ASSESSING THE EFFECTIVENESS OF PHONE-BASED DIGITAL AGRICULTURAL EXTENSION AND ADVISORY IN ETHIOPIA: EVIDENCE FROM EXPERT SERVICE PROVIDERS

BY MESSAY SINTAYEHU BESHAH

A THESIS SUBMITTED TO THE CENTER FOR REGIONAL AND LOCAL DEVELOPMENT STUDIES IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE MASTER OF ART IN REGIONAL AND LOCAL DEVELOPMENT STUDIES

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Title Page

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DECLARATION

I, Messay Sintayehu, hereby affirm that the thesis research titled "Assessing the Effectiveness of Phone-Based Digital Agricultural Extension and Advisory in Ethiopia: Evidence from Expert Service Providers" is entirely my original work. I confirm that this research has not been submitted, in whole or in part, to qualify for any other academic degree at any university. I have duly acknowledged and referenced all the materials referred to and utilized in this research.

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PRINCIPAL ADVISOR STATEMENT OF CERTIFICATION

I hereby certify that the thesis titled "Assessing the Effectiveness of Phone-Based Digital Agricultural Extension and Advisory in Ethiopia: Evidence from Expert Service Providers" was conducted by Messay Sintayehu as part of the requirements for the completion of the Master of Arts in Regional and Local Development Studies at Addis Ababa University. I confirm that this thesis represents an original piece of work and has been submitted with my approval.

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BOARD OF EXAMINERS STATEMENT OF CERTIFICATION

ASSESSING THE EFFECTIVENESS OF PHONE-BASED DIGITAL AGRICULTURAL EXTENSION AND ADVISORY IN ETHIOPIA: EVIDENCE FROM EXPERT SERVICE PROVIDERS

This thesis paper is prepared by Messay Sintayehu and submitted to the Center for Regional and Local Development Studies (CRLDS) in partial fulfillment of the requirements for the Master of Art in Regional and Local Development Studies.

Approved by Board of Examiners

We have examined and approved the thesis research report prepared and submitted to the Center for Regional and Local Development Studies.

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LIST OF ABBREVIATIONS AND ACRONYMS

AAU	Addis Ababa University
AGRA	Alliance for a Green Revolution in Africa
AI	Artificial Intelligence
ATI	Agricultural Transformation Institute
DA	Development Agent
ECX	Ethiopian Commodity Exchange
EIAR	Ethiopia Institute of Agricultural Research
FTC	Farmer Training Center
GDP	Gross Domestic Product
GIZ	German Corporation for International Cooperation
GO	Government Organization
ICT	Information Communication Technology
ILRI	International Livestock Research Institute
IoT	Internet of Things
IVR	Interactive Voice Response
LDI	Livestock Development Institute
MoA	Ministry of Agriculture
NGO	Non-government Organization
NRM	Natural Resource Management
PBDAEAS	Phone-based digital agricultural extension and advisory service
PES	Participatory Extension System
PS	Private Sector
PxD	Precision Development
RII	Relative Importance Index
SMS	Short Message Service
SNV	Netherlands Development Organization
SPSS	Statistical Packages for Social Science
TV	Television
US$	United States Dollars

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ABSTRACT

The effectiveness of phone-based digital agricultural extension and advisory services (PBDAEAS) in Ethiopia is a critical factor in enhancing agricultural productivity and livelihoods, given the sector's substantial contribution to the country's GDP and population's livelihood. Despite significant investments in traditional agricultural extension services, challenges persist, highlighting a gap in the understanding and utilization of digital solutions. This study investigates the PBDAEAS effectiveness, focusing on expert service providers to fill this research gap. The study was conducted in Ethiopia, a country where agriculture is the mainstay of the economy and where digital transformation in agriculture is still in its nascent stages. The study followed a quantitative research approach and a descriptive research design. A structured survey questionnaire was used to measure experts' perspectives of PBDAEAS effectiveness as explained by the variables cost, time, customization, and utilization. A census survey was used targeting 330 experts working in the digital agricultural extension and advisory services and based in Addis Ababa city, Sidama regional state, and Oromia regional state. The collected data were analyzed quantitatively using Descriptive Statistics and Relative Importance Index technique. The findings indicate that PBDAEAS is effective in several key areas. It is a low-cost means to disseminate standardized information to smallholder farmers, and it can timely deliver seasonal agriculture information to farmers. In addition, PBDAEAS facilitates better two-way communication with farmers and is easy for farmers to access agricultural information and advice. The study's implications are significant for policymakers and stakeholders in the agricultural sector. It recommends increased investment in PBDAEAS by the government and other key stakeholders to boost agricultural productivity and improve the livelihoods of smallholder farmers.

Key words: Phone-based digital agricultural extension and advisory service; Cost; Time; Customization; Utilization; Overall Effectiveness

CHAPTER ONE

1. INTRODUCTION

1.1 Background

The latest estimated population of Ethiopia stands at 127,857,431, according to the latest United Nations data analyzed by Worldometer (UNESA, 2022). Agriculture is the mainstay of the economy, accounting for 38.5% of the gross domestic product (GDP) and 85% of the population's livelihood (NPC, 2015; BMGF, 2010; Dercon et al., 2009). In the past forty years, the agricultural and rural development policies and strategies of the country have undergone changes to align with the economic development and rural transformation objectives of the governments. Despite these efforts, smallholder farming has experienced low agricultural production and productivity, leading to inadequate food supply for the country's growing population. Consequently, the nation has been persistently struggling with issues of food and nutrition security. Recognizing the prevailing issues, the government consider improving agricultural production and productivity through expanding and reinforcing the agricultural extension system to reduce poverty, ensure food security and sustainably manage the natural resources (Dufera & Wollega, 2018).

The government of Ethiopia has been at the forefront of innovators seeking to improve their public agricultural extension through large-scale investments in their existing system and capabilities. In the mid-2000s, for example, the government expanded its network of development agents (DAs) to an estimated 60,000, leading to one of the lowest ratios of farmer per extension worker in the world (Bachewe, 2019). However, even this expanded in-person extension system is faced with numerous challenges. Despite large DA numbers relative to other countries, there remains only one DA for every 476 farmers (Bachewe, 2019). Only 31% of male and 21% of female farmers report interacting with a DA in the past year (Mann and Warner, 2015). The DAs are expected to cover a vast area of land and that leads to limited quality control over the content dissemination and performance. While DAs focus on a specific geography, they have limited information on individual household needs and local conditions to customize their advice. In addition to these, the in-person extension system may be financially unsustainable, costing 1% of GDP (Krishnan and

Patnam 2014). To address these and other limitations of the conventional approach, it seems like digital agriculture is a preferred method by different actors in the sector.

The application of digital technology in agriculture can have a transformative and positive disruptive impact in increasing production, productivity, and adaptive capacity. According to research by McKinsey, increasing connectivity in agriculture through digital technologies could add US$500 billion to global GDP by 2030 (Stephenson 2021). In developed regions like the Global North, the agricultural technology market is primarily driven by precision agriculture technologies such as drones, robotics, IoT, AI, and blockchain. However, in agricultural economies like Ethiopia, where the widespread adoption of precision agriculture technologies may be financially challenging, mobile technologies continue to play a crucial role as the primary digital tools in agriculture. The increasing use of mobile phones, along with advancements in agricultural measurement and computational technologies, opens up new possibilities for overcoming the obstacles to providing pertinent information to small-scale farmers (Fabregas et.al 2022).

Ethiopia's digital agriculture is still in its infancy, with very few digital service providers and a handful of government-led digital initiatives. An overview of Ethiopia's digital agriculture ecosystem reveals that digital solutions (using IVR, video, radio, etc) are provided by a variety of public, private, international development and research institutions, and non-governmental organizations primarily focusing on advisory services for smallholder farmers (Tamene and Ashenafi, 2022). Ethiopia's MoA has made digital extension service a major pillar of its new agricultural extension strategy and together with the ATI have made large investments in expanding digital agricultural advisory services to supplement the in-person extension system.

The Ethiopian Extension Strategy which was released in 2017 puts digital means as one key strategic intervention points. Promotion of Digitalized & ICT-based Extension Communication System is the title of this specific strategic intervention. The strategy acknowledges that in Ethiopia, information primarily reaches farmers via indirect means such as radio and TV, as well as direct verbal communication channels including training sessions, meetings, conferences, and social gatherings, supplemented by observational learning. The strategy also states that enhancing the effectiveness of these channels can be achieved by providing farmers with access to new information and communication technologies (ICTs). ICTs offer an efficient and scalable means of delivering information to farmers in an engaging manner. In line with that ICT-based technology promotion and dissemination is identified as one intervention which includes the use mobile phones, IVR short codes (such as 8028 Farmer Hotline), video-based extension approach, DIGISOFT, Digital Agriculture, Farm Radio, TVs, and more (MoANR, 2017).

According to Fabregas et.al (2022), the utilization of information and communication technologies (ICT) and mobile phones, specifically, enables the delivery of low-cost, timely, and personalized information on a large scale. To determine the extent to which this holds true in Ethiopia, it is necessary to conduct research that gathers evidence from both the service providers and the service receivers. In this research, the researcher aims to investigate the factors that determine the relative of importance of phone-based digital agricultural extension and advisory services in Ethiopia, using evidence obtained from service providers. The study will take into consideration various phone-based digital agricultural extension and advisory services, such as SMS, IVR (inbound and outbound), and Smartphone applications. The study will investigate both the supply and demand sides of the service provision using the evidence collected from service providers. Through this investigation, the study will identify specific variables and assess their contribution to the effective provision of phone-based digital agricultural extension and advisory services in Ethiopia.

1.2 Statement of the Problem

Despite experiencing rapid economic and agricultural growth over the past two decades, Ethiopia remains one of the poorest countries in Africa. A significant portion of its population still relies on traditional farming practices, which impede rapid agricultural transformation and structural changes. The agricultural extension system is critical to this transformation (Bachewe et al., 2017). Consequently, Ethiopia has invested significantly in its agricultural extension system, aligning with national policies aimed at boosting agricultural production and productivity. However, despite these investments, the Ethiopian Agricultural Extension Strategy's goal of transforming subsistence farming into a market-oriented, commercially viable system faces numerous challenges.

The challenges facing Ethiopia's agricultural extension system are multifaceted. These include high maintenance costs, difficulties in reaching remote areas, limited resources, capacity gaps, delays in service delivery, and a lack of personalized advice. Such obstacles have severely hampered the quality and effectiveness of extension services in the country (Guush et al., 2018). Digital agricultural extension and advisory services, particularly those delivered via mobile phones, hold promise for overcoming these barriers. Information and communication technologies (ICT), especially mobile phones, enable the cost-effective, timely, and personalized delivery of information on a large scale. This is particularly beneficial for providing dynamic information that requires frequent updates, such as weather forecasts and market prices, and for reaching farmers in remote or conflict-affected regions (Fabregas et al., 2022).

In Ethiopia, digital transformation is still in its early stages. Recent years have seen the launch of some government-led digitalization initiatives and the emergence of digital services from non-governmental and private sectors (Tamene & Ashenafi, 2022). Among these, phone-based digital agricultural extension and advisory services stand out, leveraging SMS, interactive voice response (IVR) systems, and smartphone applications to reach smallholder farmers. Since 2014, various organizations have been involved in developing and disseminating digital agricultural content.

Despite the potential advantages of these services—such as cost minimization, timely delivery of advisories, customized content, and large-scale reach—their effectiveness in the Ethiopian context remains uncertain due to a lack of empirical evidence. This research aims to address this gap by examining the factors influencing the effectiveness of phone-based digital agricultural extension and advisory services in Ethiopia, using evidence from expert service providers. Data was collected via a Likert scale and analyzed using descriptive analysis and the Relative Importance Index (RII) to understand the effect of cost, time, customization, and utilization on the effectiveness of these services.

1.3 Objective of the Study

General Objective

The general objective of this study is to assess the effectiveness of phone based digital extension and advisory services in the agriculture sector of Ethiopia.

