: INTRODUCTION OF THE STUDY

1.1 Background of the study

Technological advancement in agriculture has proven to have significant benefits such as development among rural communities, market information for producers and lower transaction costs. (Barasa, 2015). According to Ghogare and Monga (2015) e-agriculture is an internet scheme of world enterprise looking to carry food and evolve the agricultural industry by encouraging the employment of combined technologies, communication, and information. In addition, e-agriculture provides plenty prospective of adding traditional transportation of services and channels of transmission in ways that increase the agriculture organization's potential to meet the needs of the farmers (Rashid, 2014 ; Sharma *et al*, 2012). Moreover, e-agriculture offers an increase in choice of available markets accessibility to farmers ranging from local district, national level, and even internationally, and also increasing market access among farmers (Osmani and Hossain, 2015 ; Rashid, 2014). Rashid (2014) also stated that e-agriculture includes a general idea, blueprint, evolution, assessment and implementation of innovative methods to use information and communication technologies (ICTs) in rural regions, mainly focusing on agriculture.

Information and communication technologies is a broad term that encompasses all technologies that allow users to access, retrieve, store, transmit, and manipulate data in a digital platform, including the internet, wireless networks, cell phones, computers, software, middleware, video conferencing, social networks, and other media applications and services (Tata and McNamara, 2016). According to Kintoki (2017), instruments such as application software, operating systems, and computer hardware, as well as energy and telephone lines, intranets and networks, satellite systems and radio, are all critical components of e-agriculture. In addition, Kintoki (2017) states that e-agriculture issues the practical diffusion of information which is readily available, up to date and broad information to farmers by using ICTs. According to Chavula (2013), ICT sector has experienced massive advancements in Africa and this is due to common liberalization of telecommunication in the African continent giving opportunity to the use of e-agriculture by farmers on the continent. It is generally agreed that improved farm production and living standards of smallholder vegetable farmers can be enhanced through improved access to agricultural markets in the developing world, particularly in Africa (Chamberlin, 2008).

According to Frank *et al.* (2015) upgraded market access has a significant role in promoting rural income of smallholder vegetable farmers in Africa. Despite this, smallholder vegetable farmer's involvement in markets in Africa is low as a result of several factors limiting the farmers to access the markets (Frank *et al*, 2015). According to Komarek (2010) smallholder vegetable farmers in rural Africa lack adequate means to control the cost to access the markets due to high transaction costs. Furthermore, Frank *et al* (2015) states that, expanded market involvement requires proper understanding of the factors limiting market participation and due to lack of assets that are essential to protect smallholder vegetable farmers from market shock, it becomes difficult for these farmers to access markets. Moreover, aloofness of smallholder farmer's location, scares or poorly constructed/maintained roads, lack of transport and storage facilities, and struggling to access information about market prices prevent these farmers from accessing markets that are competitive (Sharma *et al*, 2012). The challenges faced by smallholder vegetable farmers in developing nations when trying to access markets can be reduced by though e-agriculture so as to improve vegetable farmers access to the markets.

1.2 Problem statement

In most developing nations a significant number of smallholder vegetable farmers reside in remote rural domain with lack of transportation, market infrastructure and weak institutions which increases transaction cost (Pathak *et al*, 2019). In addition, lack of sufficient information about markets as well as information on trade partner's limits accessibility of markets by smallholder vegetable farmers (Fan and Salas Garcia, 2018). Furthermore, a large amount of the world population is shifting their diet to vegetables given the benefits concerning health, this in turn increases the demand for vegetables for local and international markets (Martellozo *et al*, 2014). Moreover, Mason-D'ivoz *et al* (2019) notes that the increase in demand of vegetables at retail level cannot be met with the current supply and this can be attributed to lack of market access of smallholder vegetable famers residing in remote rural area. E-agriculture has the potential to increases farmers access to markets through updated available information about markets (Barasa, 2015).

Likewise, e-agriculture provides timely information (about markets), limit transaction costs, and donate to better the order of decision making to raise rural incomes and supply a platform for communication among smallholder farmers (Tata and McNamara, 2016). In addition, Awuol *et al.*

(2016) also notes that smallholder vegetable farmers need the right market information and market knowledge for their agricultural survival and such information can be made available to them through ICT tools and use e-agriculture. According to statistics South Africa (2020), indicated that 79.7% of South African households that were taking part in agriculture were involved to secure an added source of income. Additionally, another 9.1% were involved for subsistence farming while 4.7% of the households used agriculture to make profit (StatsSA, 2020).

The aforementioned studies, either explored the challenges of market access by smallholder farmers, the benefits of embracing e-agriculture in farming and insufficient studies about e-agriculture in South Africa. However, none or very few of the studies explicitly looked at the use of e-agriculture in easing market access for smallholder vegetable farmers given its potential to improve farming scope of smallholder farmers. There is therefore, a need to understand the degree to which e-agriculture can be explored as a platform to ease market access for smallholder vegetable farmers in Bojanala district. In this study, the factors affect smallholder vegetable farmers to access in markets and how e-agriculture can be used to improve market accessibility in the Bojanala district is explored.

1.3 Significance of the study

Most of the studies conducted about market access (Sharma *et al*, 2012; Aku *et al*, 2018 and Osmani and Hossain, 2015) were mainly based on the constraints of market access. Additionally, studies that were done on e-agriculture either recognized the benefits of e-agriculture or the impotence of using e-agriculture (Ghogane and Monga, 2015 and Kintoki, 2017). But, none or very few of the studies recognized the potential use of e-agriculture to ease market access for smallholder vegetable farmers. Thus, this study recognizes this gap in literature, and aimed to explore it. Consequently, this also shows that there might be a missing link between market access and e-agriculture when the South African government is formulating policies for the agricultural sector. This study can be used to bridge the gap between market access and e-agriculture when formulating policies in the country.

1.4 Research aim

The aim of this study was to explore the use of e-agriculture platform to ease market access by smallholder vegetable farmers in the Bojanala district municipality in the North West.

1.4.1 Research questions

1. What are the socio-demographic characteristics of smallholder vegetable farmers in the Bojanala District?
2. Are the vegetable farmers in the Bojanala district aware of e-agriculture?
3. Are the vegetable farmers in the in Bojanala district willing to adopt e-agriculture?
4. What are the factors affecting market access of smallholder vegetable farmers?

1.4.2 Research objectives

1. To determine socio-demographic characteristics of smallholder vegetable farmers in the Bojanala District.
2. To determine whether the smallholder farmers in the Bojanala district are aware of e-agriculture.
3. To investigate the willingness of vegetable farmers to adopt e-agriculture.
4. To explore the factors affecting market access of smallholder vegetable farmers.

1.5 Limitations of the study

The study was limited to the district of Bojanala in the North West province and is not general for the entire North West province. It was difficult to get accurate information about accessing markets as some of the respondents were illiterate. The smallholder vegetable farmers in the district have many characteristics which vary but this study only concentrate on selected characteristics. The study concentrated on the desired characteristics of the study and the local language was used when collecting data to increase understanding of the questionnaire.

1.6 Delineation

This study was conducted in Bojanala district in the North West province of South Africa delineated to sample of smallholder vegetable farmers in the Bojanala district. This study is responsible for exploring the potential use of e-agriculture to ease market access of smallholder vegetable farmers. The study did not consider smallholder livestock farmers because of the increased demand for vegetable for both local and international markets as people are shifting diet

to healthy foods. In addition, this study also concentrated on smallholder farmers instead of commercial farmers because of the need for smallholder farmers to access markets and promote rural economic growth. Lastly, the study concentrated on market access that are linked with digital access so as to explore the potential use of e-agriculture.

1.7 Ethical consideration

The nature of the problem being examined, the data being collected, and the data gathering procedures all raise ethical concerns throughout the research process (Cooper and Schindler 2008). Cooper and Schindler (2008) also noted that scientists encounter obstacles in conducting good work, such as acquiring access, obtaining informed consent, and ensuring that the research's aftereffects do not harm persons or the community.

Standardization and consistency were established for the study procedure for all smallholder farmers in the Bojanala District in accordance with the North West University's laws and regulations. Farmers' data was kept as private as possible, and the results were solely utilized for study. This was done by asking every respondents questions individually/privately and the questionnaire was then put away until data capturing. All respondents were given a thorough explanation of the study's objectives, and they were advised that participation was not required, but rather voluntary, and that they might opt out at any moment. Finally, because this study was conducted during the covid-19 pandemic, the principal investigator took into account the regulation of covid-19 and applied these regulations/protocols when collecting data. The use of face masks and sanitiser and, social distancing was mandatory for both the respondents and data collectors at all times.

1.9 Outline of the Dissertation

This study consists of five chapters. Chapter one illustrated the introduction to the study in context, addressed the research problem, the significance of the study and objectives of the study. Chapter two consists of literature reviewed on e-agriculture, ICTs, adoption of new innovation and market access constraints. Chapter three is inclusive of methodology of the study where description of the study area, research design, population of the study and method of data analysis will be discused. The results of the study were discussed and detailed in chapter four. Lastly, chapter five consist of conclusion, recommendation and study implications, followed by a list of references.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter consists of literature on smallholder farmers in South Africa. the role of ICT in e-agriculture this studies were done both locally and internationally and the role of ICT in e-agriculture. The chapter also reviews literature on the smallholder characteristics, studies on market access and market access challenges. Lastly, literature on online marketing of agricultural produce and challenges the farmers face in order access formal markets will be reviewed in this chapter.

2.2 Smallholder vegetable farmers in rural areas of South Africa

Smallholder farmer and small scale farmer are two terms that are used interchangeably. South Africa's smallholder farmers, according to the National Department of Agriculture, Forestry, and Fisheries (2012), are defined as the total number of farmers or families involved in any agricultural production (in this case vegetables). Smallholder vegetable growers are characterized by labor-intensive small farms and the use of traditional ways to produce their veggies (Pienaar and Traub, 2015). Furthermore, many farmers lack institutional capability, government services, and support (Louw, 2013). The former homelands, which were delineated by the Native Land Acts of 1913 and 1936, are home to the majority of South Africa's vegetable producers, who produce mostly for domestic use (Pienaar and Traub, 2015). Furthermore, Pienaar and Traub (2015) notes that of the 4 million smallholder farmers in South Africa an estimation 160000 farm to sell their produce to the market. Moreover, Pienaar and Traub (2015) states that a significant number of vegetable farmers in South Africa are women, children and elderly people and also showed that an average age of smallholder farmers in rural domain is 56 years.

2.3 ICT infrastructure and networks in rural areas

Rural schools and communities today lack access to high-quality education and services that their urban counterparts take for granted (Herselman, 2003). Rural communities in South Africa are living below the poverty line and remain impoverished due to a lack of access to critical

infrastructure for economic growth and development (Mdlongwa, 2012). Many deep rural villages in South Africa lacked basic infrastructure such as electricity reticulation and communications (Herselman, 2003). The development of the local economy in rural South Africa and Africa in general, according to Mdlongwa (2012), is severely hampered by a lack of infrastructure, services, and know-how. In the sphere of information and communication technologies, this is especially true.

2.4 Educational attainment and employment in rural areas

Individuals' ability to receive, decode, and understand information critical to make innovative judgments is a component of education (Teklewold *et al*, 2006). Individuals will be able to obtain additional information as a result of this. Farmers with greater education, according to Teklewold *et al,* (2006), should be aware of more sources of knowledge and be more efficient in evaluating and interpreting innovations than those with less education. As a result, farmers with greater levels of education are thought to be more likely to adopt than farmers with lower levels of education (Doss and Morris, 2001). As a result, adoption differs depending on one's educational degree (i.e. illiterate, read and write, primary and secondary). Although education is not an input, it is critical in determining a farmer's ability to accept new technology such as ICTs (Doss and Morris, 2001). Gender differences in education exist, and on average, male farmers have more education than female farmers (Doss and Morris, 2001). Computers were first introduced in South African schools in the 1980s, primarily in private schools and a few well-resourced government institutions (Mdlongwa, 2012).

Traditional teaching methods have remained unchanged in South African schools throughout the last few decades (Mdlongwa, 2012). In South Africa, educational institutions, particularly formerly underprivileged schools, confront numerous obstacles, including a decreased ability to collect school fees from pupils' parents and dwindling government financial support (Mdlongwa, 2012). Mdlongwa (2012) also emphasizes the importance of incorporating ICT into the learner's education. Learners who are exposed to ICT can build abilities that will give them an advantage in an increasingly digitally saturated workplace (Gillwald *et al,* 2012). Another important barrier to ICT

2.5 Role of ICT in e-agriculture

Information and communication technology (ICT) encompasses a wide range of technologies, applications, and services, according to Pradhan and Mohapatra (2015). ICT employs various types of software and hardware and frequently operates across telecommunication networks. Application software, operating systems, and computer hardware, as well as energy and telephone lines, intranets and networks, satellite systems, and radio, are all provided by ICT (Kintoki, 2017). Information management technology, communication technology, and computer technology are the three technologies that make up ICT. Data, knowledge, and information are managed, exchanged, and processed using these technologies. Information and communication technologies (ICTs) are key tools utilized in e-agriculture to help agricultural development, according to Dlodlo and Kalezhi (2015). Information and communication technologies (ICTs) help to coordinate access to information and communication for agricultural and rural development (Ghogare & Monga, 2015). ICTs encourage and spread existing and new farming knowledge and information within the agricultural sector, as information is critical for rural and agricultural growth as well as economic and social transformation (Kintoki, 2017).