Specific Objectives

- To examine the relative importance of cost on the effectiveness of phone based digital agricultural extension and advisory services in Ethiopia
- To determine the relative importance of time on the effectiveness of phone based digital agricultural extension and advisory services in Ethiopia
- To investigate the relative importance of customization on the effectiveness of phone based digital agricultural extension and advisory services in Ethiopia
- To observe the relative importance of utilization on the effectiveness of phone based digital agricultural extension and advisory services in Ethiopia
- To observe the relative importance of the overall effective phone based digital agricultural extension and advisory services in Ethiopia

1.4 Research Questions

In this research, the following five research questions have been formulated.

- To what extent is phone-based digital agricultural extension and advisory service considered cost-effective in Ethiopia?
- To what extent is phone-based digital agricultural extension and advisory service is considered timely in Ethiopia?
- To what extent is phone-based digital agricultural extension and advisory service is considered useful to provide customized advisory in Ethiopia?
- To what extent is phone-based digital agricultural extension and advisory service is preferred for utilization by smallholder farmers in Ethiopia?
- To what extent is the phone-based digital agricultural extension and advisory service considered to be effective in Ethiopia?

1.5 Significance of the Study

As digital extension and advisory services is relatively new in Ethiopia, the study will have a significance in exploring the impact of cost, time, and customization on the effectiveness of phone-based digital agricultural extension and advisory services. By conducting this research, valuable insights will be gained in the following aspects.

Firstly, understanding the significance of cost is crucial as it directly affects the accessibility and affordability of these services. By investigating how cost influences effectiveness, the study can provide recommendations on how to optimize cost structures to ensure wider adoption and usage of phone-based digital agricultural extension and advisory services.

Secondly, the significance of time in relation to effectiveness is important because timely and prompt access to information and advice is crucial for farmers to make informed decisions. By determining the impact of time on effectiveness, the study can shed light on the importance of timely delivery of information and identify potential bottlenecks or areas for improvement in the delivery process.

Thirdly, investigating the significance of customization is essential as it recognizes the diversity of farmers' needs and preferences. By understanding how customization affects effectiveness, the study can provide insights into tailoring the content and delivery of phone-based digital agricultural extension and advisory services to better meet the specific requirements of different farmers, leading to improved outcomes.

Lastly, the significance of this study lies in its potential to contribute valuable insights into the role of farmers' utilization of digital extension and advisory services in the effectiveness of phone-based digital agricultural extension and advisory service provision. By investigating utilization, the study aims to shed light on the dynamics between farmers' engagement with digital platforms and the overall effectiveness of digital extension services. Understanding this relationship is crucial for policymakers, development practitioners, and agricultural service providers in Ethiopia, as it can inform strategies for optimizing the utilization of digital tools and enhancing the delivery of agricultural extension services to better meet the needs of farmers and promote sustainable agricultural practices.

Overall, the significance of this study lies in its potential to inform policymakers, development practitioners, international organizations, and donors whether phone-based digital agricultural extension and advisory services are effective or not. If the findings are positive, it will encourage government and non-government actors to put in the necessary resources to expand and strengthen digital services. Ultimately, this will benefit farmers and contribute to the long-term growth and sustainability of Ethiopia's agricultural sector.

1.6 Scope of the Study

The study focused on evaluating the effectiveness of phone-based digital agricultural extension and advisory services in Ethiopia, specifically within the crop and livestock sub-sectors. The modes of delivery considered in these services include SMS, IVR (inbound and outbound), and app-based services.

The researcher concentrated on the phone-based digital agricultural extension and advisory service providers in Ethiopia, including government organizations, non-government organizations, and private companies. These entities were believed to possess firsthand knowledge and experience in digital agricultural extension and advisory services, which they gained from offering either pure digital agriculture extension services or a combination of digital and agent-based agriculture extension services. These organizations and companies are based in Addis Ababa city and two other regional states, namely Oromia and Sidama.

The study analyzed five key variables to assess the effectiveness of phone-based digital agricultural extension and advisory services using the Relative Importance Index. These variables were cost (evaluating the low-cost nature of the services), time (assessing the timeliness of service delivery), customization (examining the ability to deliver customized content), utilization (measuring the application and adoption of the services by farmers), and effectiveness (determining the overall performance of the services at scale).

1.7 Operational Definition

- Phone-based digital agricultural extension and advisory service: This is a phone-based (mobile and landline) digital agricultural extension and advisory service provision to farmers and extension vis SMS, IVR and/or Smartphone.
- SMS: A short advisory text that is pushed to farmers and extension workers
- IVR-Inbound: An interactive voice response system that allows farmers to access pre-recorded agricultural advice messages through menu selection.
- IVR-Outbound: A push call system that allows farmers to access audio agricultural advice messages by answering the call.
- App based services: advisory services offered to agriculture extension workers and/or farmers via Telegram or WhatsApp groups and BOTs
- Cost: The cost of phone-based extension and advisory service per farmer reached
- Time: Timely reach of farmers and extension workers during disaster emergency, disease outbreak, weather updates, etc.
- Customization: The delivery of customized extension and advisory based the profile data collected from the farmer/farm.
- Utilization: The extent to which farmers actively engage with and apply digital extension services in their agricultural practices. The degree of use or application of digital extension service by farmers is expressed by preference, ease of use, understanding and adoption.
- Scale: The large-scale reach of farmers and extension workers using SMS, IVR and/or Smartphones.
- Pure digital extension and advisory service provision: Organization that are engaged in the provision of digital extension and advisory services only.
- Hybrid digital extension and advisory service provision: Organization that are engaged in the provision of digital and in-person extension and advisory services.

CHAPTER TWO

2. LITERATURE REVIEW

This section encompasses the literature review, divided into theoretical and empirical components. The theoretical literature delves into development theories highlighting agriculture's significance, agricultural development theories, and agriculture extension theories/models. The empirical literature review focuses on digital agriculture, agricultural extension, and phone-based digital agricultural extension & advisory. The conceptual framework of the study has been formulated in accordance with the insights gleaned from the reviewed literature.

2.1 Theoretical Literature Review

In classical development thinking, agricultural growth was seen as a crucial tool for both industrialization and the structural transformation of the economy. This transformation involved a diminishing share of labor engaged in agriculture and a declining percentage of GDP originating from the agricultural sector as the economy diversified away from farming. However, it is essential to recognize that agriculture serves multiple functions in support of the multifaceted nature of development. These functions extend beyond mere contributions to economic growth and include vital roles in poverty and hunger reduction, addressing rural-urban income disparities, mitigating vulnerability and food insecurity, and providing environmental services (Alain de Janvry and Elisabeth, 2015).

Consequently, agriculture is reclaiming its position as a pivotal instrument in development agendas. This is especially pertinent for Sub-Saharan Africa, where agriculture is poised to be the primary engine of economic growth, and the majority of the rural poor rely on agriculture for their livelihoods. In the subsequent sections, the literature review focuses on theories and models pertinent to [agricultural] development and agricultural extensions from early days to recent times.

2.1.1 Agriculture in Early Development Theories

The understanding and implementation of economic growth and development, especially with regard to the involvement of the agricultural sector, have evolved significantly over time. One notable early development theory is Walt Rostow's approach to leading sector growth stages. Rostow delineates five stages in the transformation from a primitive to a modern economy: (a) the traditional society, (b) the preconditions for take-off, (c) the take-off, (d) the drive to maturity, and (e) the age of mass consumption (Robert Potter et al. 2008).

Rostow's primary focus is on the societal progression from one stage to another, and his historical analysis is aimed at providing policy guidance to developing countries. His framework clearly emphasizes the dynamic role played by the agricultural sector in this transition process. In an open economy, industries in the primary sector may function as leading sectors, shouldering the responsibility of propelling growth during specific periods. Additionally, agriculture is tasked with fulfilling crucial roles: (a) supplying food for a rapidly expanding population, (b) creating a mass market for the products of emerging industrial sectors, and (c) generating the capital investment necessary for new leading sectors outside of agriculture (Vernon W Ruttan, 1965).

W. Arthur Lewis's agriculture-industry two-sector model stands out as one of the earliest and most debated frameworks. Instead of a rigid classification into agriculture-non-agriculture or agriculture-industry, Lewis introduces a distinction between capitalist and subsistence sectors within a closed economy (Vernon W. Yorgason 1972). In this arrangement, the capitalist sector utilizes reproducible capital and is responsible for all industrial output, while the subsistence sector initially contains non-reproducible capital, mainly in the form of agricultural land. According to this classification, the primary factor to be shifted from agriculture to industry is labor. The industrial sector has access to an abundant supply of this factor, priced at the prevailing subsistence wage in the agricultural sector. Lewis posits that the wage differential between the industrial and agricultural sectors may need to be substantial, potentially reaching 30 percent, to induce labor migration, primarily due to market imperfections.

2.1.2 Theories of Agricultural Development

Agriculture is a pivotal force in ensuring both food security and economic development. Nevertheless, a substantial portion of the global population, particularly in rural areas, relies directly or indirectly on agriculture for their livelihoods. The primary goals of agricultural development center around enhancing the material and social well-being of individuals. Numerous theories and models have been formulated to understand and guide agricultural development, including the frontier model, the conservation model, and others. Given the specific focus of this thesis research on agricultural extension and advisory, two pertinent models, the diffusion theory and the high pay-off input model, have been chosen for in-depth examination.

2.1.2.1 The Diffusion Theory

The exploration of the diffusion of innovations model commenced with the inquiry conducted by Bryce Ryan and Neal C. Gross in 1943, focusing on the adoption of hybrid seed corn among Iowa farmers. By 1941, approximately thirteen years following its introduction by agricultural researchers, nearly 100 percent of Iowa farmers had embraced this innovation. Ryan and Gross delved into the swift diffusion of hybrid corn within two Iowa communities, aiming to unravel the dynamics of this phenomenon and apply the insights gained to the diffusion of other agricultural innovations. Notably, the impact of the hybrid corn study extended well beyond the realm of agricultural innovations and transcended the tradition of diffusion research in rural sociology that Ryan and Gross epitomized (Encyclopedia of Public Health, 2023).

Scholars in diffusion theory have crafted analytical models to elucidate and predict the dynamics of how an innovation, defined as a novel idea, practice, or object, spreads within a socio-technical system. One scholar by the name of Rogers (1972) proposes a categorization of adopters into innovators, early adopters, early majority, late majority, and laggards, and he asserts that their adoption process over time aligns with the classical normal distribution curve. According to Rogers, innovators represent the initial 2.5% of adopters, followed by early adopters, early majority, late majority, and laggards constituting the subsequent 13.5%, 34%, 34%, and 16%, respectively. Another scholar Bass (1969) formulated a model for the diffusion of consumer durables and other products. Over time, the Bass model has found utility in predicting the diffusion of innovations across various domains, including retail service, industrial technology, agriculture, education, pharmaceuticals, and consumer durable goods markets, since its initial development.

In agriculture development, diffusion model is grounded in the empirical observation of significant variations in land and labor productivity among farmers and regions. According to this perspective, achieving agricultural development involves more effective dissemination of technical knowledge and a reduction in productivity differences among both farmers and regions (Udemezue &

Osegbue, 2018). Even in pre-modern societies, the diffusion of improved husbandry practices played a crucial role in productivity growth.

This diffusion model has significantly influenced research and extension efforts in farm management and production economics since the emergence of agricultural economics as a distinct sub-discipline in the late 19th century, bridging agricultural sciences and economics. However, the limitations of the diffusion model as a foundation for designing agricultural development policies became increasingly apparent as technical assistance and community development programs, rooted explicitly or implicitly in the diffusion model, fell short of generating rapid modernization of traditional farms or substantial growth in agricultural output (Ibid).

2.1.2.2 The High pay-off Input Model

The High Payoff Input Model emerged in the 1960s as a response to the inadequacy of policies based on models like the diffusion model. The crux of transforming a conventional agricultural sector into a robust contributor to economic growth lies in strategic investments aimed at providing farmers in impoverished nations with access to modern, high-yield inputs (Udemezue & Osegbue, 2018). The perspective shifted from viewing farmers in traditional agricultural systems as inefficient resource allocators to acknowledging their rational and efficient decision-making. The prevailing poverty among farmers was attributed to the scarcity of technical and economic opportunities available in most impoverished countries, limiting their ability to respond effectively.

Ruttan (1977) classified the new high pay-off inputs into three.

a) The capacity of public and private sector research institutions to produce new technical knowledge

b) The capacity of the industrial sector to develop, produce and market new technical inputs.

c) The capacity of farmers to acquire new knowledge and use new input effectively.

However, apart from the generation and acquisition of knowledge, the model did not delineate the detailed methodology and steps for their implementation.

2.1.3 Theories of Agricultural Extension

In this section a review of four agricultural extension theories will be discussed.

2.1.3.1 Theory of Perception from the Top Down

Top-down processing is a significant theory in cognitive psychology that pertains to perception. This theory posits that the way humans process sensory information in cognition, including perception, recognition, memory, and understanding, is influenced and structured by our prior experiences, expectations, and the meaningful context in which the information is presented (Solso, 1998). According to top-down processing, our perceptions are formed by starting with a broader object, concept, or idea before delving into more specific details. In essence, top-down processing occurs when we move from the general to the specific, from the overall picture to the finer points. In this process, our abstract impressions can impact the sensory data we perceive. Top-down processing is also referred to as conceptually driven processing, as it is influenced by our expectations, existing beliefs, and cognitions. Sometimes, we are conscious of these influences, but in other cases, this process occurs without our awareness.

One form of top-down perception is Construction Perception. Constructive perception involves the perceiver constructing a cognitive understanding or perception of a stimulus. This process utilizes sensory information as the basis for the structure but also incorporates other sources of information to form the perception. This perspective is also referred to as intelligent perception, as it asserts that higher-order thinking is crucial in perception. It also highlights the significance of learning in perception (Fahle, 2005). Some researchers have noted that our perception is influenced not only by the world around us but also that the world we experience is actually shaped by our perception (Goldstone, 2003).

2.1.3.2 Diffusion of Innovation Theory

The Diffusion of Innovation Theory originated in 1962, pioneered by scholar Everett Rogers. This theory has been pivotal in shaping both extension theory and practice, particularly concerning the stages of innovation development. Rogers emphasizes that diffusion is not a singular, all-encompassing theory but rather comprises various theoretical perspectives connected to the overarching concept of diffusion, essentially constituting a meta-theory (Sennuga et al., 2021). The discussion that follows focuses on four factors identified by numerous researchers that influence the adoption of an innovation.

a. The innovation itself: Comprehending the essence of innovation and its ultimate objective of enhancing the well-being of smallholder farmers and rural communities can aid in predicting the likelihood of the adoption of such innovations. Moreover, the adoption rate among smallholder farmers is contingent on various factors, including the nature of the innovation, its inherent characteristics, the personal attributes of rural farmers, and the local environment where the technology/innovation transfer process occurs. (Palis et al., 2010).

b. The communication channels: Utilizing accurate and appropriate communication channels plays a crucial role in facilitating and influencing the adoption rate of innovation within rural communities. Therefore, employing the right communication channels possesses the inherent capability to effectively disseminate timely and current information to smallholder farmers (Sennuga et al., 2021). These communication avenues encompass mass media, traditional media, print media, on-farm researcher-led demonstrations, farmer-to-farmer information-sharing systems, community leaders, community broadcasting, modern ICT, interpersonal communication, and small group communication. A noteworthy discovery by Mwombe et al. (2014) highlights the effectiveness of modern ICT, specifically mobile technology text messaging, in significantly impacting the rapid dissemination and subsequent adoption of agricultural innovation among smallholder banana farmers in Kenya.

c. Time: Diffusion refers to the communication and spread of innovation through channels over time within a social system (Rogers, 2003). The duration it takes for information about an innovation to propagate can have an impact on the adoption of that innovation among smallholder farmers.

d. The nature of society: The adoption of innovation among smallholders can be significantly influenced by the local context to which the innovation is communicated. The success of innovation diffusion is contingent upon various factors, including the nature of the society, social norms, beliefs, attitudes, and knowledge of the target users. Consequently, the characteristics of the farmers' society may play a crucial role in shaping their decision to adopt an innovation (Sennuga et al., 2021).

2.1.3.3 Social Cognition Theory

Social Cognitive Theory, also known as Social Learning Theory, is a psychological framework developed in 1986 by Albert Bandura. This theory emphasizes the role of observational learning, imitation, and modeling in the acquisition of behaviors, attitudes, and emotional reactions. Bandura proposed that individuals learn not only through direct experiences but also by observing others and the consequences of their actions. Key concepts of Social Cognitive Theory include Observational Learning, Modeling, Reciprocal Determinism, Self-Efficacy, and Vicarious Reinforcement. For this review purpose the focus is on Self-Efficacy (Schunk & Mullen 2012). The Social Cognitive Theory underscores the significance of self-efficacy, defining it as an individual's perception of their ability to employ technology effectively to accomplish a specific task (Compeau and Higgins, 1999).

2.1.3.4 Theory of Planned Behavior

The Theory of Planned Behavior, originally known as the Theory of Reasoned Action in 1980, was developed to forecast an individual's intention to participate in a specific behavior at a particular time and place. This theory aimed to provide an explanation for all behaviors within individuals' self-control. At the core of this model lies behavioral intent, which is shaped by one's attitude regarding the likelihood of the behavior producing the anticipated outcome and the subjective assessment of the associated risks and benefits (Wayne, 2022). While the Theory of Planned Behavior is robust in explaining and foreseeing farmers' technology adoption behavior, it conspicuously overlooks the idiosyncratic behaviors and the intricate interconnections among farmers, workers, families, and third parties (Henri-Ukohal, 2011).

2.1.3.5 Technology Acceptance Model

The Technology Acceptance Model, introduced by Davis in 1989, represents the pioneering effort to identify psychological factors influencing technology acceptance among farmers. Derived from the Theory of Reasoned Action proposed by Fishbein and Ajzen in 1980, this model is rooted in information system theory, focusing on how users, particularly smallholder farmers, come to adopt and implement technology (Sennuga et al., 2021).

The model posits that when presented with new technology, several motivational factors impact decisions on its implementation and use, specifically:

- Perceived Usefulness (PU): This refers to the extent to which a person believes that using a particular system would enhance job performance and output efficiency.
- Perceived Ease of Use (PEU): The degree to which a person perceives that the technology requires minimal effort.

Both perceived usefulness and perceived ease of use contribute to shaping farmers' attitudes toward new technology, subsequently influencing their intention to adopt the technology (Venkatesh and Davis 2000).

Summary: the agricultural extension theories and the Ethiopian agricultural extension

This agricultural extension theories section provides an overview of five key theories of agricultural extension, starting with the Theory of Perception from the Top Down, which emphasizes how prior experiences and expectations shape cognition. It highlights the process of top-down processing, moving from general to specific perceptions, and introduces the concept of Constructive Perception. The Diffusion of Innovation Theory, pioneered by Everett Rogers, examines factors influencing innovation adoption, including the innovation itself, communication channels, time, and societal context. Social Cognitive Theory, developed by Albert Bandura, focuses on observational learning and self-efficacy, while the Theory of Planned Behavior forecasts individuals' intentions to adopt specific behaviors. Finally, the Technology Acceptance Model, derived from the Theory of Reasoned Action, emphasizes perceived usefulness and ease of use in technology adoption among farmers.

Looking at the Ethiopian agricultural extension system, the government is dedicated to increasing agricultural production sustainably to meet various demands, including food, industrial raw materials, and foreign currency earnings. Agricultural extension services play a crucial role in achieving these goals, recognized by development experts as essential for agricultural development, poverty reduction, and food security. Despite past efforts to improve the extension system, it has not yielded the desired results, prompting the need for a strategy aligned with agricultural development demands and future directions. Since the establishment of research-based agricultural extension services, Ethiopia has implemented various extension systems. Throughout the various development policies and strategies, the extension system remains pivotal, aiming to transform smallholder subsistence agriculture into a commercial production system through the adoption of agricultural technologies. Ethiopia boasts one of the densest agricultural extension systems globally, with approximately 21 development agents per 10,000 farmers, supported by Farmer Training Centers (FTCs) and Participatory Extension Systems (PESs) established since 2010 (MoANR, 2017). These initiatives, coupled with farmer group organization and FTC categorization, aim to create a sustainable, farmer-owned agricultural extension system conducive to agricultural transformation and development.

To conclude the theoretical review, here is a summary analysis combining the extension theories and the country's extension system. The theories of agricultural extension, including the Theory of Perception from the Top Down, the Diffusion of Innovation Theory, the Social Cognitive Theory, the Theory of Planned Behavior, and the Technology Acceptance Model, intersect with Ethiopia's agricultural extension system to shape its dynamics and outcomes. In Ethiopia, where agricultural extension plays a pivotal role in transforming smallholder subsistence agriculture into a commercially viable sector, these theories inform the design and implementation of extension programs. The top-down processing theory influences how extension messages are structured and delivered, considering farmers' prior experiences and expectations. The diffusion of innovation theory guides the adoption of new agricultural technologies, emphasizing factors like innovation characteristics, communication channels, time, and societal context. Social cognitive theory underscores the role of observational learning and self-efficacy in farmers' adoption behaviors, while the theory of planned behavior highlights the influence of attitudes, subjective norms, and perceived behavioral control. Additionally, the technology acceptance model examines farmers' perceptions of technology usefulness and ease of use, crucial for technology adoption. In Ethiopia's extension system, which includes Farmer Training Centers, participatory extension systems, and farmer groups, these theories collectively inform strategies to enhance farmers' knowledge, attitudes, and adoption behaviors, contributing to the country's agricultural development goals.

2.2 Empirical Literature Review

The Empirical Literature Review section focuses on the central idea of this research i.e. Phone Based Digital Agriculture Extension. In line with that issues covered are Digital Agriculture and Digital Agriculture Extension, Approaches in Phone-Based Digital Agriculture Extension, Benefits of Phone-Based Digital Agriculture Extension, and the Implementation of Phone-Based Digital Agriculture Extension.

2.2.1 Digital Agriculture and Digital Agricultural Extension

2.2.1.1 Digital Agriculture

In recent years, there has been a growing interest in the application of digital technologies in agriculture also known as digital agriculture (Kotsur et al., 2019). This emerging field involves the use of digital technologies, innovations, and data to transform business models and practices across the agriculture value chain (Xie et al., 2021). The introduction of digital farming tools and technologies has revolutionized the way agricultural systems are managed. These technologies include automation, informatization, digitization, and the use of information and communication technologies in rural areas (Nasirahmadi & Hensel, 2022). One of the main features of digital agriculture is the incorporation of innovative Information and Communication Technology, Internet of Things, big data analytics and interpretation techniques, machine learning, and Artificial Intelligence (Strobel, 2020). These technologies have enabled farmers to gather and analyze data more effectively, allowing them to make informed decisions regarding crop management, resource allocation, and overall farm operations. This has led to increased efficiency, productivity, and sustainability in agricultural production (Vakulenko & Xiaowei, 2022). Furthermore, digital agriculture tools have also provided a deeper understanding of the interrelations within the agricultural production system and the consequent effects on farm performance (Nasirahmadi & Hensel, 2022).

By leveraging digital agriculture in developing countries, there is a great potential to address unique challenges and drive agricultural transformation. The implementation of digital farming technologies can improve crop management, resource allocation, and overall farm operations, ultimately leading to increased productivity and sustainability. In addition, the use of digital tools along the agricultural value chain can empower farmers with access to information and communication technologies, providing them with valuable insights and knowledge. This can enable them to make informed decisions and optimize their agricultural practices. Furthermore, the application of digital technologies, such as big data analytics and interpretation techniques, can contribute to enhancing the resilience of agricultural systems in developing countries (Khan et al., 2021). Overall, digital agriculture offers immense potential to transform the agricultural sector by improving efficiency, productivity, and sustainability (Vakulenko & Xiaowei, 2022).