Farming enterprises can use ICTs to access university and government research and reports, communicate with customers and suppliers, access product information, pricing, and application software, collaborate with other specialists and producers, sell production, and buy inputs (Kintoki, 2017). Furthermore, according to Awuor (2016), ICTs provide a wide range of social and public services to farmers in remote rural locations, since these technologies become important tools for facilitating access to market prices. According to Kintoki (2017), e-agriculture serves numerous functions in rural agricultural development: it facilitates the practical dissemination of knowledge on food and forestry, animal husbandry, and agriculture through the use of ICTs. Provides farmers with easy access to accurate, up-to-date, and complete information, particularly in rural locations. By leveraging public-private partnerships, ICTs can be used to improve market access.

2.5.1 ICT role in rural development

Information and Communication Technology (ICT) is an acronym for information and communication technology. ICT includes things like information technology, corporate software, audio-visual systems, and middleware, which allow users to access, store, transmit, and change

data as needed (Pramanik et al, 2017). The exponential growth of internet users, the introduction of modern communication devices, and significant advancements in cloud and grid computing, among other factors, have aided ICT's development as a rapidly developing technological field over the previous decade, according to Pramanik et al (2017). Furthermore, according to Pramanik et al. (2017), extensive use of information and communication technology can assist a country develop an information-rich society and sustain livelihoods with competent leadership. Rural development is a planned, ongoing process of strengthening the socioeconomic well-being of people living in rural areas in order to improve their quality of life. We have primarily concentrated on enhancing education, agricultural processes, health care facilities, disaster management, tourism (where applicable), and other areas with the help of information and communication technology, thereby contributing to economic growth and improving quality of life.

According to Pramanik *et al* (2017), China has the world's largest population, with a substantial proportion of rural residents, and the country has used information and communication technology as a catalyst for rural development and improved quality of life. Furthermore, a large-scale assessment of Chinese middle and high schools found that the usage of information and communication technology (ICT) is narrowing the gap between urban and rural locations (Pramanik *et al*, 2017). According to the report, the country should invest in sufficient infrastructure to encourage more people to participate in ICT-based education. The availability of information and communications technology has resulted in tremendous economic growth in rural China (Lu *et al*, 2015). Rahaman (2013) examines the influence of ICT on the socio-economic situation of rural Bangladesh, highlighting the tremendous increase in rural people's usage of mobile phones, computers, and the internet. The authors investigated previous ICT implementation failures and offered a strategy with goal determination and a sustainability plan, as well as relevant literature evaluations on the ICT-based rural development model for South Africa (Pramanik *et al*, 2017).

2.6 Factors affecting adoption and usage of e-agriculture

The use of e-Agriculture is still in its early stages, evolving around the enormous multiplier impact capability that has the potential to drastically improve the farmer's economic and social situation, i.e. empowerment. Language restriction, according to Lwoga (2010), is a barrier to greater distribution of agricultural knowledge through community radio to local communities, limiting

farmers' ability to improve their agricultural activities. According to Mwakaje (2010), a number of constraints, including cost, availability, knowledge, and reliability, have hampered the use of ICT technology among farmers. Inadequate government digital service centres and facilities, lower internet speed, quality of information, inadequate ICT experts, lack of awareness towards benefits of ICT in Agriculture, user-friendliness of the technology, expensive to use, attitude towards new technology, lack of training, inadequate number of e-agriculture related programs in electronic media, and miserably ranked first, according to Rashid and Islam (2016). Rashid and Islam (2016) also discovered that age, farm size, annual household income, farming experience, agricultural knowledge, organizational membership, and Cosmo etiquette have no bearing on farmers' concerns with e-Agriculture.

2.6.1 Communication and influence

Communication and influence, according to Pathak *et al* (2019), alter adopters' willingness to adopt innovation. Furthermore, the nature of the social network in which the adopter participates to the intended communication plan, such as agricultural extension efforts, to promote the application of innovation is all part of the innovation adoption process (Pathak *et al*, 2019). The usage of communication channels, such as social networks, homogeneity, peer opinions, marketing, expert opinions, advocates, crossovers, and change agents, is a predictor of communication and influencing variables (Kountios *et al*, 2018). This factor defines the availability and power of a social network via which farmers meet new people and exchange their ideas and interests, including social contacts made through social media platforms like Twitter, Facebook, and Instagram (Kountios *et al*, 2018). Individuals or groups from outside the farm who help farmers enhance and change the farm's effectiveness and development are known as change agents (Pathak *et al*, 2019). Farmers' attitudes and behaviors can impact farm decisions, including the adoption of new technologies, therefore a specific network of farmers, their neighbors, and friends is described as a determinant in the eyes of their peers (Bagheri and Bordbar, 2014). Expert advice is critical for improving and changing the farm's efficiency and development. Pathak *et al*, (2019) further state that crop consultants, agricultural scientists, agricultural engineers, consulting service providers, universities, research centers, agronomists, and veterinarians are all considered expert viewpoints.

2.6.2 Adopter's characteristics

The qualities of persons involved in decision-making, such as farmers' needs, motivations, values and goals, skills, learning styles, and society, are particularly significant in the process of adopting innovation (Pathak *et al*, 2019). Farmers and farm personnel need management and technical skills to use technology, and many agricultural technology adoption studies consider criteria like education and training levels, managerial capabilities, and farmers' job experience as skill indicators (Bagheri and Bordbar, 2014). The degree of risk aversion, which varies depending on age and level of education, is a major motivating factor. For capitalized technologies that require a large capital investment, financial risk can be a significant issue in selecting whether to embrace those (Pathak *et al*, 2019). Aligning the potential influence of a technology with the lifestyle and business goals of farmers could be a factor in the adoption process. As a result, think about the adopter's values and aspirations. Triability refers to a user's ability to experiment with new ideas, and it aids early adopters in answering issues about how innovation works in agricultural settings (Kumar *et al*, 2018). Technology that can be tried in installments in limited space and time is adopted more frequently and quickly than innovation with less trial and error.

2.6.3 Characteristics of the innovation

According to Pathak et al (2019), the technological aspects selected are highly likely to be influenced by the features of the new innovation. The technology's comparative advantage over existing technology is measured in terms of effectiveness or cost-effectiveness, and the technology's efficacy can include environmental benefits as well as substantial information on field variability (Kumar *et al*, 2018). In the adoption phase, compatibility of the farmer's values and the innovation is critical, and technologies that are well linked with the farmer's values, standards, and perceived needs are compatible innovations (Kountios *et al*, 2018). Compatibility of new technology hardware and software components with the farmer's existing systems is a common example. A try ability feature can be defined as a technique that can be quickly tested with minimal criteria before the farmer confirms adoption (Kountios *et al*, 2018). Observability is critical since it informs farmers about the capabilities of new technology. It can apply to technology trials as well as the period when farmers or other industry members embrace the technology.

2.7 Market access and constraints

2.7.1 Affordability of Information and communication technologies

Acquiring ICT services significantly varies in different countries and also differs in a country (Shabolov *et al*, 2021). Additionally, Shabolov *et al* (2021) notes that 51% of the globe's population has access to internet while 49% of the population has still does not have access to internet. Moreover, Shabolov *et al* (2021) argues that there is a geographical divide, and that those who live in rural are disadvantaged in terms of ICT infrastructure, connectivity and digital engagement. This is attributed to affordability of ICT services because investment must be made in order to reach those in remote areas (Shabolov *et al*, 2021). Recently, Thomas *et al* (2016) argues that people in the urban areas have more access to ICT services because they earn more compared to their counterparts and so they can afford to pay for ICT services since their daily activities are based on using ICT tools.

2.7.2 Online marketing of agricultural produce

Online marketing is described as the use of information technology as a communication tool to support the implementation of business processes (Burgess *et al*, 2001). Information technology-enabled business activities, according to Kopraset *et al* (2021), include the use of digital technology and social media to provide information, receive online orders, and execute online transactions. To encourage direct-to-consumer marketing, some alternative farmers are resorting to modern approaches such as social networking (Kopraset *et al*, 2021). Furthermore, Kopraset *et al* (2021) identify three models of online marketing: employing information technology and digital social media to promote business products and services, providing information, news, and services, and introducing new products and services. Social media is used to process transactions. Information technology and digital social media are becoming more functional as a result of the application of innovation to bring value to operations in the vegetable supply chain through information management and multitasking. (Kopraset *et al*, 2021).

For the business's survival and expansion, including the use of online marketing models as a strategy for generating competitive advantages, allowing customers to get more value from the company's products or services than competitors. According to Laudon (2016), selling through online advertising channels is increasing popularity in agricultural businesses that provide items

that are desired in everyday life, such as sparkling veggies, secure vegetables, and natural vegetables (Kopraset *et al*, 2021). By merging technology and creativity, farmers and marketers have established a one-of-a-kind advertising channel model. As a result, they may alternate on line 24 hours a day, increasing opportunities for people all around the world. This will lower costs, increase sales, produce an aggressive gain, and provide two-way information (Kopraset *et al*, 2021). Rahaman (2019) examines the influence of ICT on the socioeconomic position of rural Bangladesh, highlighting the tremendous increase in rural people's use of mobile phones, computers, and the internet.

2.7.3 Socio-economic and demographic factors

According to Alam and Imran (2015) socio-economic and demographic factors such as income, employment and level of education, just to name a few result into digital division among the members of the society. This results in parts of the society particularly in the rural areas not being able to effectively and efficiently use ICT tools to better their lives both economically and socially (Alam and Imran, 2015). Additionally, Shabolov *et al* (2021) argues that digital innovation has a significant impact on economies and societies as discovered by previous studies and this does not only occur within a country but also across the borders of countries.

2.7.4 Market access

Market access is a term that explains itself, it describes the possibility of an enterprise to sell its produce whether locally or internationally (Keshave, 2013). According to Koppmair *et al* (2016) access to markets is important for households who are selling their vegetable produce and those who are buying the produce. Additionally, there are different markets which can be accessed by smallholder vegetable farmers which are local markets (in the village), district markets, national markets and international markets (Koppmair, 2016). Furthermore, Local markets and district markets mostly consists of smaller quantities being sold to satisfy immediate needs and are also important for fresh produce such as vegetables but district markets are usually distant and farmers have to travel long distance to reach them hence they do it occasionally (Koppmair, 2016). However, local markets are not available in every village.

According to Keshave (2013) price of the produce is dictates the market, however Omiti *et al* (2009) argues that the price has some influence on the market but is not sufficient to dictate it all alone. In contrast, Sichoongwe *et al* states that crop diversity on output influences access to markets as it increases choice for the consumer and also decreases risk. Moreover, Bittinge (2010) argues that farmers are predicted to alter their production as markets access improves so as to produce vegetables that are mostly demanded rather than those who are less demanded. However, information and communication technologies has the ability to improve market access for smallholder farmers as it provides farmers with timely and accurate information about local and outside markets and reduces the transaction cost and reduces time taken to search for markets (Fan and Salas Garcia, 2017). Except for the gender of the household head, average farm size owned, distance to the market, and transportation cost, Aku et al (2018) found no statistically significant differences between vegetable farmers who belonged to a farmer association and those who did not. Access to markets has a significant and long-term positive impact on farm income.

2.7.5 Challenges of market access

According to Osmani and Hossain (2015) the productivity of smallholder farmers is relatively low failing to have produce surplus to sell in the markets. Additionally, famers face challenges such as unsuitable government policies, insufficient access to reliable market information and local institutions challenges (Sharma *et al*, 2012). High transaction costs, lack of appropriate skills and organizations may act as barriers of market access to smallholder farmers (Osmani and Hossain, 2015). Moreover, aloofness of smallholder farmer's location, scares or poorly constructed/maintained roads, lack of transport and storage facilities, and struggling to access information about market prices prevent these farmers from accessing markets that are competitive (Sharma *et al*, 2012). Lastly, smallholder farmers are restricted to non-contestable markets dictated by few powerful buyers (Osmani and Hossain, 2015).