Over the past ten years, the number of digital agriculture services in developing nations has surged by 1220%, rising from 53 to 700 active services. The majority of these services, 62%, are located in sub-Saharan Africa. These services cater to five primary use cases: digital advisory, agri digital financial services (providing access to financial services), agri e-commerce, digital procurement (facilitating access to markets), and smart farming (enabling access to assets). Despite this growth, the sector is still in its early stages. Many of the active services are small-scale, reliant on donor funding, and are in the pilot phase (Stephenson J et al., 2021).

2.2.1.2 Digital Agricultural Extension

Digital agricultural extension is a scalable, cost-effective solution that allows farmers access to actionable knowledge (Kurdyś-Kujawska et al, 2021). Even when there is an in-person extension, interactive platforms are a significant addition to conventional extension services. When conventional in-person communication networks are impossible in an emergency setting, investing in low-cost digital tools to provide farmers with information and market connections they need, gathering real-time information on the challenges on the ground, and adapting these tools to tackle new challenges are becoming urgent priorities. Digital agricultural extension is now helping millions of farmers around the world gain access from the palm of their hand to the best agricultural knowledge and advice (Olagunju et al., 2021).

In sub-Saharan Africa, there are almost 400 digital agriculture solutions with 33 million registered farmers. However reliable data at scale on their active use and impact on farmer climate resilience is limited. Bundled digital agriculture models (e.g., digital advisory services and financial services together in one product) have been shown to increase smallholder farmer income by 57% and productivity by 168%, making a substantial contribution to their climate resilience and adaptive capacity (Stephenson J et al., 2021).

2.2.2 Approaches of Phone Based Digital Agriculture Extension

In this age of ICT, extension staff and farmers are showing interest and attention in the use of digital agricultural extension and advisory services. These services are provided in different mediums such as phone, video, radio, smartphone app, social media site, website, and television. The information farmers get access through digital agricultural extension and advisory include input availability & price, production technique & management, technology introduction, weather forecast, disease outbreak, natural disaster warning, market price, financial management, and more.

Agricultural extension services delivered via mobile phones vary in their design complexity and the technologies employed. This section summarizes the different approaches to providing these services according to Fabregas et al., (2022).

a. Text Message-Based Services

The most common type of phone used in developing countries is a basic mobile device with call and text capabilities. Text messaging, or SMS, is still the most cost-effective way to reach people in many parts of the world. It allows for the dissemination of written messages of up to 160 characters to a large audience in near real time. While this makes text messaging an attractive option for reaching farmers in resource-poor areas at a low cost, it has limitations. Complex information is difficult to convey through text messages, and excessive messaging can overwhelm or irritate farmers. Additionally, farmers with low mobile literacy may struggle with two-way communication, especially in contexts where they have to pay for outgoing text messages.

b. Interactive Voice Response (IVR) Services

Another technology available on basic phones is interactive voice response (IVR), which enables computers to interact with users through voice. This system allows farmers to listen to prerecorded information and record new questions. While it may be more inclusive of users with low literacy levels, it requires users to listen to audio messages and can be more costly to operate than text-based systems.

c. Advanced Technology-Based Services (Smartphones and Tablets)

Smartphones and tablets offer new opportunities for sharing information and learning. Farmers can watch instructional videos, take pictures of crop pests for identification and recommendations, and use apps to better understand crop risks. However, access to smartphones and tablets is limited in some regions, requiring innovative delivery approaches to reach a larger audience, such as involving agricultural extension officers, agro-dealers, and other local agents familiar with smartphone technology.

2.2.3 Advantages of Phone Based Digital Agriculture Extension

Implementing phone-based digital agricultural extension solutions necessitates collaboration with various stakeholders, such as government entities, agricultural agencies, communications regulatory bodies, and local telecommunications companies. To establish and expand a digital agricultural extension service, it is essential to address technological, policy, financial, and product-related prerequisites, including:

- Technological prerequisites: telecommunications infrastructure (existing mobile network operators, mobile aggregators, or mobile solutions providers)
- Policy prerequisites: regulations for user protection, data security, privacy, and access to mobile data
- Product prerequisites: customer acquisition and agronomic content
- Financial prerequisites: initial setup costs and ongoing operational expenses

According to Fabregas et al., (2022) Information and Communication Technology (ICT) and phone-based agricultural extension and advisory services offer the potential for delivering low-cost, timely, and personalized information at scale (to a large audience). Additional information is discussed below.

a. Cost [Low]

Digital technologies have the potential to enhance agricultural market operations at a minimal cost per farmer. While the initial setup of mobile phone coverage involves fixed costs, the ongoing cost of phone communication in rural areas is nearly negligible due to underutilized cell phone towers. Although cellular companies often charge prices above the marginal cost, government regulation could lead to lower access fees. The low marginal distribution costs of mobile phones suggest significant returns on investment, despite the substantial upfront capital required to establish a digital agricultural system in a new setting. Notably, the return on investment in digital agriculture can be substantial, as evidenced by cost-benefit ratios such as 1:48 US$ for the Satellite-Assisted Pastoral Resource Management in Ethiopia, 1:10 US$ for the Precision Agriculture for Development program in India, and up to 1:70 in Kenya.

b. Timely [Delivery]

Phone-based agricultural extension and advisory services are particularly valuable for delivering dynamic information that necessitates frequent updates, such as weather forecasts and market prices. They also excel in providing information to farmers in remote areas with limited infrastructure, conflict-affected regions beyond the reach of in-person extension services, and disaster-affected areas where timely information delivery can be life-saving.

c. Customized [Advisory]

Digital agriculture's ability to enhance the quality of tailored advice through data utilization is a significant advantage. Phone-based agricultural extension and advisory services facilitate two-way communication with farmers, enabling the collection of information about local conditions, farmers' backgrounds, and input experiences. This data can be leveraged to generate personalized recommendations tailored to the specific needs of individual farmers, whether at the location, farm, livestock, or soil level. Delivering customized extension and advisory content to farmers increases the likelihood of addressing critical issues and enhancing production and productivity.

2.3 Conceptual Framework of the Study

This study aimed to assess the effectiveness of digital agricultural extension and advisory services in Ethiopia, drawing on insights from expert service providers. The study centered on phone-based digital agricultural extension and advisory services, which encompass SMS service, IVR service (both inbound and outbound), and app-based services designed for smartphones and tablets, including Telegram/WhatsApp app groups and bots. These services represent a diverse array of digital tools aimed at providing agricultural information and guidance to farmers, and the study aimed to assess its effectiveness within the Ethiopian context. Here is an explanation of the variables considered for the study.

1. Cost: This variable assesses the economic feasibility of the services. Lower costs can enhance accessibility, productivity and sustainability.
2. Time: This evaluates the timeliness of information delivery, which is crucial for the relevance and usefulness of the advisory services.
3. Customization: This measures the ability to tailor information to the specific needs of farmers, enhancing the relevance and applicability of the advice.
4. Utilization: This looks at the utilization and adoption of the advisory services by farmers, indicating the practical effectiveness and acceptance of the services.
5. Overall Effectiveness: This is the cumulative outcome of the above factors, reflecting the general success and impact of the phone-based digital agricultural extension services.

The conceptual framework of the study is visually depicted in Figure 2.1, providing a clear illustration of the relationships under examination. By delving into these factors, the study seeks to shed light on the key elements that contribute to the successful implementation of phone-based digital agricultural extension and advisory services in Ethiopia, ultimately benefiting agricultural policy makers, practitioners, and stakeholders in the sector.

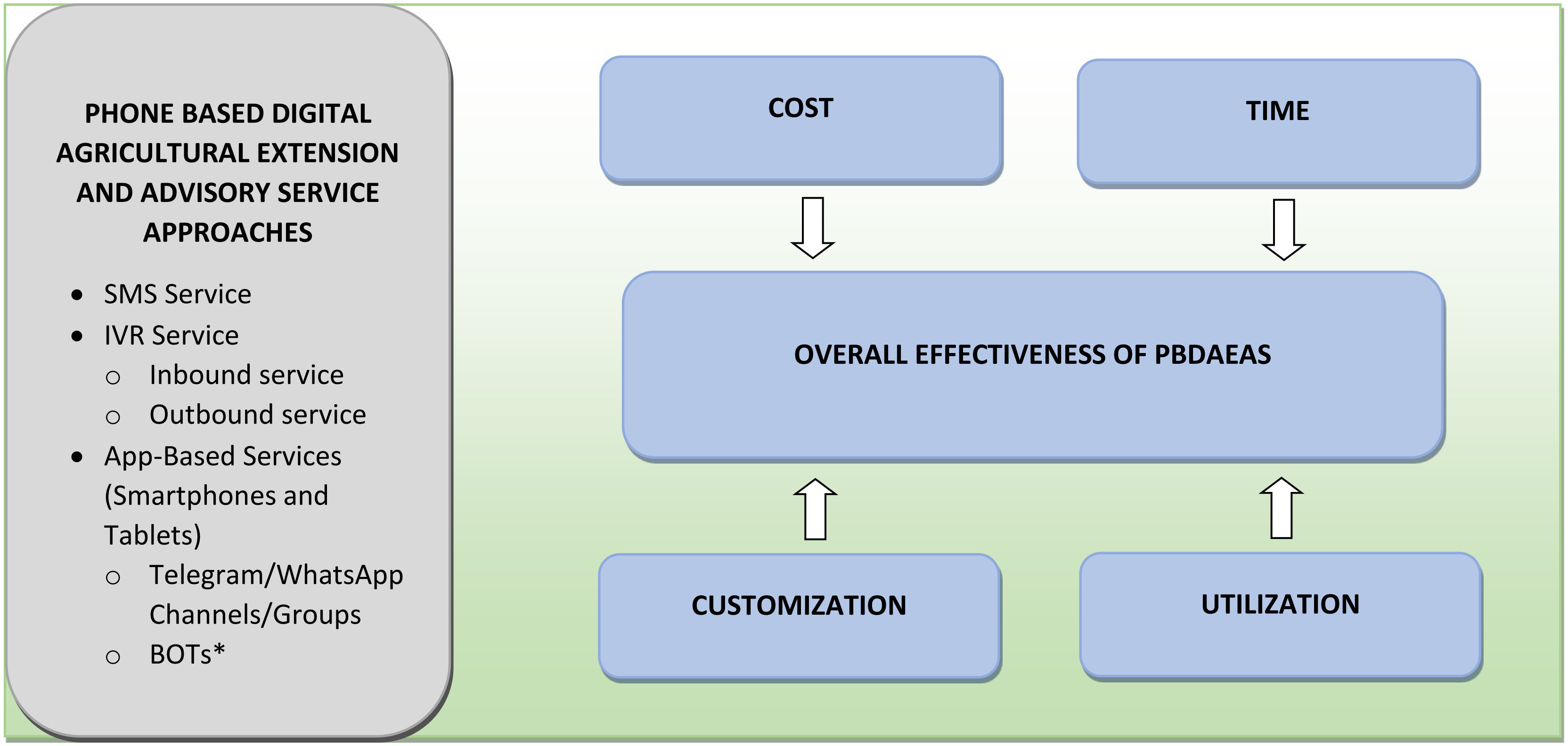

Figure 2. 1: Conceptual framework of the study

Color Definition

The agriculture sector | **The phone-based digital service** | **Variables** | **Relationship**

* BOT, short for robot, is a software application that is designed and programmed to perform specific tasks or engage in conversations with users without requiring direct human involvement (Dunham & Melnick, 2008)

CHAPTER THREE

3. RESEARCH METHODOLOGY

This chapter discusses the research methodology of this study. The chapter starts by discussing the philosophical stance of this study. Following that the chapter clearly states the research strategy, research approach, research design, study site selection criteria, sampling method, data source, data collection method and data analysis technique.

3.1 Research Paradigm, Design, and Approach

3.1.1 Research Paradigm

The study followed the post-positivism approach within the epistemology philosophical paradigm. Post-positivism argues that the idea and the identity of a researcher influence what they observe and therefore impacts upon what they conclude. Post-positivism seeks to attain objective conclusions by acknowledging and addressing the biases inherent in the theories and knowledge constructed by theorists (McGlinchey, 2021).

3.1.2 Research Design

The research designs followed for this study are Descriptive Design. Descriptive Research Design was used to describe the demographic results of the respondents, frequency of the variables, and analyze the relative importance the variables under study.

3.1.3 Research Approach

The study also followed the deductive approach for analysis and reasoning by first exploring the theories. Based on the theoretical literature review, an in-depth empirical review was made to eventually develop the conceptual framework of the study. The process of deductive reasoning begins with a theory and then breaks it down into smaller concepts to logically derive specific conclusions from the given premises (Soiferman, 2010). With the deductive approach the researcher measured concepts quantitatively to assess importance and effectiveness of the variables. In line with the post-positivism thinking and the deductive reasoning approach, the study used a quantitative approach to collect numerical perception data on the factors that depict phone-based digital extension and advisory service effectiveness.

3.2 Description of the Study Area

3.2.1 Research Site Selection Criteria

The research site selection criteria were as follows.

i) The study focused on the organizations and companies that are engaged in the provision of phone-based digital agricultural extension and advisory services.

ii) The organizations and companies selected for the study were engaged in a pure digital extension service or in a hybrid (digital & regular) extension service.

iii) All types of organization (GO, NGO & PS) engaged in a pure or hybrid digital & regular extension service were considered for the study.

iv) The organizations and companies were based in Addis Ababa city and two other regional states namely Oromia and Sidama.

3.2.2 Description of the Study Area

The research took place in Addis Ababa and two regional states: Oromia and Sidama. Addis Ababa is home to federal government institutions and major service providers like Ethio Telecom, which are crucial for the infrastructure supporting phone-based digital agricultural extension and advisory services. Additionally, the city hosts key digital extension and advisory services, including the Ministry of Agriculture (MoA), Agricultural Transformation Institute (ATI), International Livestock Research Institute (ILRI), Livestock Development Institute (LDI), Precision Development (PxD), Ethiopian Institute of Agricultural Research (EIAR), and others. The regional states were selected to access development agents operating at the woreda level, also known as public extension workers. Therefore, the inclusion of the regional states aimed to specifically target these development agents.

3.3 Type and Source of Data

The type of data used in this study was primary. Primary data focusing on the variables were collected using a structured questionnaire. The level of measurement was ordinal and data were collected using 5-point Likert Scale method.

3.4 Sampling Procedure and Techniques

The sampling method used for this study was a census survey. A census survey, in the context of data collection, involves gathering information from every individual or element within a population. This comprehensive approach aims to provide a complete and accurate picture of the entire population, leaving no room for sampling error. The rationale behind conducting a census survey is to obtain precise and detailed information about every member of the population, which can be crucial for various purposes such as government planning, resource allocation, and policymaking.

This study employed census survey for its data collection. The specific reasons for using this method are the following.

i) There are limited organizations and companies engaged in pure digital agricultural extension and advisory services.

ii) There are limited organizations and companies engaged in hybrid digital agricultural extension and regular extension services.

Therefore, all organizations and companies fulfilling the above two criteria were considered for the study. In addition to the institutions, individual participants identification was made based on the knowledge, exposure and experience in digital agricultural extension and advisory service. The organizations and companies considered in this study are summarized in table 3.1.

Table 3. 1: Organizations and number of respondents considered for the survey

No	Name	GO/NGO /PS	Sub sector	Pure or Hybrid Digital Extension	Number of respondents
1.	MoA	GO	Crop, Livestock, NRM	Hybrid	65
2.	ATI	GO	Crop, Livestock, NRM	Pure	18
3.	PxD	NGO	Crop, Livestock	Pure	5
4.	EIAR	GO	Crop, Livestock, NRM	Hybrid	10
5.	Ethio Telecom	GO	-	Pure	5
6.	LDI (NAGII)	GO	Livestock	Pure	20
7.	SNV	NGO	Livestock	Hybrid	20
8.	ILRI-ADGG	NGO	Livestock	Pure	2
9.	Digital Green	NGO	Crop, Livestock	Hybrid	30
10.	ILRI-CIAT	NGO	Livestock	Pure	5
11.	ILRI-CIMMYT	NGO	Crop, Livestock	Pure	5
12.	AGRA	NGO	Crop, Livestock	Pure	5
13.	GIZ	NGO	Crop, Livestock, NRM	Pure	1
14.	Lersha	PS	Crop, Livestock	Hybrid	1
15.	Farm Radio	NGO	Crop, Livestock	Pure	3
16.	Sasakawa Africa Association	NGO	Crop	Hybrid	2
17.	Mercy Corps	NGO	Crop	Hybrid	5
18.	ECX	GO	Crop	Pure	3
19.	Hello-Tractor	PS	Crop	Hybrid	1
20.	Green Henon	PS	Crop	Hybrid	1
21.	MASA Farm Consultancy	PS	Crop	Hybrid	1
22.	Hello-Erf	PS	Crop	Hybrid	1
23.	Relink Agri	PS	Crop	Hybrid	1
24.	Six woreda offices from 2 regional states[1]	GO	Crop, Livestock	Hybrid	120
Total Population Size					**330**

A total of 330 respondents drawn from various organizations were considered for the census study.

[1] The experts needed from the woredas offices are Development Agents also knows as Public Extension Workers

3.5 Data Collection Methods and Data Management

3.5.1 Description of Variables

The description of the variables is summarized in table 3.2.

Table 3. 2: Description of variables

Variable	Variable	Type of Variable (Collection)	Definition
Variable	Cost	Ordinal	Cost of extension and advisory service per farmer reached
	Time		Timely delivery of extension and advisory service
	Customization		Delivery of customized contents to targeted farmers
	Utilization		Degree of use or application of digital extension service by farmers (preference, ease of use, understanding and adoption)
	Overall Effectiveness		Effective provision of phone-based digital agricultural extension and advisory service at scale

3.5.2 Data Collection

The content of the questionnaire was strictly guided by the literature review and the conceptual framework of the research. Accordingly, questions were developed for the five variables. Questionnaires were distributed to the identified respondents and the researcher has monitored the process to make sure the right person was providing the response.

3.5.3 Data Management

In this study data management was done using Microsoft Excel. The data collected from online survey and hard paper questionnaires were properly encoded on the Excel Sheet. Data cleaning and management were conducted both on Microsoft Excel and the SPSS software before running the analysis.

3.5.4 Units of Analysis

The unit of analysis refers to the primary entity under investigation of the study (William & Trochim, 2023). In this study the unit of analysis is individual person. Data on five variables (see figure 2.1) were collected from individual experts who are affiliated with the organizations identified in table 3.1.

3.6 Data Validity and Reliability

3.6.1 Data Validity

In this quantitative research study, a Likert scale was utilized to collect data from participants. The Likert scale is a widely accepted and validated measurement tool for assessing attitudes, opinions, and perceptions. To ensure the validity of the data, several measures were taken. Firstly, the Likert scale items were carefully designed and reviewed to ensure clarity and relevance to the research objectives. The items were derived from reviewed literature findings and adapted to suit the specific context of the study. Secondly, during the data collection process, participants were provided with clear instructions regarding the Likert scale and its response options. They were encouraged to provide honest and thoughtful responses, reflecting their true attitudes and perceptions. Efforts were made to minimize response biases by ensuring anonymity and confidentiality. Participants were assured that their responses will be treated with strict confidentiality and only aggregated data will be reported. To analyze the collected data, descriptive statistics and Relative Importance Index metods were employed.

3.6.2 Reliability Test

According to Kothari (2004), Cronbach's alpha can be used to check the reliability of a structured Likert scale data collection instrument. Cronbach's alpha is a statistical measure that assesses the internal consistency of a scale by examining how closely related a set of items are as a group. According to Ab Hamid et al., (2011), to calculate Cronbach's alpha, responses from the Likert scale items are inserted into statistical software and run the analysis. The resulting value of Cronbach's alpha ranges from 0 to 1, with higher values indicating greater internal consistency. In this study, Cronbach's alpha test was used to check reliability of the structured instrument and ensure that the items within the scale are consistently measuring the same underlying construct.

3.7 Methods of Data Analysis

3.7.1 Methods of Quantitative Data Analysis

The data analysis technique used in this study is quantitative data analysis. The details are described below.

- Quantitative analysis was used to analyze the collected data.
- The analysis was done using SPSS 23 software.
- Descriptive statistics such as frequency and percentage were used to summarize the demographic data of the respondents and the responses on the five variables.
- Relative Importance Index (RII) analysis was conducted to analyze effectiveness of the five variables (cost, time, customization, utilization and overall effectiveness).

Relative Importance Index (RII) Analysis

The RII is a statistical method used in quantitative research to assess and rank the significance of various factors or variables based on respondents' perceptions. This method is particularly useful when it is essential to prioritize factors influencing a particular outcome (Kometa et al., 1994). The RII method transforms ordinal data collected via Likert-scale surveys into a ratio scale, making it easier to compare the relative importance of different variables. The RII for each variable is calculated using the formula:

$$\text{Relative Importance Index} = \frac{\sum W}{A*N} = \frac{5n_5+4n_4+3n_3+2n_2+1n_1}{5*N}$$

Where,

- W is the weight assigned to each response,
- A is the highest weight, and
- N is the total number of respondents.

The RII values range from 0 to 1, with higher values indicating greater importance or priority. The interpretation involves ranking the variables based on their RII scores. A higher RII means that the variable is considered more significant by the respondents.

3.7.2 Model Specification and Measurement of Variables

The quantitative research study utilized a Likert scale to collect data and employed RII for analysis. The model specification and measurement of variables are as follows:

1. Variable 1: Cost

Measurement: Participants rated the cost associated with phone-based digital agricultural extension and advisory services on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," with higher scores indicating PBDAEAS is a low-cost than the conventional extension service.

2. Variable 2: Time

Measurement: Participants rated the time required to access and utilize phone-based digital agricultural extension and advisory services on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," with higher scores indicating PBDAEAS timelier than the conventional extension service.

3. Variable 3: Customization

Measurement: Participants rated the level of customization available in phone-based digital agricultural extension and advisory services on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," with higher scores indicating PBDAEAS has an advantage on customization than the conventional extension service.

4. Variable 4: Utilization

Measurement: Participants rated their level of utilization of phone-based digital agricultural extension and advisory services on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," with higher scores indicating PBDAEAS has an advantage on utilization than the conventional extension service.

5. Variable 5: Overall Effectiveness

Measurement: Participants rated the outcome variable on a Likert scale, ranging from "Strongly Disagree" to "Strongly Agree," with higher scores indicating higher importance of PBDAEAS.

3.8 Ethical Consideration

In conducting the research, the researcher prioritized ethical considerations to ensure the well-being and rights of the participants. Here are the steps taken to ensure that all ethical consideration were fulfilled.

1. The researcher has obtained an ethical clearance certificate from the AAU Academic Ethical Clearance Committee, demonstrating compliance with ethical standards.

2. Voluntary participation was emphasized throughout the study, with participants providing informed consent before their involvement.

3. Measures were implemented to maintain anonymity and confidentiality, safeguarding the privacy of participants and their data.

4. Regarding secondary data, the researcher has diligently adhered to citation and acknowledgment protocols, giving proper credit to the sources and individuals whose work contributed to my study. This included citing relevant literature, methodologies, and insights that informed my research process. All relevant information that couldn't be included in the report itself are annexed.

5. The researcher is committed to communicate the final report, when finalized, to all research participants to ensure transparency and accountability.

CHAPTER FOUR

4. RESULT AND DISCUSSION

This chapter presents the data analysis, findings, and discussions derived from the conducted research. The questionnaire was administered in two formats: online and hard copy. A total of 330 research participants were included, with 210 respondents approached via the online survey, representing various development organizations in Addis Ababa and 120 development agents (DAs) from two regional states (Oromia and Sidama) contacted to fill hard copy questionnaires. To ensure reliability, the data instrument underwent testing using Cronbach's alpha. SPSS version 23 was used to test reliability and analyze descriptive statistics and Relative Importance Index.