According to Antwi and Seahlodi (2011), Vegetable growers' success (operation and decision) is dependent on market availability, accessibility, and price.. As a result, the majority of smallholders receive uneven and incomplete market data resulting to lack of accessibility (Aku *et al*, 2018). This is because information is distributed across a variety of agencies, government departments, and private sector groups, making it difficult for smallholder farmers to get it, according to Aku *et*

al (2018). The Market Information System (MIS) must be enhanced to address the asymmetrical and insufficient information problem in order to establish a more competitive economic environment by minimizing informational asymmetry between agricultural commodities buyers and sellers (Aku *et al*, 2018). Farmers in most parts of Africa rely on trade information, despite the fact that it is more likely to be incorrect than information obtained from other sources such as the government, non-governmental organizations, and processing companies (Antwi and Seahlodi, 2011).

2.8 Theoretical framework

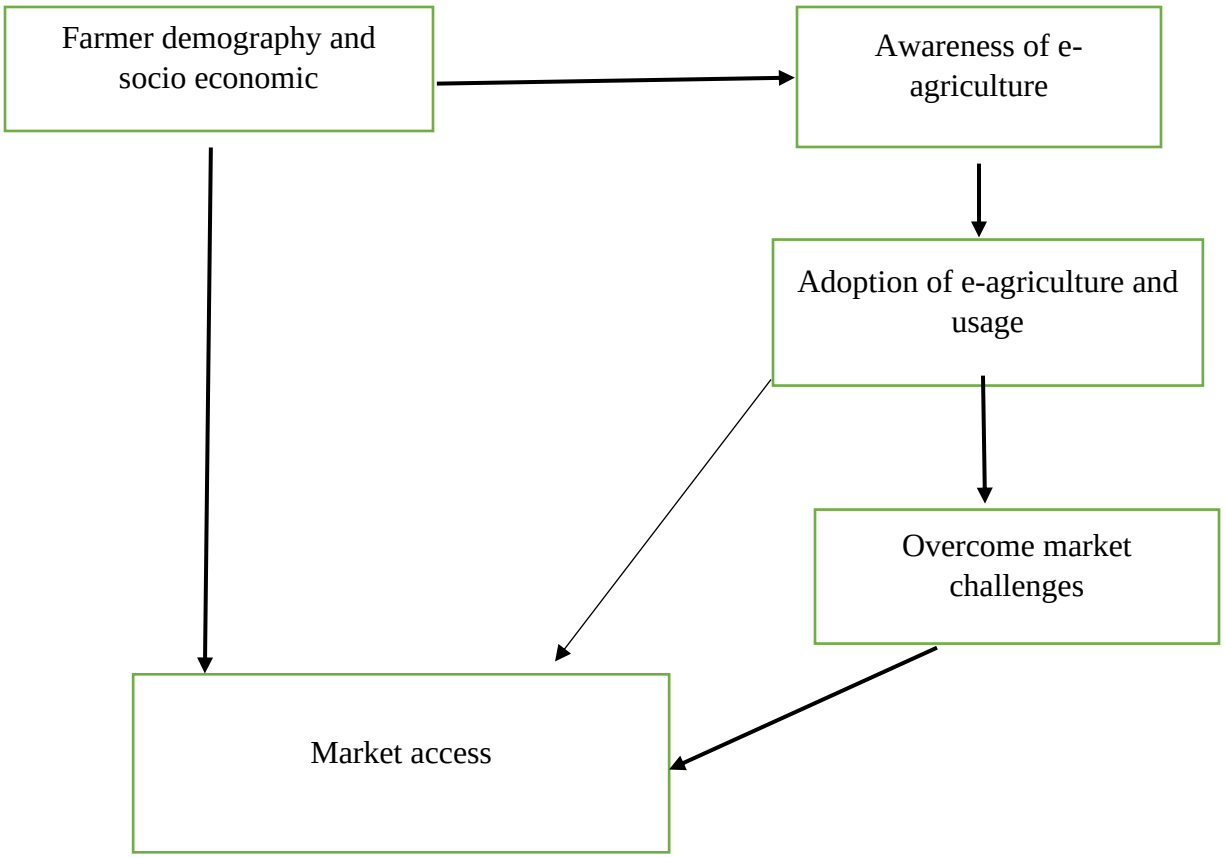
The study draws from the three theories adoption theory, utility maximization theory and Roger and shoemaker (1971) seminal model. Adoption theory looks the individual and the decisions they make about whether or not to adopt or reject a particular innovation and the degree to which it is incorporated into the proper context (Venkatesh, 2007). Utility maximization theory refers to the concept that farmers and businesses strive to get maximum satisfaction when making economic decisions (Herrnstein *et al*, 1993). The land mark Sender-Message-Channel-Receiver model outlines the process involved in the transmission of an innovation (in this case e-agriculture) through channels, over time, and among members of the social system, recognized the critical relationship between the sources of message and its influence on the recipient (Herrnstein *et al*, 1993).

These three theories relate to this study because the adoption decision of the farmer regarding e-agriculture has to be examined and incorporation of the e-agriculture into their farming activities. In addition, the utility theory is included in this study because with e-agriculture the farmer has the ability to reach more, and different market and therefore maximize market access and profit of the farm. Lastly, the land mark SMCRE model was incorporated in this research since the transmission of e-agriculture among farmers, social system of the farmer and critical relationship between the farmers and e-agriculture have to be understood.

2.9 Conceptual framework

A conceptual framework represents the researcher's synthesis of the literature on how to explain the phenomenon. It gives out the actions required in the course of the study, given the previous

knowledge of other researchers point of view and observation on the subject of research (Aku *et al*, 2018). This research was conducted to identify use of e-agriculture platform for ease markets access by smallholder vegetable farmers. To conduct this study a conceptual framework is needed to give an insight on what to expect when conducting the study, it shows how the variables are related to each other. The flow of the Figure 3.1 is illustrated by arrows.



Market access through e-agriculture

Figure 2. 1: Author's compilation (2021)

Demographic and socio economic characteristics of the farmer may act as barriers to access to markets and the use of e-agriculture. In order to access to use agriculture the farmers have to be aware of the concept of e-agriculture, awareness stimulates interest (in e-agriculture). When the vegetable farmer can use e-agriculture, he/she is in a state were he/she can overcome market access constraints and be able to market their products using the e-agriculture platform.

The conceptual framework gives an illustrations of variables relationship. Farmers socio-demographic (age, level of education, income level etc.) leads to the farmer being aware of e-agriculture. Awareness about e-agriculture leads to adoption of e-agriculture given that the e-agriculture is compatible with the farmers' values and needs. Adoption of e-agriculture depends on the farmers' view of the innovation and trial that was observed by the vegetable farmer when putting e-agriculture to test. Adoption of e-agriculture introduces the farmer to different markets for selling his/her produce and can help vegetable farmers in access these markets by providing accurate information which leads to accessing markets. The adoption stage leads to overcoming market access challenges by embracing e-agriculture and using ICT tools to effectively utilize e-agriculture as platform for market access.

2.10 Chapter summary

A significant number of South African smallholder farmers reside in rural areas as a result of the 1913 and 1936 native land acts. Rural areas in South Africa have poor infrastructure for economic growth and development. According to the literature reviewed, ICT infrastructure is poor in rural areas, education is also poor and so is the rate of employment in the rural South Africa. In order to benefit from the use of e-agriculture the vegetable farmers have to be aware of the concept, and use of e-agriculture and be willing to adopt the concept of e-agriculture in order to overcome market constraints. Additionally, famers must be able to use ICT tools in order to effectively benefit from e-agriculture. Literature reveals that to use e-agriculture to access markets farmers must be well equipped with necessary tools, and the farmer's communication channels and ICT infrastructure at the farmers' disposal.

CHAPTER THREE: STUDY METHODOLOGY

3.1 Introduction

This chapter describes the research methodology, which includes a description of the study region, research design, study population, sampling techniques and processes, data collection method, data analysis, reliability and validity, and ethical considerations..

3.2 Description of the study area

In the North West Province, the Bojanala Platinum District Municipality is a Category C municipality this means that the district has more than one municipality. It is bordered on the north by the Waterberg District Municipality, on the south by the Dr Kenneth Kaunda District Municipality, on the east by the City of Tshwane Metro, on the south-east by the West Rand District Municipality, and on the west by the Ngaka Modiri Molema District Municipality. It consists of five local municipalities: Kgetlengrivier, Madibeng, Moses Kotane, Moretele, and Rustenburg. It is one of four district municipalities in the province. Rustenburg is the headquarters of Bojanala Platinum. The district covers an area of 18 333 km2².

Figure 3. 1: Map of Bojanala district

Source: www.Bojanala.gov.za (2020)

Northwest province population has 13.8% of severe inadequate food access and 21.9% of food access inadequacy according to statsSA (2020). This may indicate that the farmers in the areas are unable to reach markets in the area to sell their produce. The former homelands, which were delineated by the Native Land Acts of 1913 and 1936, are home to the majority of South Africa's vegetable producers, who produce mostly for domestic use (Pienaar and Traub, 2015).

3.3 Research paradigm

According to Denscombe (2008), a study paradigm is the regulation of customary beliefs and consensus divided between scientists about obstacles should be understood and worked on. Quantitative, qualitative, and mixed method paradigms are the three categories of paradigms (Denscombe 2008). This study used interpretative paradigm because of the type of questions of this study. Interpretative research focusses on analytically disclosing those meaning-making practices, while showing how those practices configure to generate observable outcome (Albon and Mukkherji, 2010). Additionally, the advantage of using interpretative methods of research is the responses are valid and close to the truth (Albon and Mukkherji, 2010). It gives good reflection of how people are truly feeling often providing an accurate picture and measuring what the researcher set out to measure (Albon and Mukkherji, 2010).

3.4 Research approach

Study approaches are detailed study strategies and methods that cover everything from broad assumptions to data collection, analysis, and interpretation in great detail (Denscombe 2008). This study used a mixed method approach because it required both qualitative and quantitative data. Qualitative study uses methods such as respondent’s observations or articles that result in a narrative. A quantitative study collects and analyzes numerical data. The mixed method approach as a research paradigm contains a specific set of ideas and behaviors that distinguish it from the other major research paradigm (Denscombe 2008). A mixed method means that the researcher collect and analyze both qualitative and quantitative data within the same study, this is important for this study as it requires both quantitative and qualitative data.

3.5 Research design

Because the data gathered was focused on respondents' opinions and attitudes, a cross-sectional descriptive survey design was used for this study. A descriptive survey emphasizes a precise numerical or numerical description and depiction of the respondents' opinions, beliefs, and abilities (Cooper and Schindler, 2008). This form of survey aids in the removal of any bias that may have happened during the data collection process as it considers both the farmers' opinion and numerical values. The farmer might not have a numerical value for a question but might have some idea he has observed when performing farm activities. The data was gathered to answer the study's questions, and a model was used to analyze the data to exclude any irrelevant information.

3.6 Population of the study

The term "study population" refers to a subset of the targeted population from which the sample of the study is actually extracted (Cooper and Schindler, 2008). According to the Bojanala district's department of agriculture and rural development (2020), there are 309 smallholder farmers spread around the area, with 120 of them producing vegetables such as spinach beans, potatoes, butternut, cabbage, and tomatoes.

3.7 Sampling techniques and sample size

Sampling entailed selecting a representative sample of the population and using the information gathered as research data (Frey et al, 2000). Respondents were randomly selected from five municipalities in the Bojanala district, namely Moses Kotane, Moretele, Rustenburg, and Kgetlengriver, using a random sampling technique. Random was used mainly for its simplicity, and lack of biasness as each respondent in the population has an equal chance of being chosen and the sample represents the entire population. To calculate the sample size two steps will be taken, first to calculate the sample size for infinite population and calculate the adjusted the sample size for the required population:

S = infinite population

Z = z-score (at 95%) = 1.96

P = population proportion (assumed to be 0.5)

M = marginal error = 0.05

$$s = \frac{z^2 \times p \times (1-p)}{m^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

$$s = \frac{1.96^2 \times 0.5 \times (1-0.5)}{0.05^2}$$

$$s = 384.16$$

The infinite population is equal to 384.16

The second step is the determine the sample size of the required population (adjusted S)

Population = 120

Infinite population (s) = 384.16

$$\text{adjusted S} = \frac{S}{1+[\frac{(S-1)}{POPULATION}]} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

$$\text{adjusted S} = \frac{384.16}{1+\frac{(384.6-1)}{120}}$$

$$\text{adjusted S} = 92$$

The sample size of the study was determined to have 92 respondents from the targeted population of vegetable farmers in the Bojanala District. Random sampling was chosen because it removes any sort of bias or at least it should, this is because respondents from the subset of the larger population are chosen at random, each member in the population has the same probability of being chosen.

3.8 Method of data collection

Primary data was collected by the researcher from first-hand sources through interviews, it was in line with the research project directly from the farmers (Yin, 2017), and this required farm visits. Questions included qualitative and quantitative questions and open and, non-open questions. Three

agricultural economists (enumerators) were helping with data collection as they are experienced the field of data collection. The data collectors were asking questions to the respondents and taking note of their responses individually. Additionally, a workshop was held to help the colleagues who were helping with data collection understand the nature of the questionnaire and clear any misconceptions and any other obstacle about what was done during data collection. The survey was conducted by visiting farms where farmers farm and ask them questions.

3.9 Data analysis

The data for this study was analyzed using three tools which are descriptive statistics (charts, frequencies, tables, mean and percentages), binary logistic model and factor analysis for different suited objectives.

3.9.1 Socio-demographic characteristics of smallholder vegetable farmers in the Bojanala District.

Objective 1 was analyzed using descriptive statistics to characterize socioeconomic and demographic characteristics. Descriptive statistics describes coefficients that summarize a given data set (Kenton, 2018). Descriptive statistics involved the use of charts, frequencies, graphs, mean, standard deviation, tables and percentages.

3.9.2 To determine whether the smallholder farmers in the Bojanala district are aware of e-agriculture.

To investigate objective 2: To determine whether the farmers in Bojanala district are aware of e-agriculture statistics was used. Frequencies, tables and standard deviation will be calculated in order to examine the objective.

3.9.3 To investigate the willingness of vegetable farmers to adopt e-agriculture.

A binary logistic model was used to investigate objective 3. According to Green (2002), the most common method for analyzing binary responses is binary logistic regression. Green (2002) also points out that a random utility model can be used to motivate ordered choice models; for example, assuming the utility of choice j is:

$$U_{ij} = Z'_{IJ}\beta + \varepsilon_{ij} \qquad (3.1)$$

If the farmer makes choice *j* in particular (willing to adopt or not willing to adopt), then we assume that U_{ij} is the maximum among the *j* utilities. Thus, the standard model will be managed by the probability that choice *j* is made which is:

Probability $\left(U_{ij} > U_{ik}\right)$ for all other k ≠ j (3.2)

Furthermore, (Greene, 2002) points out that if Y_i reflects the choice made, then the binary logistic model will be represented as follows: With J disturbances distributed identically and independently, the binary logistic model will be represented as follows:

$Prob(Y_i = j) = \frac{e^{\beta jxi}}{\sum_{k=0}^{J} e^{\beta kxi}}$ Where j = 0, 1……..J (3.3)

Equation 3.6 represents a Binary logistic model logistic model that can provide a set of probabilities for the J + 1 choice for the decision taker with characteristics X_i. Consequently, we can compute J log-odds ratio as in equation 3.2 above. From the point of view of estimation, it is useful that the odds ratio P_j/P_k does not depend on other choices which follow from the independence of disturbances in the original model (Greene, 2002).

3.9.4 Description of variables

The description of variables is illustrated on Table 3.2 below indicating the variables (independent and dependent) description and the hypothesis. Some variables are also include in the table to predict their influence to the dependent variable.

Table 3. 1: Shows the description of variables in Binary logistic regression

VARIABLES	DESCRIPTION	HYPOTHESIS (PRIOR EXPECTATION)
DEPENDENT VARIABLE		
Willingness to adopt e-agriculture		+/-
INDEPENDENT VARIABLES		
GENDER	1=female; 0=male	+
AGE	Age in years	-
FEDUC	Level of education(Years in school)	+
HS	Household size(in number of persons)	+
SOI	Source of income(yes= 1; No= 2	+
TSI	Type of source of information(1=access to internet; 0 otherwise)	+
POF	Reason for producing crops(1=both consumption and market sales; 0 otherwise)	-
FAEX	Experience in farming(in years)	+
AOLI	Amount of land in use(in hectors)	-
LOC	Level of commitment(1=fulltime; 0= part-time)	+

Source: Authors own compilation (2021)

Gender: This variable is measured as a dummy where 1= female farmer and 0= male farmer. Women are participating more in farming activities compared to men, this may be attributed to men migrating to urban areas for employment opportunities.

Age: The variable age represents the famers' real age in years. In comparison to younger farmers, older farmers are less willing to adopt new advances.

Level of education: The number of years the farmer spent in school is used to calculate this variable. Literate farmers, according to Oyakale (2014), are more inclined to adopt new agricultural advances.

Household size: This is a continuous variable that is determined by the number of individuals in the home.

Source of income: This variable is measured as a dummy, with 1 indicating farmers who have income and 0 indicating farmers who do not. Source of income has a favorable impact on technology adoption; it is an important tool for addressing the credit constraints that smallholder farmers in developing countries confront (Mwangi and Kariuki, 2015).

Reason for producing crop: This variable is measure as a dummy variable where 1= consumption, and marketing and 0= otherwise. A farmer farming for consumption and marketing may be likely willing to adopt e-agriculture to improve market access abilities.

Farming experience: The number of years a farmer has been committed to farming is used to calculate this variable. Farmers with greater expertise are more likely to be skeptical of new technology since they already have a method of doing things.

Amount of land in use: This variable is continuous and is measured in hectares.

Level of commitment: This variable is treated as a dummy variable where 1= full time farmer and 0= part time farmer.

3.9.5 To explore the factors affecting market access of smallholder vegetable farmers.

To examine objective 4 factor analysis was used to determine factors affecting market access. Factor analysis is a statistical tool used to describe variability among observed correlated variables in terms of a potential called factors (Laurent *et al*, 2021). Factor analysis is mostly used in social science studies but modern studies (Lavanya and Santharooban, 2018; Laurent *et al*, 2021 & Dash *et al*, 2021) have adopted the method into the field of agriculture. Only components that explain the data set are taken into account, not the unique variance of all variables. Principle Component

Analysis, on the other hand, starts by extracting the highest level of variation and putting it into the first factor, then subtracting the variation described by the first two components and extracting the maximum variance for the second factor; however, this is not relevant for this study because it only needs factors that explain the majority of the variance. Factor analysis is based on the **common factor model**, illustrated in Figure 3.2.

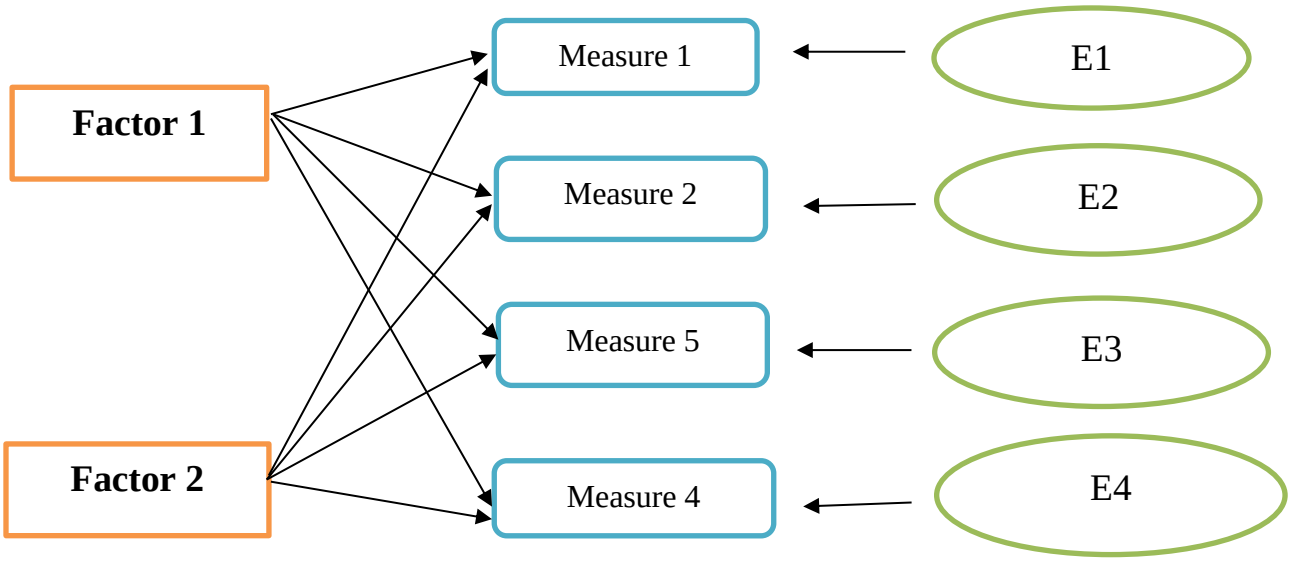


Figure 3. 2: The common factor model

Source: Decoster, 1998 page number

According to Decoster (1998), every observed feedback (Measure 1 to Measure 4) in this case variables (age, gender, level of education, farming experience, household size, amount of farming land, and amount paid for ICT services) are affected by underlying common factors (Factor 1 and Factor 2) and partially by underlying unique factors (Factor 1 and Factor 2). (E1 to E4). Each measure has a different strength of linkage between individual factors.

In factor analysis, the pattern of correlation (or covariance) between the observed measurements is investigated. Highly correlated (positive or negative) measures or variables are most likely influenced by the same factors, whereas uncorrelated measures or variables are most likely influenced by different factors (Decoster, 1998).

3.10 Reliability and validity

The main aim of reliability in research was to regulate errors and biasness in the results (Yin, 1989). According to Mzuyanda (2014) reliability looks at the conditions of how reliable the apparatus used are. Additionally, reliability involves stability and evaluates results that would be produced if the data collecting apparatus was used to same respondent on a separate occasion (Mzuyanda, 2014). Lastly, reliability ensures that gathered measurements are consistent throughout the study. Validity of the study was chosen in relation to the design of the research in order to check for bias.

Validity in research refers to the degree to which the research's components represent the theory, concept, or variable under investigation (Yin, 2017). Consistency was employed meaning each questionnaire was treated the same as the previous and the next one to avoid any biasness or false results (Yin, 2017). Internal validity was used to ensure validity of the results of the study (Yin, 2017). According to Lowe *et al* (2002) internal validity evaluates the study design and how accurate does it eliminate biasness. Internal validity is applicable to both qualitative and quantitative research. For this study Cronbach's alpha was used as a calculation to ensure reliability and validity of the research Cronbach Alpha was used to measure consistency and bias.

In order to compute Cronbach Alpha a Listwise deletion was determined to verify the degree of theory to components. Listwise deletion is a statistical strategy for dealing with missing data and if a single value is missing in this procedure the entire record is rejected from analysis (Pepinsky, 2018). Cronbach's alpha is a scale dependability indicator, according to Heo et al (2015). It is a measure of internal consistency, or how closely a collection of objects are related to one another. The presence of a "high" alpha value does not imply that the measure is one-dimensional, and if you want to prove that the scale in question is one-dimensional in addition to checking internal consistency, you can conduct other analyses (Heo *et al*, 2015). Exploratory factor analysis is one method for determining dimensionality.

3.11 Chapter summary

This chapter provided an overview of research technique, which included a description of the subject area, research design, study population, sampling size and methods, data collection method, data analysis, and reliability and validity. A questionnaire was distributed to the

respondents via face-to-face interviews in order to collect the data. The binary logistic model and factor analysis were employed to analyze descriptive statistics. The research findings are discussed in the following chapter.

CHAPTER FOUR: RESULTS INTERPRETATION

4.1 Introduction

In this chapter, the study's findings will be discussed. The data findings and discussions will be primarily based on the farmers' demographic and socioeconomic characteristics, smallholder vegetable farmers' awareness of e-agriculture, farmers' willingness to adopt e-agriculture, and factors affecting smallholder vegetable farmers' market access in the markets. The study's findings were interpreted using descriptive statistics- frequency tables, graphs, and pie charts.

4.2 Socio-demographic characteristics of vegetable farmers

4.2.1 Demographic characteristics of smallholder vegetable farmers

Demographic characteristics are commonly used are race, age, income, educational level, employment status, and location (Wanger, 2007). For this study demographics include Gender, Age, Population Group, Marital Status, Farmers' Status and Level of Education.

Table 4. 1: Demographic characteristics where n=92

Gender	**Frequency**	**Percentage (%)**
Male	31	33.70
Female	61	66.30
Total	92	100
Population group		
African	77	83.70
Coloured	15	16.30
Total	92	100
Marital status		
Single	16	17.39
Married	46	50
Divorced	22	23.91
Widowed	8	8.70
Total	92	100
Farmers farming status		
Full time	42	45.65
Part time	50	54.35
Total	92	100
Level of education		
None	45	48.91
Primary	31	33.70
Secondary	16	17.39
Total	92	100

	Mean	**Minimum**	**Maximum**
Age	53.66	25	68

Source: Field Survey 2021

4.2.1.1 Gender of the household head

The results on Table 4.1 show that 33.70% of the respondents were male and 66.30% were female. This results show that male farmers participate more in farming activities compared to women. A study by Palacios-Lopez *et al* (2017) revealed that women in Africa participate in agriculture more than men as they use agriculture as primary source of food and income to take care of their families and their contribution to labour rages from 60% to 80%. The results of this are in line with the literature reviewed on gender as the results indicate that most of the respondents were females with

a percentage that is within the range (60% to 80% participation) as suggested by Palacios-Lopez *et al* (2017).