4.1 Response rate and Reliability Test

4.1.1 Response rate

In survey research, there is a growing expectation for higher response rates and researchers are encouraged to aim for response rates around 60% as a goal, and this expectation is shared by journal editors and associate editors (Fincham, 2008).

In this study, out of the total 330 questionnaires distributed to federal and regional research participants, 210 were administered online, with 153 responses received. Additionally, 120 regional participants were provided with hard copy questionnaires, resulting in 103 responses. Thus, the overall response rate reached 77.6%, with a total of 256, out of 330, participants providing answers.

4.1.2 Reliability test

According to Kothari (2004), a measuring device is considered dependable if it consistently produces reliable results. To assess the internal consistency and accuracy of the measurement scale used in this study, a reliability test was conducted using Cronbach's alpha. Ab Hamid et al. (2011) recommended that a Cronbach's alpha value of 0.7 or higher indicates good reliability. According to Flo et al. (2018), a commonly accepted rule for describing internal consistency when using Cronbach's alpha is: $\alpha \geq 0.9$ = excellent, $0.9 > \alpha \geq 0.8$ = good, $0.8 > \alpha \geq 0.7$ = acceptable, 0.7 > α ≥ 0.6 = questionable, 0.6 > α ≥ 0.5 = poor, and 0.5 > α = unacceptable. For this study two reliability test results, at pretest stage and post data collection, are presented in Table 4.1 and 4.2.

a) Pretest reliability test

Various guidelines exist for determining the appropriate sample size for a pretest. Cooper and Schindler (2011) recommend a sample size ranging from 25 to 100 individuals. Hill (1998) and Isaac and Michael (1995) suggest that a sample size of 10 to 30 individuals is sufficient for a pilot test. Another approach proposed by Connelly (2008) is to set the pilot sample size as ten percent (10%) of the projected sample size for the main study. These recommendations provide researchers with a range of options for selecting an appropriate sample size for their pilot studies.

Pretesting and reliability testing of the data collection instrument was conducted at the initial stage of data collection on 10% (N=33) of the sample size (330). The resulting α coefficient of reliability (Cronbach's coefficient α) for each variable is 0.733 for Cost, 0.822 for Time, 0.919 for Customization, 0.757 for Utilization, and 0.590 for Effectiveness of PBDAEAS. As shown in table 4.1, the overall α coefficient of reliability for all measurements is 0.882.

Table 4.1: Pretest reliability test analysis (Cronbach's alpha)

Variable/s	No of Item	Cronbach's Alpha	Internal Consistency	Rule
All Variables • **Cost, Time, Customization, Utilization, Overall Effectiveness**	20	0.882	Good	Acceptable

Source: Own survey, 2024

b) Post data collection reliability test

Post completion of the data collection, reliability test was conducted for all variables. The total number of respondents (N) is 256. The resulting α coefficient of reliability (Cronbach's coefficient α) for each variable is 0.630 for Cost, 0.818 for Time, 0.819 for Customization, 0.622 for Utilization, and 0.518 for Effectiveness of PBDAEAS. As shown in table 4.2, the overall α coefficient of reliability for all measurements is 0.819.

Table 4. 2: Post data collection reliability test analysis (Overall Cronbach's alpha)

Variable	No of Item	Cronbach's Alpha	Internal Consistency	Rule
All Variables • **Cost, Time, Customization, Utilization, Overall Effectiveness**	20	0.859	Good	Acceptable

4.2 Descriptive Analysis of Demography

This section covers demographic statistics of the 256 respondents that include gender, age, education, institution, position, and experience. The results are presented below.

4.2.1 Gender and Age of Respondents

In the obtained sample of 256 respondents, the data revealed that 74% were male, while the remaining 26% were female. When considering the age distribution, 8% of the respondents were 25 years or below, 72% fell within the 26-40 age range, and 20% were 41 years or older. See figures 4.1 and 4.2.

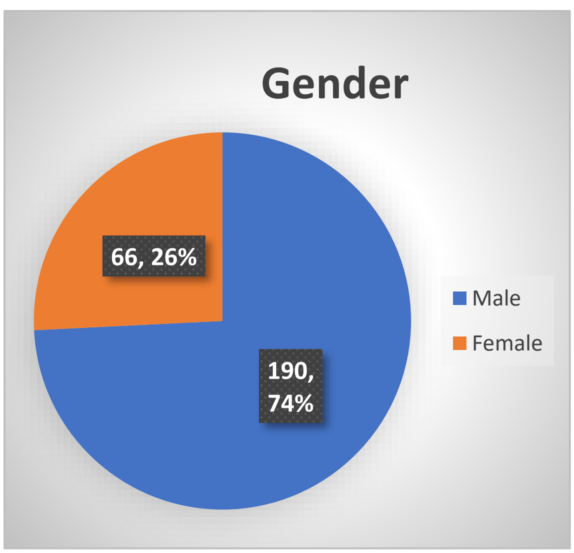

Figure 4. 2: Respondents gender mix; number and percentage

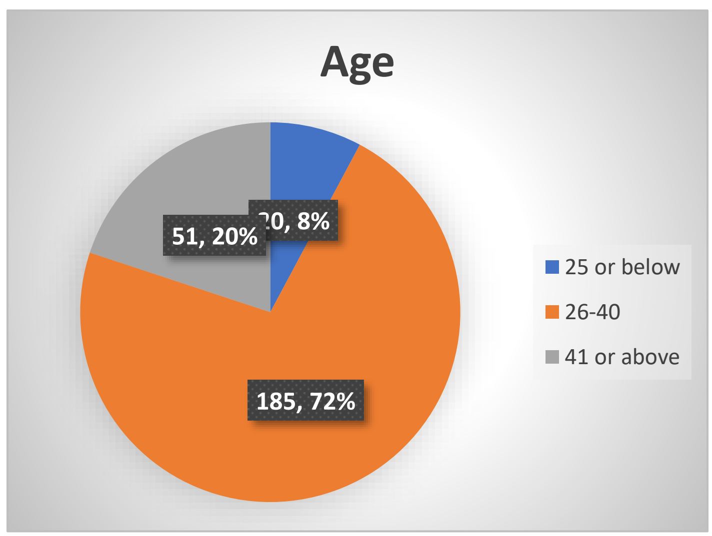

Figure 4. 1: Respondents age group number and percentage

4.2.2 Education, Institution and Position of Respondents

In terms of the education levels, out of the 256 respondents 52% had MA/MSc, 44% had BA/BSc, and 4% had PhD. In terms of institutional affiliation, 66% of the respondents were from government institutions and the rest 30%, 2%, and 2% were from non-government organizations, development partners, and private sector respectively. Looking at their main responsibilities, the majority, 72%, were experts and the rest 19% and 9% were middle level and top level managers respectively. See figures 4.3, 4.4, and 4.5.

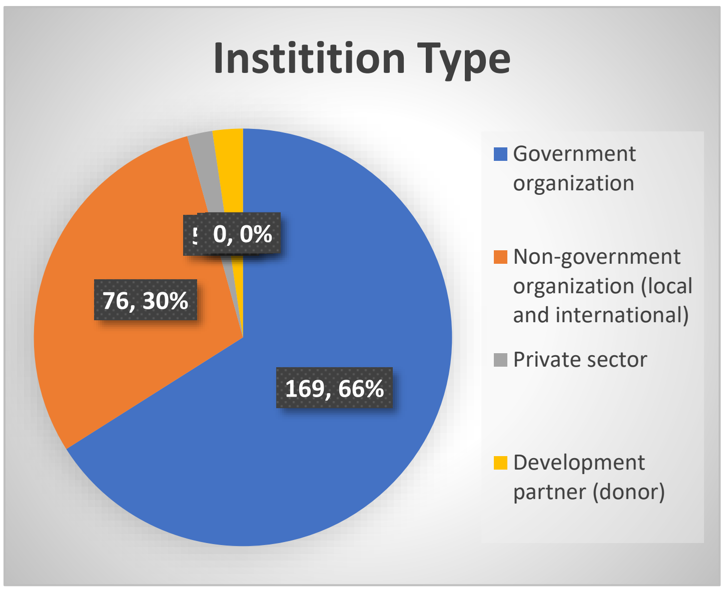

Figure 4. 3: Respondents institutional affiliation

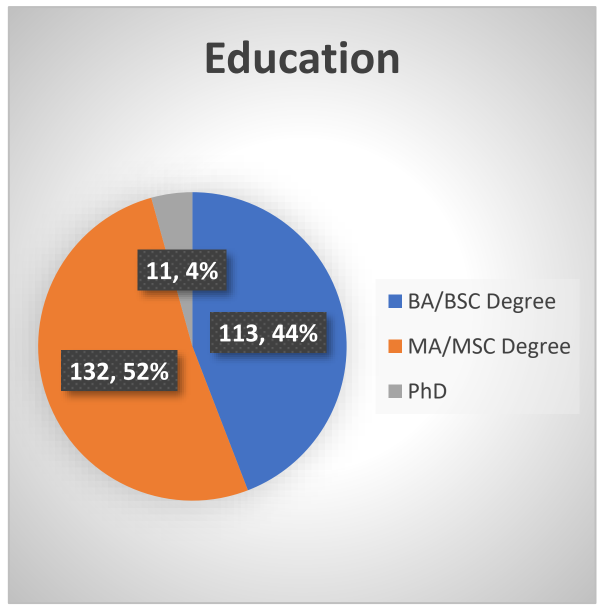

Figure 4. 4: Respondents educational level

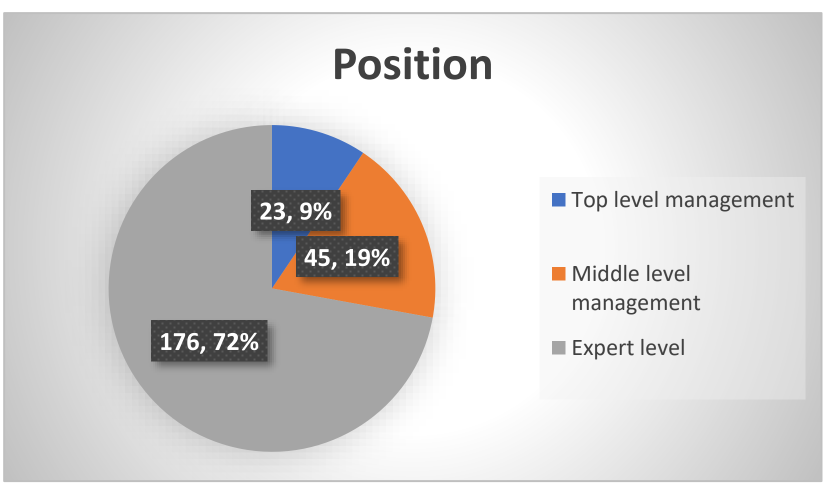

Figure 4. 5: Respondents level of responsibility

4.2.3 Respondents' Experience in Digital Agriculture Extension

Tables 4.3, 4.4, and 4.5 present a summary of the respondents' experiences in the type, specific activity and years in digital agricultural extension and advisory service in the country.

a) Respondents' direct experience in the type of Digital Agricultural Extension service

Table 4.3 presents the respondents' direct experience in different types of Digital Agricultural Extension services. Among the 256 participants, 89% reported having experience with Phone/Mobile services, while 9.7% had experience with Video services. A smaller proportion, 1%, had experience with Radio services, and only 0.3% reported experience with Other types of services.

Table 4.3: Respondents' direct experience in the type of Digital Agricultural Extension service

	Frequency	Percentage (%)
Phone/Mobile	227	89
Video	25	9.7
Radio	3	1
Other	1	0.3
Total	**256**	**100**

Source: Own survey, 2024

b) Respondents' direct experience in the Digital Agricultural Extension Service activities

Table 4.4 presents the respondents' direct experience in various Digital Agricultural Extension Service activities. Out of the 256 participants, 20% reported experience in Content development, while a majority of 60% had experience in Content dissemination. Additionally, 9% of the respondents had experience in Research/Monitoring activities, and 11% reported involvement in Other activities.