4.2.1.2 Age of the household head

According to Rashid and Islam (2016), age has no bearing on the difficulties farmers confront when using e-agriculture. To put it another way, the age of the household head is a critical aspect since it determines whether the household benefits from the older person's experience or makes decisions based on the risk-taking attitudes of younger farmers (Makhura and Mokoena, 2003).

Table 4.1 illustrates that the average number of years among the respondents is 53.66 years with a minimum of 25 years and a maximum of 68 years. In addition, the results show that most of the people taking part in farming in the area are old and they are more reliant on the methods that they have been using for throughout their faring years and the results also show that youth participation in agriculture in the area is low due to migration to urban areas for better employment opportunities.

4.2.1.3 Population group

The results on Table 4.1 indicate that 83.70% of the smallholder farmers are African and 16.30% of the smallholder farmers are coloured. This shows that most of the smallholder vegetable farmers living in Bojanala district are African with a lesser number of other population groups. This results indicate empowering these farmers with better methods for farming and marketing of their produce will have a positive impact on economic growth as blacks are most disadvantaged population group economically in South Africa.

4.2.1.4 Marital status

Table 4.1 also shows 17.39% of the respondents were single, 50% of the respondents were married, 23.91% of the respondents were divorced and 8.70% were widowed. The purpose of marital status evaluation was to make sure that all the marital groups were accommodated. It generally believed that married households have more stability in farming when compared to their counterparts and in some instances have more economic power when compared to their counterparts (Mzuyanda, 2014).

4.2.1.5 Level of education

According to Oyekale (2014), literate farmers are likely to adopt new innovations such as e-agriculture than illiterate farmers. Table 4.1 reveals that a significant number of famers are old and have none or little formal education this may be due to the injustices of the apartheid government. It was found that 48.91% of the farmers have no formal education, 33.70% of the farmers only went to primary school, 17.39% of the farmer went secondary school and none have tertiary education. Most of the farmers have no formal education and this may be as a result of being disadvantaged by the previous government of apartheid but due to advancements in telecommunications, digitalization, the rapid growth of smartphone and the provision of extension services by the government it important to consider other variables not just education level.

4.2.2 Socio-economic characteristic of smallholder farmers

Farmers' socio-economic characteristics describe the social and economic experiences of which influences the personality, attitude and lifestyle of the farmers (Chavula, 2013). The former homelands, which were disadvantaged by the Native Land Acts of 1913 and 1936, are home to the majority of South Africa's vegetable producers, who produce mostly for domestic use (Pienaar and Traub, 2015). In this study socio-economic characteristics are farmers' status, source of income, type of source of income, children and number of children.

Table 4. 2: Socio-economic characteristics where n=92

Source of income	**Frequency**	**Percentage (%)**
Yes	65	70.65
No	27	29.35
Total	92	100
Type of source of income		
None	27	29.35
Government grant	42	45.65
Formal employment	16	17.39
Off-farm income	7	7.61
Total	92	100
Children		
Yes	82	89.13
No	10	10.87
Total	92	100
Number of children		
None	10	10.87
1 to 5 children	60	65.22
6 or more children	22	23.91
Total	92	100
Household size		
Less than 5	62	67.39
6 and more	30	32.61
Total	92	100
Farmers status		
Full time	42	45.65
Part time	50	54.35
Total	92	100

Source: Field Survey 2021

4.2.2.1 Income and Type of source of income

Source of income has a positive effect on technology adoption; it acts as an essential approach for controlling credit constraints faced by smallholder farmers in developing nations (Mwangi and Kariuki, 2015). Famers with higher level of income are able to afford and adopt new technologies such as ICT compared to those with little farm income (Diiro, 2013). Previous studies indicate that

most of small-scale farmers have inadequate external sources of income because they depend on farming (Mzuyanda, 2014).

Table 4.2 shows that 29.35% of the respondents have no income besides farming, 46.74% of the respondents receive grants from the government, 17.39% of the respondents are formally employed while 7.61% of the respondents have other forms of off-farm income. In contrast to previous studies, the results of this study show that most of the respondents have other sources of income besides faming this can be accredited government grants and the rapid growth of the city of Rustenburg which is rich in platinum mineral, providing employment to the community.

4.2.2.2 Number of children and household size

According to the results in Table 4.2, 10.87% of the respondents do not have children, 65.22% of the respondents have between 1 and 5 children while 23.91% have 6 or more children. Table 4.2 also indicate that 67.39% of the farmers have a household size of less than 5 members and 30.61% of the farmers have a household size of 6 or members.

A large household may benefit from family members taking part or helping with farming activities on the farm, this can also result in increased production/surplus in the farm which has to be sold at the market in order to make profit (Mzuyanda, 2014).

4.2.2.3 Farmer's status

Table 4.2 illustrates that 45.65% of the farmers farm full time and 54.35% of the farmer's farm part time. The study considers the farmers' status because full time farmers invest more time invested into farming activities than part time farmers which gives them more time to improve their farming management and production.

4.3 Awareness of e-agriculture by smallholder vegetable farmers

Beale and Bolen (1955) were one of the first to conduct a study that suggested that awareness is a critical initial stage of agricultural technology diffusion process. Extension services is a key aspect of technology adoption as farmers are usually made aware of effective use and benefits of new technologies from extension officers (Mwangi and Kariuki, 2015).

Table 4. 3: Awareness about e-agriculture where n=92

Access to information	**Frequency**	**Percentage (%)**
Television	2	2.17
Radio	35	38.04
Newspaper	12	13.04
Internet	16	17.39
Extension agent	27	29.35
Total	92	100
Farmer information share		
Yes	79	85.87
No	13	14.13
Total	92	100
If no, reason		
Lack of trust	9	6.52
Benefits sharing	7	7.61
N/A	79	85.87
Total	92	100
If yes, does it help with problem solving ?		
Yes	79	85.87
N/A	13	14.13
Total	92	100
Knowledge about e-agriculture		
Yes	3	3.26
No	89	96.74
Total	92	100
Preferred method of farming		
Traditional	66	71.74
Innovative	26	8.26
Total	92	100
Technology impact		
Yes	78	84.78
No	14	15.22
Total	92	100

Source: field survey 2021

4.3.1 Access to agricultural information

Access to extension services by small scale farmers was proven to have a big influence on the awareness of modern technology since extension facilitates the farmer's learning process and provide farmers with useful information (Kinyanjui, 2012). According to Table 4.3, 2.17% of the farmer's access information on television, 38.04% of the farmers rely on radio for agricultural information, 13.04% of the farmers acquire farming information from reading newspapers, 17.39% of the farmer's extract farming information from the internet and 29.35% of the farmers receive information from the extension agents.

The results reveal that the most of the farmers access their information through the radio which can be associated with them being old, most of the information in present times is sourced from the internet. Less than 30% of the farmers receive their information from extension agents which indicates inadequate extension services in the area.

4.3.2 Farmer's information share and reason

According to Oreglia (2013), sharing of information among smallholder farmers is very important as it can help with problem solving and increase competition among farmers. The results on Table 4.3 show that 85.87% of the farmers share farming information with other farmers while 14.13% of the farmers do not share information with other farmers. The results on Table 4.3 also shows that 6.52% of the farmers do not share information due to lack of trust and 7.61% of the farmers do not share information because they do not want to share benefits. The results further show that 85.87% of the farmers who share information indicated that information sharing helps with problem solving at the farm.

This show that more than 80% of the farmers share information with other farmers in order to solve problems and also share information about markets. Additionally, a significant amount of the vegetable farmers recognise the importance of sharing information with other farmers which is an important aspect of e-agriculture.

4.3.3 Knowledge about e-agriculture

Inadequate government digital service centers and facilities, slower internet speeds, poor information quality, a scarcity of ICT professionals, and a lack of awareness about the benefits of ICT in agriculture are all factors that contribute to a lack of e-agriculture knowledge (Rashid and Islam, 2016).

Table 4.3 shows that only 3.26% of the farmers have knowledge about e-agriculture and 96.74% of the farmers don't have any knowledge about e-agriculture. Most of the farmers do not have knowledge about e-agriculture but are aware of the importance of technological incorporation in the agriculture or farming.

4.3.5 Preferred method of farming and impact of technology

Innovative farming has a significant potential in improving farming in developing or rural domain as it aims towards sustainable agriculture and increased production while minimizing the cost of production (Pivoto, 2018). The results on Table 4.3 show that 71.74% of the farmers preferred traditional method of farming while only 28.26% of the vegetable farmers prefers innovative method of farming. Also, the results show that 84.78% think technology has a positive impact in agriculture and 15.22% of the farmers do not share the same narrative.

The results show that most prefer traditional method of farming over innovative method of farming. In contrast, most of the farmers acknowledged that technology has a positive impact in agriculture. This indicates that the farmers do not prefer innovative method of faming due to trust of the adopter about innovation or lack of resources because they do acknowledge the importance of technology.

4.3.6 Technology impact

Information and communication technology (ICT) represents a vast number of technologies, applications, and services, according to Pradhan and Mohapatra (2015). ICT uses a variety of software and hardware and frequently operates across telecom networks.

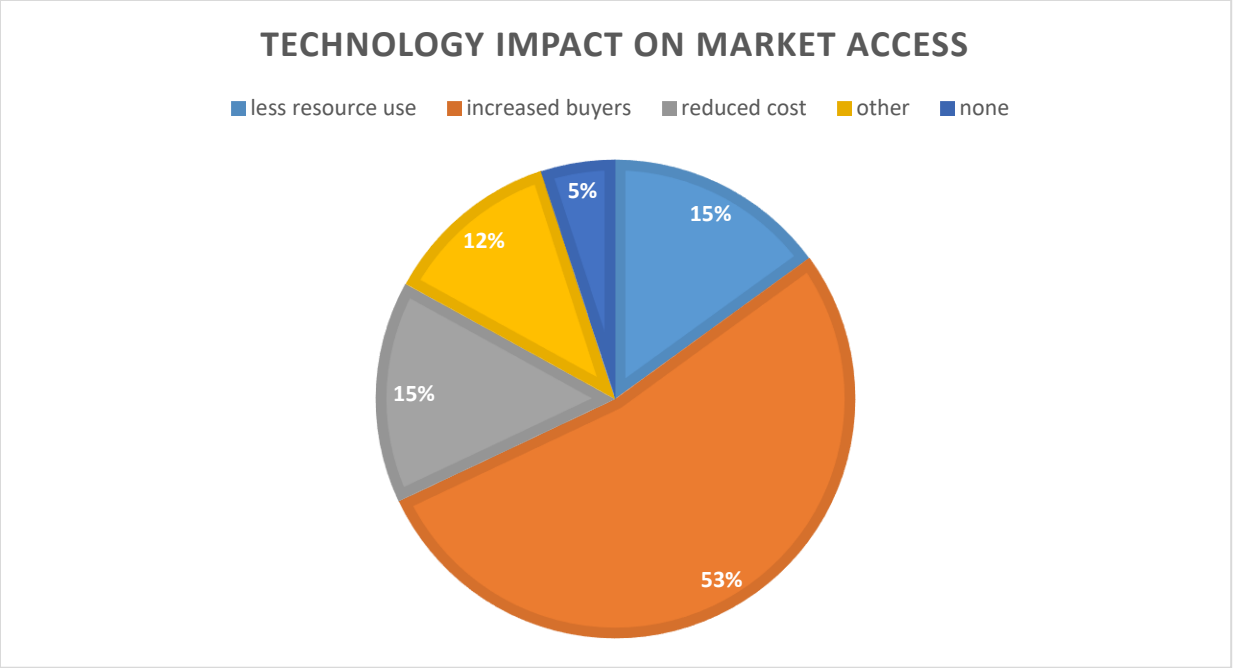


Figure 4. 1: Technology impact on markets access

Source: Field survey 2021

Figure 4.2 shows the reasons given by responding farmers about the impact of technology in accessing markets. The figure illustrates that 15% of the farmers indicated that the technology results in less resource use when accessing markets, 53% of the vegetable farmers outlined that it exposes the farmer to a large amount of buyers, 15% of the farmers indicated that technology reduces the cost of market access, 12% indicated that there are another benefits of technology and 5% of the farmers do not see any benefits regarding technology in agriculture.

4.4 Adoption of e-agriculture of e-agriculture by smallholder vegetable farmers

The use of e-Agriculture is still in its infancy, evolving around the enormous multiplier impact capability that has the potential to drastically alter the farmer's economic and social situation (Lwoga, 2010). According to Islam (2016), adoption necessitates taking into account the farmers' information sources and disseminating the knowledge through a reliable source.

Table 4. 4: Adoption of e-agriculture where n=92

Smartphone ownership	**Frequency**	**Percentage (%)**
Yes	34	36.96
No	58	63.04
Total	92	100
Information search		
Yes	34	36.96
N/A	58	63.04
Total	92	100
Willing to adopt e-agriculture		
Yes	42	45.66
No	50	54.34
Total	92	100
Farmers organization		
Yes	18	19.57
No	74	80.43
Total	92	100
Online marketing		
Yes	20	21.74
No	72	78.26
Total	92	100
If no, why?		
N/A	20	21.74
Understanding	63	69.48
Resources	9	9.78
Total	92	100
ICT institute in the area		
Yes	73	79.35
No	19	20.65
Total	92	100
How often do you visit the ICT institute		
None	19	20.65
Twice a month	9	9.78
More than 3 times	12	13.04
Other	52	56.52
Total	92	100

	Mean	Min	Max
Amount payable	I6.30	1	60

Source: Field survey, 2021

4.4.1 Smartphone ownership and use for information search

Smartphone technology holds promise for agriculture's future development because it can simplify and improve a variety of operational operations, and it can also be used in conjunction with precision agriculture technologies like e-agriculture (Michels *et al*, 2020). The results on Table 4.4 show that 36.96% of the farmers own a smartphone while 63.04% of the farmers indicated that they do not own a smartphone. The results on Table 4.4 also show that 36.96% of the farmers all use their smartphones to search for information on the internet.

The study reveals that most the respondents do not own a smartphone while the respondents who own a smartphone use it to search for information, the farmers who own smartphone are significant to initiate the first step of being aware of e-agriculture and trial phase of the innovation as their number is not necessarily low.

4.4.2 Willingness to adopt e-agriculture

The results in Table 4.4 reveal that 45.66% of the vegetable farmers are willing to adopt e-agriculture while 54.34% of the farmers are not willing to adopt e-agriculture. According to Mwinuka *et al* (2017) the rate at which a new technology is adopted is largely determined by its profitability, the degree of risk it entails, capital requirements, agricultural policies, and farmer socioeconomic characteristics.

The results indicate that almost half of the farmers are willing to adopt e-agriculture the other half is not willing to adopt e-agriculture and this can be attributed to lack of knowledge about e-agriculture or the farmers have no practical example of e-agriculture at their disposal in order to make an informed decision.

4.4.3 Farmer’s organization

According to Lee *et al* (2021), Government departments must rely on the community to transmit information, just as businesses must pay attention to community operations such as farmers’ organization. The results on Table 4.4 indicate that 19.57% of the farmers belong to farmer

organizations and 80.43% of the farmers do not belong to any farmer's organization. The study results however show that most of the farmers in the area do not belong to farmer's organizations. This may indicates that most the farmers in the area are not organized which is a disadvantage for adoption of e-agriculture as it easier reach and communicate with farmers in groups rather than individually.

4.4.4 Online marketing and reason for no usage

Lee *et al* (2021) also notes that Covid-19 has ravaged the world in recent years, and many physical stores have had to migrate to online stores. Table 4.4 shows that 21.74% of the farmers' market their products online and 78.265 of the farmers do not market their vegetables online. The vegetable farmers who do not sell their produce online gave reason for not marketing online. The results exhibit that 69.48% of the farmers do not use online marketing due to lack understanding and 9.78% indicated that they do not use online marketing because of lack of resource as seen in Table 4.4.

It was revealed by the data that most of the farmers do not market their vegetables produce online because of the lack of understanding. However, with proper understanding which can be provided by extension services or government policies which are in line with promoting sustainable agriculture through technological innovations the farmers can better understand online marketing and its benefits during the present time of covid-19. Training of extension agents about knowledge of online marketing can be helpful in assisting farmers understand online marketing.

4.4.5 ICT institute in the area, how often do you visit and amount payable

According Kintoki (2017) information and communication technologie are important tools used in e-agriculture to support agricultural development. An ICT institution contains tools such as internet connection, computers and printers. Table 4.4 illustrates that 79.35% of the farmers do not have ICT institution in their area and 20.65% of the farmers have ICT institution in their area. The results show that there is poor ICT infrastructure in most of the areas covered by this study. The table also shows that 20.65% of the farmers do not visit an ICT institution, 9.78% visit the institution twice a month, 13.04% visit the institution more than three times a month and 56.52% of the farmers indicated that they visit the institute randomly. Table 4.4 convey the amount of

money paid when visiting the ICT institute in Rands, the average was R16.30 with a minimum of 0 and a maximum of R60.

The respondents revealed that they have ICT institutions in their areas and also indicated that they do visit the institution and paying an average amount of R16.30 which is considerably fair. This is advantageous when initiating e-agriculture as platform to ease market access as farmers have ICT tools at their disposal. The results also revealed that 79.35% of the visit the institution at least once a month.

4.5 Factors affecting market access of vegetable farmers

Market access is a term that explains itself it describes the possibility of an enterprise to sell its produce whether locally or internationally (Keshave, 2013). According to Koppmair *et al* (2016) access to markets is important for households who are selling their vegetable produce and those who are buying the produce.

Table 4. 5: Resource owned by the smallholder vegetable farmer, where n=92

Reason for producing crops	**Frequency**	**Percentage (%)**
Own consumption	51	55.43
Consumption and marketing	41	44.57
Total	92	100
Land acquisition		
Bought	37	40.22
Inherited	40	43.48
Other	15	16.36
Total	92	100
Farm ownership		
Individual	65	70.65
Family members	27	9.35
Total	92	100

	Mean	**Minimum**	**Maximum**
Amount of land	3.44	0.5	20

Source: Field survey, 2021

4.5.1 Reason for producing crops

Table 4.5 indicates that 55.43% of the farmer's produce vegetables for own consumption and 44.57% of the vegetable farmers indicated that they are producing vegetables for consumption and marketing meaning some of the produce is sold to make profit. Given that a significant number of farmers are farming for consumption and marketing it is advisable to recommend adoption of e-agriculture to them and introduce them to new markets, These results illustrate that the farmers farming for consumption have an edge on those who farm for marketing and consumption. This variable was analyzed in order to have a clear picture of how many farmers are farming in order to market their products and make profit.

4.5.2 Land acquisition and farm ownership

The results in Table 4.5 show that 40.22% of the farmers bought the land they use for farming, 43.48% of the farmers inherited the land used for farming and 16.30% of the farmers were allocated the farming land by local authority in their region. The table also shows that 70.65% of the vegetable farmers individually own the land they are farming in and 29.35% of the farmers indicated that family members own the farm. The farmers who own the land they are farming can be motivated to increase profit and expand farming facilities and farmers who do not own the farm might not be interested in expanding farming facilities due to the fact that they do not own the farm.

4.5.3 Amount of land in use

According to (Rashid and Islam, 2016), the size of a farm has little bearing on the challenges that farmers experience when using e-agriculture. According to the data in Table 4.5, the average quantity of land used by farmers is 3.44 hectares, with a minimum of 0.5 hectare and a high of 20 hectares. Farmers with more acreage are more likely to seek to enhance productivity and profit, and are more willing to try new methods to achieve their goals. Since land size has no bearing on the challenges faced by farmers when using e-agriculture it is advisable to adopt e-agriculture.

4.5.4 Farm production and ranking of produce in terms of cash

Production on the farm enables the vegetable farmer to have food in the household and/or surplus to be sold to the market and make profit (Pinaar and Traub, 2015). The existence of the

farm depends on the ability of the farm to produce products that can be used for trading and consumption (Pinaar and Traub, 2015).

Table 4. 6: Vegetables ranked in terms of cash where n=92

Spinach	**Frequency**	**Percentage (%)**
Poor	39	42.39
Average	32	34.78
Outstanding	21	22.83
Total	92	100
Beans		
Poor	15	16.30
Average	29	31.52
Outstanding	34	36.96
N/A	14	15.22
Total	92	100
Potatoes		
Poor	11	11.96
Average	25	27.17
Outstanding	56	60.85
Total	92	100
Cabbage		
Poor	29	31.52
Average	34	36.96
Outstanding	29	31.52
Total	92	100
Tomatoes		
Poor	30	32.61
Average	44	47.83
Outstanding	18	19.57
Total	92	100

Source: Field survey 2021

4.5.5 Vegetables ranked in terms of cash

Aloofness of smallholder farmer's location and struggling to access information about market prices prevent these farmers from accessing markets that are competitive (Sharma et al, 2012). In addition, smallholder farmers are restricted to non-contestable markets dictated by few powerful buyers (Osmani and Hossain, 2015). The results in Table 4.6 show that 42.39% of the farmers rank spinach in terms of cash as poor, 34.78% rank spinach average in terms of cash and 22.83% of the farmers rank it outstanding in terms of cash. Additionally, the table indicates that 16.30% of the

farmers ranked beans as poor in terms of cash, 31.52% ranked beans as average in terms of cash, 36.95% ranked it outstanding and 15.22% of the farmers do produce beans. Furthermore, 11.96% of the farmers ranked potatoes poor in terms of cash, 27.17% of the farmers ranked potatoes average in terms of cash and 60.87% ranked potatoes outstanding. Moreover, 31.52% of the farmers ranked cabbage poor in terms of cash, 36.96% of the farmers ranked it average and 19.57% of the farmer's ranked cabbage outstanding in terms of cash. Lastly, 32.61% of the farmers ranked tomatoes as poor, 47.83% of the farmers ranked tomato average in terms of cash while 19.57% of the farmers rank tomato outstanding in terms of cash.

4.5.6 Marketing of vegetables

Marketing is a term that explains itself, it describes the possibility of an enterprise to sell its produce whether locally or internationally (Keshave, 2013). According to Koppmair *et al* (2016) access to markets is important for households who are selling their vegetable produce and those who are buying the produce.

Table 4. 7: Marketing of vegetable farmers n=92

Quantity harvested	**Frequency**	**Percentage (%)**
50kg	23	25.00
20kg	35	38.04
10kg	19	20.65
1kg	5	5.43
Bunch	10	10.87
Total	92	100
Quantity sold		
50kg	10	10.87
20kg	14	15.22
10kg	17	18.48
N/A	51	55.43
Total	92	100
Wish to sell		
N/A	30	32.61
50kg	36	39.13
20kg	9	9.78
10kg	7	7.61
1kg	7	7.61
100kg	3	3.26
Total	92	100
Reason for difference		
Profit	44	47.83
Expand	18	19.57
N/A	30	32.61
Total	92	100
Where		
Town	5	5.43
Township	17	18.48
Village	18	19.57
N/A	52	56.52
Total	92	100
To whom		
N/A	52	56.52
Individual	33	35.81
Large scale	7	7.61

Source: Field survey 2021

4.5.7 Quantity harvested, quantity sold, wish to sell and reason for the difference

Table 4.7 illustrates that 25% of the vegetable farmers indicated that they harvested 50kg, 38.04% harvested 20kg, 20.65% harvested 10kg, 5.43% harvested 1kg and 10.87% of the farmers harvested a bunch. Table 4.7 also shows that 10.87% of the farmers sold 50kg of the harvested vegetables, 15.22% of the farmers sold 20kg, 18.48% of the farmers sold 10kg and 55.43% of the farmers did not sell their vegetables in the last 12 months. The table further shows that 39.13% of the farmers wish to sell 50kg of vegetables, 9.78% wish to sell 20kg, 7.61% of the farmers wish to sell wish 10kg, 7.61% of the farmers wish to sell 1kg, 3.26% of the farmers wish to sell a bunch and 32.61% of the vegetable farmers do not wish to sell.

The statistical results of this study show that majority of the vegetable harvested less than 20kgs and majority of the farmers did not sell their produce, this can be as a result of the regulations of the covid-19 pandemic and the harvested vegetables were consumed by the household.

4.5.8 Place of selling and to whom

The results in table 4.7 illustrates that 5.43% of the vegetable farmers sold their produce in the nearest town, 18.48% of the farmers sold their produce in the township, 19.57% of the farmers sold their produce in the village while 56.52% of the farmers did not sell their produce. In addition, table 4.8 shows that 35.87% of the farmers sold their produce to individual customers, 7.61% of the vegetable farmers sold their produce to a large scale farmer.

These results reveals that most of the farmers do not sell their produce due to the covid-19 pandemic and because their way of marketing requires contact as they have to sell to customers physically in the township, village or in the nearest town. It is for this reason that e-agriculture can be very helpful in the marketing of the farmer's produce during the present time of the new normal.

4.6 Binary logistic model representing willingness to adopt e-agriculture

According to Green (2002) a binary logistic regression is the most common method used to analyze binary responses. The results in Table 4.9 illustrates indicate willingness to adopt e-agriculture by smallholder vegetable farmers and the results are represented on the Table 4.8 below.