Table 4.4: Respondents' direct experience in the Digital Agr Extension Service activities

	Frequency	Percentage (%)
Content development	51	20
Content dissemination	152	60
Research/Monitoring	24	9
Other	29	11
Total	**256**	**100**

Source: Own survey, 2024

c) Respondents' years of experience in the Digital Agricultural Extension Service

Table 4.5 presents the distribution of respondents based on their years of experience in Digital Agricultural Extension Services. Among the 256 participants, 86% had 7 years or less of experience. A smaller proportion, 14%, reported having 8-15 years of experience, while none of the respondents had 16 years or more of experience in the field.

Table 4.5: Respondents' years of experience in the Digital Agricultural Extension Service

	Frequency	Percentage (%)
7 years or less	221	86
8 – 15 years	35	14
16 years or above	0	0
Total	**256**	**100**

Source: Own survey, 2024

4.3 Descriptive Analysis of Variables

This section presents a descriptive analysis of the key variables involved in the study. The analysis aims to provide insights into the distribution, central tendency, and variability of each variable, namely Cost (C), Time (T), Customization (CU), Utilization (U), and Effectiveness of PBDAEAS (E). The descriptive statistics include mean scores, standard deviations, and frequency distributions for a comprehensive understanding of respondents' perceptions towards these variables. Additionally, the full response frequency graphs for all variables are put under Annex 2 of this report.

4.3.1 Overall response (per scale) frequency summary

Table 4.6 summarizes the total responses by the respondents for each measurement scale. It provides insights into participants' perceptions based on the Likert scale responses across categories including Cost (C), Time (T), Customization (CU), Utilization (U), and Effectiveness (E). The majority of respondents either "Strongly Agree" (35%) or "Agree" (40%) with the statements, indicating a positive overall perception of PBDAEAS. These two scales account for 75% of the entire responses. Some respondents also chose "Neither Agree, Nor Disagree" (19%) suggesting a neutral stance on certain aspects. Conversely, a smaller percentage expressed disagreement, with "Disagree" at 4.3% and "Strongly Disagree" at 1.7%. These last two scales accounting for only 6%. This distribution highlights a generally favorable outlook towards PBDAEAS in comparison to the regular extension service.

Table 4. 6: Summary of overall response frequency

Likert Scale	Scale Definition	Total Response/Scale Frequency (C, T, CU, U, E)	Percentage
5	Strongly Agree	1802	35%
4	Agree	2030	40%
3	Neither Agree, Nor Disagree	981	19%
2	Disagree	222	4.3%
1	Strongly Disagree	85	1.7%
	Total	**5120**	**100**

4.3.2 Cost

Table 4.7 presents the frequency scores of the variable COST across four distinct categories denoted as:

- C1: PBDAEAS is a low-cost means to develop content.
- C2: PBDAEAS is a low-cost means to access farmer profile data and have two-way communication with farmers.
- C3: PBDAEAS is a low-cost means to disseminate standardized information to smallholder farmers.
- C4: PBDAEAS is a low-cost means to do monitoring and experimentation.

Table 4. 7: Descriptive statistic of Cost

Cost								
	Frequency Scores					Statistic		
Questions	**SA (5)**	**A (4)**	**NA-ND (3)**	**D (2)**	**SD (1)**	**Mean**	**Std. Dev.[2]**	**Coeff. of Var.[3]**
C1	69	69	78	27	13	3.601563	1.139934	0.3165109
C2	33	90	104	25	4	3.480469	0.894213	0.256923
C3	72	116	40	20	8	3.875	1.009756	0.260582
C4	36	77	121	17	5	3.476563	0.885304	0.254649

Source: Own survey, 2024

[2] Standard Deviation
[3] Coefficient of Variation

The responses to the questions related to the Cost categories were analyzed using the Relative Importance Index (RII) to determine their relative importance. The results are presented in Table 4.8.

Table 4. 8: RII analysis and result of Cost

Question	SA (5)	A (4)	NA-ND (3)	D (2)	SD (1)	Total	Total No	A*N	RII	Rank
C1	345	276	234	54	13	922	256	1280	0.7203125	2
C2	165	360	312	50	4	891	256	1280	0.69609375	3
C3	360	464	120	40	8	992	256	1280	0.775	1
C4	180	308	363	34	5	890	256	1280	0.6953125	4

Interpretation of Results

The RII values for each Cost category are as follows:

- C1: 0.7203
- C2: 0.6961
- C3: 0.775
- C4: 0.6953

Based on these RII values, the rankings of the cost categories are:

1. C3: PBDAEAS is a low-cost means to disseminate standardized information to smallholder farmers (RII = 0.775).

2. C1: PBDAEAS is a low-cost means to develop content (RII = 0.7203).

3. C2: PBDAEAS is a low-cost means to access farmer profile data and have two-way communication with farmers (RII = 0.6961).

4. C4: PBDAEAS is a low-cost means to do monitoring and experimentation (RII = 0.6953).

4.3.3 Time

Table 4.9 presents the frequency scores of the variable TIME across four distinct categories denoted as:

- T1: PBDAEAS can timely deliver seasonal agriculture information to farmers
- T2: PBDAEAS can timely deliver weather information to farmers
- T3: PBDAEAS can timely deliver disaster and disease information to farmers
- T4: PBDAEAS can facilitate timely collection of monitoring and experimentation data

Table 4. 9: Descriptive statistic of Time

Time								
	Frequency Scores					Statistic		
Question	**SA (5)**	**A (4)**	**NA-ND (3)**	**D (2)**	**SD (1)**	**Mean**	**Std. Dev.**	**Coeff. of Var.**
T1	82	104	54	11	5	3.964844	0.9386757	0.2367497
T2	78	100	66	3	9	3.917969	0.96055	0.245165
T3	82	87	47	30	10	3.785156	1.132728	0.299255
T4	68	88	44	25	31	3.535156	1.30712	0.369749

Source: Own survey, 2024

The responses to the questions related to the Time categories were analyzed using the Relative Importance Index (RII) to determine their relative importance. The results are presented in Table 4.10.

Table 4. 10: RII analysis and result of Time

Question	SA (5)	A (4)	NA-ND (3)	D (2)	SD (1)	Total	Total No	A*N	RII	Rank
T1	410	416	162	22	5	1015	256	1280	0.79296875	1
T2	390	400	198	6	9	1003	256	1280	0.78359375	2
T3	410	348	141	60	10	969	256	1280	0.75703125	3
T4	340	352	132	50	31	905	256	1280	0.70703125	4

Interpretation of Results

The RII values for each Time category are as follows:

- T1: 0.79296875
- T2: 0.78359375
- T3: 0.75703125
- T4: 0.70703125

Based on these RII values, the rankings of the time categories are:

1. T1: PBDAEAS can timely deliver seasonal agriculture information to farmers (RII = 0.79296875).

2. T2: PBDAEAS can timely deliver weather information to farmers (RII = 0.78359375).

3. T3: PBDAEAS can timely deliver disaster and disease information to farmers (RII = 0.75703125).

4. T4: PBDAEAS can facilitate timely collection of monitoring and experimentation data (RII = 0.70703125).

4.3.4 Customization

Table 4.11 presents the frequency scores of the variable CUSTOMIZATION across four distinct categories denoted as:

- CU1: PBDAEAS allow a better two-way communication with farmers
- CU2: PBDAEAS can generate customized recommendations using the data it generates
- CU3: PBDAEAS can improve the quality of customized advice using the data it generates
- CU4: PBDAEAS can leverage the data it generates to derive impact through constant learning

Table 4. 11: Descriptive statistic of Customization

Customization								
Frequency Scores						Statistic		
Question	SA (5)	A (4)	NA-ND (3)	D (2)	SD (1)	Mean	Std. Dev.	Coeff. of Var.
CU1	174	71	11	0	0	4.636719	0.5643488	0.121713
CU2	152	90	12	2	0	4.53125	0.625441	0.138028
CU3	79	142	26	9	0	4.136719	0.730873	0.176679
CU4	164	79	12	1	0	4.585938	0.60101	0.131055

Source: Own survey, 2024

The responses to the questions related to the Customization categories were analyzed using the Relative Importance Index (RII) to determine their relative importance. The results are presented in Table 4.12.

Table 4. 12: RII analysis and result of Customization

Question	SA (5)	A (4)	NA-ND (3)	D (2)	SD (1)	Total	Total No	A*N	RII	Rank
CU1	870	284	33	0	0	1187	256	1280	0.92734375	1
CU2	760	360	36	4	0	1160	256	1280	0.90625	3
CU3	395	568	78	18	0	1059	256	1280	0.82734375	4
CU4	820	316	36	2	0	1174	256	1280	0.9171875	2

Interpretation of Results

The RII values for each customization category are as follows:

- CU1: 0.92734375
- CU2: 0.90625
- CU3: 0.82734375
- CU4: 0.9171875

Based on these RII values, the rankings of the customization categories are:

1. CU1: PBDAEAS allow better two-way communication with farmers (RII = 0.92734375).

2. CU4: PBDAEAS can leverage the data it generates to derive impact through constant learning (RII = 0.9171875).

3. CU2: PBDAEAS can generate customized recommendations using the data it generates (RII = 0.90625).

4. CU3: PBDAEAS can improve the quality of customized advice using the data it generates (RII = 0.82734375).

4.3.5 Utilization

Table 4.13 presents the frequency scores of the variable UTILIZATION across four distinct categories denoted as:

- U1: Farmers prefer using PBDAEAS over traditional agricultural extension methods
- U2: PBDAEAS is easy for farmers to access agricultural information and advice
- U3: Farmers understand the content provided through PBDAEAS
- U4: Farmers adopt the recommended agricultural practices delivered through PBDAEAS

Table 4. 13: Descriptive statistic of Utilization

Utilization								
Frequency Scores						Statistic		
Question	**SA (5)**	**A (4)**	**NA-ND (3)**	**D (2)**	**SD (1)**	**Mean**	**Std. Dev.**	**Coeff. of Var.**
U1	63	108	79	6	0	3.890625	0.7993564	0.2054571
U2	123	111	21	1	0	4.390625	0.65361	0.148865
U3	93	121	34	8	0	4.167969	0.771496	0.185101
U4	83	105	63	5	0	4.039063	0.805884	0.199522

Source: Own survey, 2024

The responses to the questions related to the Utilization categories were analyzed using the Relative Importance Index (RII) to determine their relative importance. The results are presented in Table 4.14.

Table 4. 14: RII analysis and result of Utilization

Question	SA (5)	A (4)	NA-ND (3)	D (2)	SD (1)	Total	Total No	A*N	RII	Rank
U1	315	432	237	12	0	996	256	1280	0.778125	4
U2	615	444	63	2	0	1124	256	1280	0.878125	1
U3	465	484	102	16	0	1067	256	1280	0.83359375	2
U4	415	420	189	10	0	1034	256	1280	0.8078125	3

Interpretation of Results

The RII values for each utilization category are as follows:

- U1: 0.778125
- U2: 0.878125
- U3: 0.83359375
- U4: 0.8078125

Based on these RII values, the rankings of the utilization categories are:

1. U2: PBDAEAS is easy for farmers to access agricultural information and advice (RII = 0.878125).

2. U3: Farmers understand the content provided through PBDAEAS (RII = 0.83359375).

3. U4: Farmers adopt the recommended agricultural practices delivered through PBDAEAS (RII = 0.8078125).

4. U1: Farmers prefer using PBDAEAS over traditional agricultural extension methods (RII = 0.778125).

4.3.6 Effectiveness of PBDAEAS

Table 4.15 presents the frequency scores of the variable EFFECTIVENESS across four distinct categories denoted as:

- E1: PBDAEAS is a low cost means to execute extension service to smallholder farmers at scale
- E2: PBDAEAS can timely deliver productivity, weather, disease, and disaster information to farmer at scale

- E3: PBDAEAS can deliver customized recommendations using the data it generates to farmers at scale
- E4: Farmers utilize the contents delivered through PBDAEAS

Table 4. 15: Descriptive statistic of Overall Effectiveness

Overall Effectiveness of PBDAEAS								
	Frequency Scores					Statistic		
Question	**SA (5)**	**A (4)**	**NA-ND (3)**	**D (2)**	**SD (1)**	**Mean**	**Std. Dev.**	**Coeff. of Var.**
E1	111	105	23	17	0	4.210938	0.8645737	0.2053162
E2	91	146	16	3	0	4.269531	0.627483	0.146968
E3	65	120	64	7	0	3.949219	0.783005	0.198268
E4	84	101	66	5	0	4.03125	0.815896	0.202393

Source: Own survey, 2024

The responses to the questions related to the Overall Effectiveness categories were analyzed using the Relative Importance Index (RII) to determine their relative importance. The results are presented in Table 4.16.