Table 4. 8: Binary logistic model results of regression model showing the willingness of farmers to adopt e-agriculture

Variables	Coefficient	Standard error	Significant level
Age	-0.058	0.0299	0.0481*
Level of education	0.706	0.3766	0.05122*
Amount of land in use	-0.0086	0.065	0.8954
Information search	0.899	0.387	0.037*
Preferred method of farming	0.22332	0.565	0.013*
Farming experience	0.6686	0.044	0.086**
Access of information	0.643	0.505	0.204**
Model summary: Observations = 92 ProbChi2 = 0.0002 Loglikelihood = -58.2 PseudoR = 0.1 89			

Source: Regression model generated through STATA (2021)

Note: *statistically significant 5% level.

**statistically significant 10% level.

4.6.1 Model fitness

In order to compare the p-value for each term in the model to your significance threshold to evaluate whether the relationship between the response and each term in the model is statistically significant (Mehrolia *et al*, 2021). For this study a significance level of 0.05 was considered implies that there is a 5% chance of determining that an association exists when there is none. The p-value for this study is 0.0002, which is less than 0.05, indicating that the model is fit to run the data. The deviance R^2 (Pseudo R) must be between 0% and 100% for the model to fit the data and the deviance of the data is 0.189 indicating fitness.

4.6.2 Age

The variable “age” was found to have a negative relationship with willingness to adopt e-agriculture and is significant at 5 percent level, in contrast to Rashid and Islam (2016) observation that age does not influence on farmers’ adoption of e-Agriculture. In contrast to the literature the results show that age can influence adoption of e-agriculture. The results in Table 4.8 indicate that the probability of older people to adopt e-agriculture decreases by 0.048. This could be as a result of not being involved in the digital present times as older people prefer old tradition of doing things

4.6.3 Level of education

The variable “level of education” was identified to have a positive relationship with the willingness to adopt e-agriculture and it is significant at 5 percent level. This indicates that as the level of education increase so does willingness to adopt e-agriculture by 0.05122 or as one has high level of education he/she is more likely to be willing to adopt e-agriculture this results are in line with literature reviewed. According to Oyekale (2014), literate farmers are likely to adopt new innovations such as e-agriculture than illiterate farmers. In contrast, the results show that most of the farmers do not have formal education and this could affect the adoption process.

4.6.4 Usage of smart phone information search

The results in Table 4.8 illustrates that searching for information using a smartphone was identified to have a positive relationship with willingness to adopt e-agriculture, significant at 5 percent level. These results show that as one uses their smartphone to search for information the more they are willing to adopt or likely willing to adopt e-agriculture. According to Michels *et al* (2020) agues in line with the findings of this study that smartphone technology has promise for agriculture's future development because it can simplify and improve a variety of operational operations and can be coupled with precision agricultural technologies such as e-agriculture.

4.6.5 Preferred method of farming

The variable “preferred method of farming” has a positive relationship with willingness to adopt e-agriculture in order to ease market access and it is significant at 5 percent. This means, vegetable farmers who prefers innovative methods of farming are willing or most likely willing to adopt e-agriculture. Precision agricultural technologies are projected to help farmers improve their farm

management efficiency by reducing input use and, as a result, lowering negative environmental externalities (Michels *et al*, 2020). The probability of innovative farmers to adopt e-agriculture increases by 0.013.

4.7 Factor analysis

The factors that affect smallholder vegetable producers' access to markets were analysed using factor analysis. Factor analysis is a statistical technique for describing variability among connected variables in terms of a set of probable factors (DeCoster, 1998). To compute factor analysis, listwise deletion must be performed, and cronbach's alpha must be calculated to ensure that the results are reliable.

Table 4. 9: Listwise deletion

	N	**%**
Valid	55	100
Excluded	0	0
Total	55	100

Source: Computed from SPSS

Table 4.9 shows the results of Listwise deletion which indicates that all the 55 components included in the model are valid and none (0%) of the components were excluded or missing, therefore the study proceeded to compute Cronbach's alpha.

Table 4. 10: Reliability statistics

Cronbach's Alpha	**N of items**
0.791	3

Source: Computed from SPSS

The three items have an alpha coefficient of 0.791, indicating that they have a high level of internal consistency. Note that a reliability coefficient of .70 or higher is considered acceptable in most studies using factor analysis.

Table 4. 11: Kaiser-Meyer- Olkin and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling	0.614
Approx. Chi-square	86.923
Difference	28
Significance level (p value)	0.000

Source: SPSS, Computed by author, 2021

Table 4.11 shows the Kaiser-Meyer- Olkin and Bartlett's test from factor analysis ran in SPSS, the Kaiser Kaiser-Meyer-Olkin Measure of Sampling is 0.614 which is valuable because anything above 0.5 is considered valuable. The table also convey that Bartlett's test of sphericity shows that the p-value is less than 0.01 which indicates statistical significance and shows that the data can be analysed by factor analysis (Rummel, 1988).

Table 4. 12: Total variance explained

Component	Total	Eigenvalues % of variance	Eigenvalues Cumulative %	Total	%of variance	cumulative	Rotation sum of squared lodgings
1	2.202	27.523	27.523	2.202	27.523	27.523	2.196
2	1.217	15.211	42.734	1.127	15.211	42.734	1.178
3	1.041	13.015	55.749	1.041	13.015	55.749	1.094
4	0.987	12.338	68.087				
5	0.899	11.236	79.324				

Source: SPSS, Computed by author, 2021

Total variance explained is illustrated in Table 4.12 which shows that there are three components or factors explaining 55.749% of the data set in total. Component 1 explains 27.523% of the data, component 2 explains 15.211% and component 3 explains 13.015% of the data set. The components were 8 but only three components were found to explain the data set with 5 components not significant in explaining the data through the Eigenvalue.

Table 4. 13: Correlation matrix

	Level of education	Age	Farming experience	Source of income	Household size	Amount payable for ICT	Land in use
Level of education	1.000	-0.397	-0.260	0.289	0.103	0.156	0.066
Age	-0.397	1.000	0.529	-0.229	0.098	-0.359	-0.048
Farming experience	-0.260	0.529	1.000	-0.064	0.035	-0.326	0.078
Source of income	0.289	-0.229	-0.064	1.000	-0.076	0.318	0.092
Household size	0.103	0.098	0.035	-0.076	1.000	0.019	-0.103
Amount payable for ICT	0.156	-0.359	0.078	0.318	0.019	1.000	-0.013
Land in use	0.066	-0.048	0.036	0.092	-0.135	-0.013	1.000

Source: SPSS, computed by author, 2021

Table 4.13 gives insight on the correlation matrix of the analysed variables against one another. It is observed that each variable correlates a 100% with itself evident by a perfect correlation of 1.000 acutely sloping down. In addition, the table illustrates that age has a negative relationship with level of education with a moderate correlation of -0.397 which means that older respondents have lower level of education. This results are in contradiction with what was found by Rashid and Islam (2016) who argued that age does not influence problems faced by farmers' in the use of e-Agriculture. The results on Table 4.13 also show that farming experience has a positive relationship with age with a strong correlation of 0.529 which indicates that that as age increases the farming experience of a smallholder vegetable farmer also increases. Furthermore, the table illustrates that source of income has a positive relationship with the amount payable at an ICT institute, this indicates that as income increases so does the amount payable at an ICT institute.

Table 4. 14: Component matrix, principal component analysis

	Component 1	Component 2	Component 3
Level of education	0.621	-0.004	0.396
Age	-0.806	-0.020	0.130
Farming experience	-0.689	0.308	0.353
Source of income	0.518	0.329	0.29
Household size	-0.062	-0.561	0.015
Payment for ICT (R)	0.043	-0.078	0.814
Farming land (ha)	0.061	0.728	0.065

Source: SPSS, Computed by author, 2021

The results in Table 4.14 illustrates the rotated principal component matrix for each of the three factors/components and factor loadings shows the interaction of each factor with each identified factor (Rummel, 1988). Component/factor 1, 2 and 3 respectively were described as demographic traits, resource needed for marketing and affordability of ICT services. Component 1 was described as demographics characteristics because of the high correlation with the level of education, age and farming experience this is also evident in literature as Bujang *et al* (2010) noted that the local market is mostly determined by demographic variables. Component 2 was described as resources needed for market access due to farming land and the household size in use having a strong correlation with the component while considering the relationship of the variables. Household size has a negative relationship with resources needed for market access meaning when the household size increases it becomes easy to produce and access to markets given the family members participate in farming activities. Component 3 was described as affordability of ICT services due to high correlation with payment for ICT services in their area or the nearest town. Even though ICT's are considered cost effective in agriculture, the remote location of smallholder farmers increases the amount paid for ICT service in rural areas (Chavula, 2013).

4.8 Chapter summary

In this chapter, descriptive statistics were used to discuss the study's findings. The data findings and discussions focused primarily on demographic and socioeconomic factors, farmer awareness of e-agriculture, and factors affecting vegetable farmers' access to markets. The results of the study

were analysed using descriptive statistics, such as frequency tables, graphs, and pie charts, and the results of the binary logistic model were also addressed in the chapter. The summary of the study, major findings, conclusions, and recommendations will be presented in the following chapter.

CHAPTER 5: SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The goal of this study was to see how smallholder vegetable farmers in the Bojanala district could use an e-agriculture platform to make it easier for them to access markets. The study's findings will be published in order to contribute to the body of knowledge. As a result, the study's primary findings will be provided in this chapter. Following the conclusion of this study, policymakers, government officials, and other researchers will be able to provide recommendations that will aid in policymaking.

5.2 Summary

This research was carried out to assist smallholder farmers in the Bojanala district of the North West Province of South Africa to identifying the use of an e-agriculture platform to facilitate smallholder vegetable farmers' access to markets. E-agriculture requires the use of ICT tools which are very essential for the effective use of e-agriculture as a platform. However, little or very few studies in South Africa have explored the use of e-agriculture as a platform in easing market access. Thus, the aim of the study was to identify use of e-agriculture platform for ease markets access by smallholder vegetable farmers in Bojanala District, North West Province. the objectives of the study were to: determine the socio-demographic characteristics of smallholder vegetable farmers; determine whether the smallholder farmers in the Bojanala district are aware of e-agriculture; investigated the willingness of farmers to adopt e-agriculture and determined the factors affecting market access of smallholder vegetable farmers in markets. Descriptive statistics, binary logistic model and factor analysis were employed to analyze collected data.

5.3 Conclusion

This study recognized the potential application of an e-agriculture platform to help smallholder vegetable growers get access to markets. Conclusions are formulated at the quantity to which e-agriculture may be used as a platform to ease marketplace access of smallholder vegetable farmer. E-agriculture has an important role in providing accurate information about market access and introducing farmers new market opportunities but without the farmer being aware or willing to adopt the concept of e-agriculture it becomes difficult to use e-agriculture. Additionally, lack of

extension services, youth participation and training of extension agents about e-agriculture and its uses in production and marketing. In general, e-agriculture has the potential to ease market access for smallholder vegetable farmers as observed in other developing nations but it is important that stakeholders in the sector participate in the adoption and use of e-agriculture.

5.4 Policy recommendations

5.4.1 ICT infrastructure improvements in the areas

This research indicated that one of the factors affecting farmers to access markets is affordability of ICT services which can be attributed to remoteness of these vegetable farmers and insufficient ICT infrastructure. For this reason, the study recommends that the government and major entities providing ICT to work together to improve service delivery through improvement of ICT infrastructure in rural areas of Bojanala district where these farmers reside. This will bring about growth in internet penetration in the Bojanala district by farmers and reduce the cost of internet access. ICT tools also promote no contact communication which is very important during the current pandemic of Covid-19.

5.4.2 Increase extension services and training of extension agents about ICT and e-agriculture through government workshops

Extension services is a key aspect of technology adoption as farmers are usually made aware of effective use and benefits of new technologies from extension officers (Mwangi and Kariuki, 2015). Extension facilitates the farmers learning process and provide farmers with useful information but due to lack of extension services in the area this process of learning cannot take place and therefore, it becomes difficult to use innovative methods of accessing markets through e-agriculture using ICT tools. The results of this study showed that 29.35% of the farmers receive information from the extension agents which is inadequate and hinders the adoption of e-agriculture. Therefore, the study recommends that the local should increase extension services in the area and train extension agents through workshops about the use of ICTs and the concept of e-agriculture in order to disseminate the information to farmers.

5.4.3 Using smartphones to enhance e-agriculture usage among smallholder vegetable farmers

The use smartphone has grown significantly in developing nations particularly the African continent with a number of countries such as Kenya, Ghana and Rwanda are recognizing the potential of smartphones in promoting sustainable agriculture, promoting adoption of new technologies in agriculture, graduation of smallholder farmers from accessing local/traditional markets to a variety of other markets. The study results illustrated that smartphones have the ability to improve the willingness to adopt new innovations such as e-agriculture and the literature reviewed indicated that smartphone usage in Africa has increased significantly in the previous decade. Consequently, the study recommends that farmers should be encouraged to use smartphones so as to enhance the use of e-agriculture to access markets for their produce.

5.5 Implication for Future Research

The research was based on smallholder vegetable farmers and did not consider other types of farmers and also was restricted to Bojanala not general for the entire province. The research findings may help other researchers when exploring the entire province, the country or in consideration of other type of farmers. This research will also establish the understanding that the introduction of a policy may eliminate some of the dominant challenges faced by smallholder vegetable farmers when access markets, but as a side effect it may increase the influence of some different challenges. The research can help researchers who will be looking at the effects of adopting e-agriculture which were not explored in this study because to understand the effects one has to have some insight of the cause. The policy makers'/government organizations/regulators might get benefitted from the finding of this research.

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APPENDIX A (QUESTIONNAIRE)

NORTH WEST UNIVERSITY

FACULTY OF NATURAL AND AGRICULTURAL SCIENCES

DEPARTMENT OF AGRICULTURAL ECONOMICS AND EXTENSION

INFORMED CONSENT

This questionnaire is for the data collection on "exploring the potential use of e-griculture platform for ease market access amongst smallholder vegetable farmers in Bojanala, North West", and supervised by Dr M Christian. The information that will be collected using this questionnaire will only be used for research topic mentioned above.

GENERAL INFORMATION

DATE OF INTERVIEW: _____

LOCATION: _____

QUESTIONNARE NO: ----------

SECTION A

DEMOGRAPHIC AND SOCIO-ECONOMIC INFORMATION

Please indicate with an X where relevant

1. Gender:

Male___. Female___.

2. Age of respondent___.

3. Population group

African___. Coloured___. Indian___. White___.

4. Marital status

Married___. Single___. Divorced___. Widowed___.

5. Farmer status

Full time___. Part time___.

6. Highest level of education (indicated by number of years in school)

None___. Primary___. Secondary___. Tertiary___. Other (Please specify) ____.

7. Do you have any other source of income besides farming?

Yes___. No___.

8. **If yes,** please indicate the source of income below.

Source of income	Mark with X	Source of income	Mark with X
Government grant		Pension	
Formal employment		Off-farm income	
Other (Please specify)			

9. Do you have children?

Yes___. No___.

10. **If yes**, how many? ___.

11. What is the household size? _____.

SECTION B

AWARENESS AND ADOPTION OF E-AGRICULTURE

1. How do you access agricultural information? *Indicate with an X (you may tick more than one source)*

Television	Radio	Newspaper	Internet	Extension agent	Other

2. What is your most reliable source of agricultural information?

Television	Radio	Newspaper	Internet	Extension agent	Other

3. Do you own a smartphone?

Yes___. No___.

4. If yes, do you use it for searching for information?

Yes___. No___.

5. Do you think technology has a positive impact on market access?

   Yes___. No___.

6. Support your answer in q5 _____

7. Do you share information with other farmers?

Yes___. No___.

8. If no, State the reason why _____

9. If yes, does it help with problem solving?

Yes___. No___.

10. Do you belong to any farmer's organization?

Yes___. No___.

11. If yes, name the organization _____

12. Do you have any knowledge about the concept of e-agriculture?

Yes___. No___.

13. If yes, state it _____

14. Do you market your products online?

Yes___. No___.

15. If no, state why you do not use online marketing _____

16. Are you willing to adopt e-agriculture?

Yes___. No___.

17. Do you prefer

Traditional_____ or innovative _____ methods in agriculture

12. Is there any institution of ICT in the area?

Yes___. No___.

13. If yes, how often do you visit the institution? *Please indicate with X*

Once a month	
Twice a month	
More than three times a month	
Other (please specify)	

14. How much do you pay for the internet in those institutions?

R _____

SECTION C

MARKET ACCESS REQUIREMENTS FOR VEVETABLE FARMERS

1. Amongst the following, what is your main objective for farming*? (Please mark relevant option with X)*

Own consumption	Marketing	Own consumption and marketing	Other (please specify)

2. Farming experience in years _____

3. The amount of farming land in use. _____*ha.*

4. How did you acquire the land? (*Please mark relevant option with X)*

Bought	
Renting and/or share tenancy	
Lease	
Inherited	
Allocated by local authority	
Other (please specify)	

5. Who owns the farm? *(Please mark with X)*

Individual	
Family members	
Farmer's group	
Co-operative	
Private company	
Trust	
Other(please specify)	

6. Do you have individual HH plot of any of listed crops (Y/N)? If Y, what is the area, rank in terms of cash income (1 most important).

Crop	**Y/N**	**Area (Ha) planted**	**Rank in terms of cash**
Spinach			
Beans			
Potato			
Butternut/Pumpkin			
Cabbage			
Tomato			
All other vegs.			

7. In the last season, how much of each crop did you harvest from **INDIVIDAUL HH** plot? How many portions of harvest did you sell? How many portions would you have wished to sell, what is reason for difference, if any?

Crop	**Qty harvested**	**Measure (Code)**	**Sold**		**Wished to sell**	
			Portion out of 10	**Amt. realized**	**Portion out of 10**	**Reason for difference**
Spinach						
Beans						
Potato						
Butternut/Pumpkin						
Cabbage						
Tomato						
All other vegs.						

Code

1. 50kg
2. 20kg
3. 10kg
4. 1kg
5. Bunch
6. Head

8. If you sold any crop in the last 12 months, where did you sell and to whom did you sell mostly?

Crop	**Where (Code)**	**To whom (Code)**	**Codes**
			Where 1. Town 2. Township 3. Village **To Whom** 1. Individual 2. Large-scale farmer 3. Middlemen/traders

APPENDIX B (MODEL OUTPUTS)

MODEL OUPOUT OF BINARY LOGISTIC MODEL FROM STATA

```
logit willingnesstoadopt accesstoagricinformation reliablesourceofinformation
>  informationsearch

note: reliablesourceofinformation omitted because of collinearity
Iteration 0:   log likelihood = -14.860082
Iteration 1:   log likelihood =  -11.38169
Iteration 2:   log likelihood = -11.209793
Iteration 3:   log likelihood =  -11.20944
Iteration 4:   log likelihood =  -11.20944

Logistic regression                     Number of obs     =         23
LR chi2(2)        =       7.30
Prob > chi2       =     0.0000
Log likelihood =  -11.20944                     Pseudo R2         =     0.1457

------------------------------------------------------------------------------
knowlwdgea~t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
accesstoag~n |   .6431535    .505932     1.27   0.204     -.348455    1.634762
reliableso~n |    .5124574    .418341     2.00   0.002      .314522     3.881132
informatio~h |    2.89968   1.387858     2.09   0.037     .1795278    5.619832
_cons |  -7.358779   3.399904    -2.16   0.030    -14.02247   -.6950887
------------------------------------------------------------------------------
Iteration 2:   log likelihood = -10.341537

Logistic regression                     Number of obs     =         15
```

LR chi2(3) = 0.04

Prob > chi2 = 0.00001

Log likelihood = -10.341537 Pseudo R2 = 0.189

---

willingness~t	Coef.	Std. Err.	z	P>|z|	[95% Conf. Interval]	
doyoumarke~e	0	(omitted)				
ifnowhy	-.2231435	1.565248	-0.14	0.887	-3.290972	2.844685
preference~d	.22332	.565111	0.174	0.013	4.8642345	1.87678
ictinstiyude	.6694306	6.168468	0.11	0.914	-11.42054	12.75941
howoftendo~t	.2231435	1.565248	0.14	0.887	-2.844685	3.290972
_cons	-1.115718	11.96871	-0.09	0.926	-24.57396	22.34252

MODEL OUTPUT OF FACTOR ANALYSIS FROM SPSS

		LEVEL OF EDUCATION	AGE	FARMING EXPERIENCE IN YEARS	AMOUNT OF SOURCE OF INCOME	HOUSEHOLD SIZE	HOW MUCH DO YOU PAY	AMOUNT BOF FARMING LAND
Correlation	LEVEL OF EDUCATION	1.000	-.397	-.260	.289	.103	.156	.066
	AGE	-.397	1.000	.529	-.229	.098	-.359	-.048
	FARMING EXPERIECE IN YEARS	-.260	.529	1.000	-.064	.035	-.326	.078
	AMOUNT OF SOURCE OF INCOME	.289	-.229	-.064	1.000	-.076	.318	.092
	HOUSEHOLD SIZE	.103	.098	.035	-.076	1.000	.019	-.135
	HOW MUCH DO YOU PAY	.156	-.359	-.326	.318	.019	1.000	-.013

	AMOUNT BOF FARMING LAND	.066	-.048	.078	.092	-.135	-.013	1.000
Sig. (1-tailed)	LEVEL OF EDUCATION		.000	.006	.003	.163	.069	.265
	AGE	.000		.000	.014	.175	.000	.325
	FARMING EXPERIEC E IN YEARS	.006	.000		.274	.370	.001	.231
	AMOUNT OF SOURCE OF INCOME	.003	.014	.274		.236	.001	.192
	HOUSEHO LD SIZE	.163	.175	.370	.236		.429	.100
	HOW MUCH DO YOU PAY	.069	.000	.001	.001	.429		.450
	AMOUNT BOF FARMING LAND	.265	.325	.231	.192	.100	.450	

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.614
Bartlett's Test of Sphericity	Approx. Chi-Square	86.923
	df	28
	Sig.	.000

Total Variance Explained

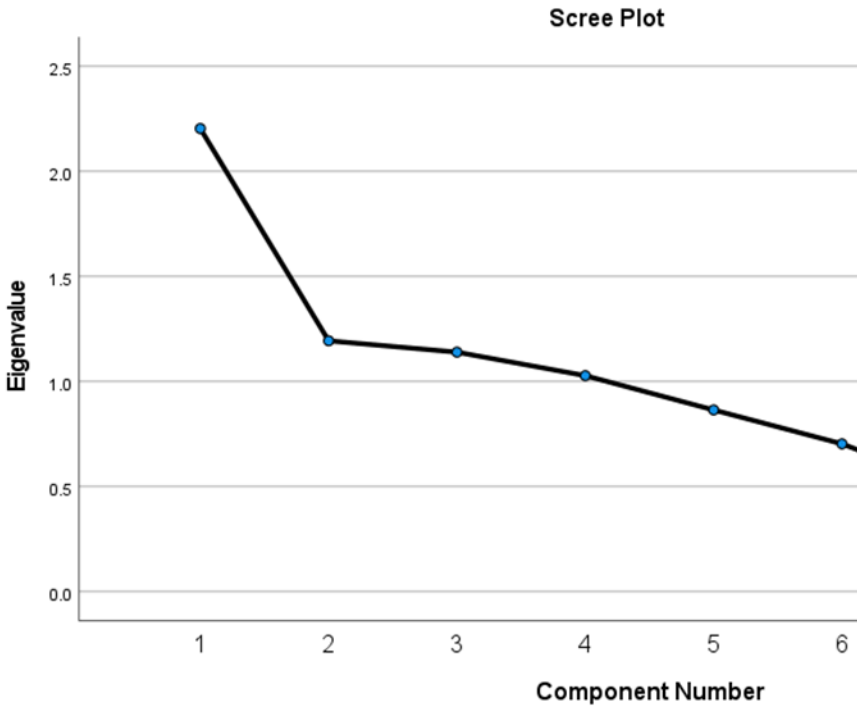
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	2.202	27.523	27.523	2.202	27.544	27.523	2.196	23.492	23.492
2	1.217	15.211	42.734	1.127	15.211	42.734	1.178	17.128	40.619
3	1.041	13.015	55.749	1.0.41	13.015	55.749	1.094	14.702	55.322
4	.987	12.338	68.087						
5	.899	11.236	79.324						
7	.471	5.890	95.027						
8	.398	4.973	100.000						

Extraction Method: Principal Component Analysis.

Communalities

	Initial	Extraction
LEVEL OF EDUCATION	1.000	.720
AGE	1.000	.702
FARMING EXPERIECE IN YEARS	1.000	.746
AMOUNT OF SOURCE OF INCOME	1.000	.661
HOUSEHOLD SIZE	1.000	.819
HOW MUCH DO YOU PAY	1.000	.549
AMOUNT BOF FARMING LAND	1.000	.584

Extraction Method: Principal Component Analysis.



Rotated Component Matrix[a]

	Component		
	1	2	3
LEVEL OF EDUCATION	.621	-.004	.396
AGE	-.806	-.020	.130
FARMING EXPERIECE IN YEARS	-.689	.308	.353
AMOUNT OF SOURCE OF INCOME	.518	.329	.290
HOUSEHOLD SIZE	-.062	-.561	.015

HOW MUCH DO YOU PAY	.043	-.078	.814	
AMOUNT BOF FARMING LAND	.236	.728	.065	

Extraction Method: Principal Component Analysis.

Rotation Method: Equamax with Kaiser Normalization.[a]

a. Rotation converged in 7 iterations.