Table 4. 16: RII analysis and result of Overall Effectiveness

Question	SA (5)	A (4)	NA-ND (3)	D (2)	SD (1)	Total	Total No	A*N	RII	Rank
E1	555	420	69	34	0	1078	256	1280	0.8421875	2
E2	455	584	48	6	0	1093	256	1280	0.85390625	1
E3	325	480	192	14	0	1011	256	1280	0.78984375	4
E4	420	404	198	10	0	1032	256	1280	0.80625	3

Interpretation of Results

The RII values for each effectiveness category are as follows:

- E1: 0.8421875
- E2: 0.85390625
- E3: 0.78984375
- E4: 0.80625

Based on these RII values, the rankings of the effectiveness categories are:

1. E2: PBDAEAS can timely deliver productivity, weather, disease, and disaster information to farmers at scale (RII = 0.85390625).

2. E1: PBDAEAS is a low-cost means to execute extension services to smallholder farmers at scale (RII = 0.8421875).

3. E4: Farmers utilize the contents delivered through PBDAEAS (RII = 0.80625).

4. E3: PBDAEAS can deliver customized recommendations using the data it generates to farmers at scale (RII = 0.78984375).

4.4 Discussion

In this section, the discussions delve into the interpretation and implications of the findings obtained from the descriptive analysis conducted on the five variables (cost, time, customization, utilization, and effectiveness of phone-based digital agricultural extension and advisory service). It is presented for each variable based on the findings from Relative Importance Index analysis and a general discussion is made by comparing the findings with the agricultural development and agricultural extension theories reviewed in chapter 2.

a) Cost (C)

The analysis reveals that among the cost-related aspects of phone-based digital agricultural extension and advisory services (PBDAEAS), the most significant is the low-cost dissemination of standardized information to smallholder farmers (C3). This high ranking suggests that stakeholders in the agricultural sector, including service providers and policymakers, view PBDAEAS as an efficient and cost-effective method for distributing vital agricultural information widely and consistently.

Following C3, the development of content (C1) is also highly valued, indicating that creating educational and informative material through PBDAEAS is seen as economically advantageous. This is crucial for ensuring that relevant and high-quality content is continually produced and made accessible to farmers.

Accessing farmer profile data and facilitating two-way communication (C2) is ranked third. While still considered important, its slightly lower RII indicates that there may be challenges or higher costs associated with these activities compared to content dissemination and development. Effective two-way communication is essential for understanding farmers' needs and providing tailored advice, yet it may require more investment in infrastructure and technology.

The category with the lowest RII is monitoring and experimentation (C4). Although it is still seen as beneficial, the lower ranking suggests that the perceived cost-effectiveness of using PBDAEAS for these purposes is not as high as for the other categories. This could be due to the complexities and resources required to conduct thorough monitoring and experimentation digitally.

In general, the RII analysis highlights all four indicators have a positive index and highlights the effectiveness of PBDAEAS is reliant on its ability to be cost-effectiveness. The insights gained can guide the allocation of resources towards digital agricultural extension services in the country.

b) Time (T)

The analysis indicates that among the time-related aspects of phone-based digital agricultural extension and advisory services (PBDAEAS), the most significant is the timely delivery of seasonal agriculture information to farmers (T1). This high ranking suggests that the stakeholders perceive the prompt dissemination of seasonal agricultural advice using PBDAEAS as critical for helping farmers make timely and informed decisions, ultimately enhancing their productivity and efficiency.

The second most important category is the timely delivery of weather information (T2) using PBDAEAS. Given the significant impact of weather conditions on agricultural activities, ensuring that farmers receive timely weather information is essential for planning and risk management.

The third ranking indicator, PBDAEAS's ability to timely delivery of disaster and disease information (T3), underscores the importance of rapid communication during emergencies. The ability to quickly inform farmers about potential threats can mitigate losses and protect livelihoods, highlighting the value of PBDAEAS in crisis management.

The lowest-ranked category is the timely collection of monitoring and experimentation data (T4). Although still important, its lower ranking suggests that while monitoring and experimentation are necessary for continuous improvement and innovation, they might not be perceived as immediately critical compared to the direct benefits of receiving timely agricultural and weather information.

In general, the RII analysis highlights all four indicators have a positive index and that the effectiveness of PBDAEAS is reliant on its ability to provide timely information, with seasonal agricultural and weather updates being the most valued by stakeholders. These insights can guide the development and prioritization of digital extension services to better meet the needs of farmers and enhance the overall impact of these services.

c) Customization (CU)

The analysis highlights that the most important aspect of customization in phone-based digital agricultural extension and advisory services (PBDAEAS) is facilitating better two-way communication with farmers (CU1). This indicates that stakeholders prioritize interactive communication, allowing for a more responsive and adaptive extension service that can better meet the individual needs of farmers.

The second most significant aspect is the ability of PBDAEAS to leverage the data it generates for constant learning and deriving impact (CU4). This underscores the importance of continuous improvement and the application of insights gained from data to enhance service delivery and effectiveness.

The third ranked indicator is the generation of customized recommendations using the data generated by PBDAEAS (CU2). This highlights the value placed on tailored advice that is specific to the context and needs of individual farmers, enhancing the relevance and utility of the information provided.

The fourth category, improving the quality of customized advice using PBDAEAS generated data (CU3), although still important, is ranked fourth. This suggests that while enhancing the quality of advice is crucial, it may be seen as a more indirect benefit compared to the direct interaction and feedback mechanisms provided by better two-way communication.

In general, the RII analysis highlights all four indicators have a positive index and the effectiveness of PBDAEAS in terms of customization is linked to its capability for interactive communication and continuous learning from data. These findings can guide the design and implementation of digital agricultural extension services to prioritize these aspects, thereby improving the overall effectiveness and adoption of these services among farmers.

d) Utilization (U)

The analysis highlights that the most significant aspect of utilization in PBDAEAS is the ease with which farmers can access agricultural information and advice (U2). This suggests that easy accessibility is an advantage that PBDAEAS has over others.

The second most important aspect is the understanding of content provided through PBDAEAS (U3). This underscores the importance of clear and comprehensible information delivery, which is essential for farmers to effectively utilize the advice and information given. Ensuring that the content is easily understood by the farmers can significantly enhance the overall impact of the digital extension services.

The third-ranked indicator is the adoption of recommended agricultural practices delivered through PBDAEAS (U4). This indicates that while accessibility and understanding are crucial, the actual implementation of the advice and practices is also vital. Strategies to encourage and support farmers in adopting new practices based on the digital advice they receive can further enhance the effectiveness of PBDAEAS.

The fourth category, farmers' preference for PBDAEAS over traditional methods (U1), though still important, is ranked lower. This suggests that while farmers may find PBDAEAS useful and easy to understand, there may still be a preference for traditional methods in some cases. This highlights the need for continued efforts to provide PBDAEAS together with conventional methods.

In general, the RII analysis highlights all four indicators have a positive index and the effectiveness of PBDAEAS in terms of utilization is strongly linked to accessibility and comprehensibility of the information provided. These findings can guide the design and implementation of digital agricultural extension services to prioritize these aspects, thereby improving the overall effectiveness and adoption of the service among farmers.

e) Overall Effectiveness (E)

The analysis reveals that the most critical aspect of PBDAEAS effectiveness is its ability to timely deliver productivity, weather, disease, and disaster information to farmers at scale (E2). The second most important factor is the cost-effectiveness of PBDAEAS in executing extension services to smallholder farmers at scale (E1). The third-ranked category is the utilization of the contents delivered through PBDAEAS by farmers (E4). The fourth category, the ability of PBDAEAS to deliver customized recommendations using the data it generates (E3), although important, is ranked lower.

In general, the RII analysis underscores the importance of Time and Cost in PBDAEA service provision at scale as the as the top priority followed by Utilization and Customization. These findings can inform strategies to optimize the design and implementation of digital agricultural extension services, ensuring they meet the critical needs of farmers and achieve their intended impact at scale.

General discussion - comparing findings with reviewed theories

The findings of this study align with various agricultural development and extension theories. The high importance of timely information delivery (T1, T2) supports the Diffusion of Innovation Theory, indicating that early adopters and early majority farmers benefit significantly from prompt seasonal and weather updates, as they can quickly adapt and improve their practices.

The study’s focus on cost-effectiveness (C1, C3) resonates with the High Pay-Off Input Model, emphasizing strategic investments in cost-effective digital tools to enhance productivity. Customization and two-way communication (CU1, CU4) align with the Theory of Planned

Behavior and Technology Acceptance Model, highlighting the importance of perceived usefulness and ease of use in adopting digital extension services.

The emphasis on accessibility and comprehension (U2, U3) echoes the Social Cognition Theory, where farmers' self-efficacy is bolstered through easy access to and understanding of agricultural information.

The findings of the study demonstrate that leveraging digital tools in agricultural extension can significantly improve efficiency, accessibility, and the overall adoption of modern farming practices, aligning well with both agricultural development and extension theories.

General discussion - comparing findings with reviewed empirical literature

The findings of this research align well with the empirical literature on digital agriculture and digital agricultural extension emphasizing the transformative potential of digital technologies in enhancing agricultural production and productivity. The study highlights the effectiveness of PBDAEAS in Ethiopia, particularly in terms of cost-effectiveness, timely information delivery, and customization. This finding coincides with the finding of Fabregas et al., 2022. The study's findings on cost and time support the empirical evidence that digital agriculture can address challenges and enhance productivity in developing countries (Khan et al., 2021). Furthermore, the research underscores the importance of tailored recommendations and interactive platforms, echoing findings that such models significantly increase farmer income and productivity, contributing to climate resilience in sub-Saharan Africa (Stephenson et al., 2021). The identified challenges, such as the need for collaboration among stakeholders and addressing technological and financial prerequisites, also align with the broader literature, suggesting that successful implementation of PBDAEAS requires comprehensive strategies involving multiple actors (Fabregas et al., 2022). Overall, the study validates the positive impact of digital agriculture tools and their potential to enhance agricultural productivity and sustainability.

CHAPTER FIVE

5. SUMMARY, CONCLUSION & RECOMMENDATION

5.1 Summary of Findings

The summary of findings for each variable is presented below.

Cost: PBDAEAS emerged as a cost-effective tool, particularly in disseminating standardized information to smallholder farmers. This aspect ranked highest (RII = 0.775), emphasizing the system's efficiency in reaching a broad audience without incurring substantial costs. The ability to develop content (RII = 0.7203125) and access farmer profile data for two-way communication (RII = 0.69609375) also showed significant cost benefits, ranking second and third, respectively. These findings suggest that PBDAEAS not only facilitates communication but also supports the creation of valuable content economically. Although monitoring and experimentation ranked lowest (RII = 0.6953125), it still represents a cost-effective aspect of the system.

Time: Timeliness is a critical factor for farmers, and PBDAEAS excels in this area. PBDAEAS 's capability to deliver seasonal agricultural information promptly ranked highest (RII = 0.79296875). This underscores the importance of timely updates for farmers planning their activities. Delivery of weather information (RII = 0.78359375) and disaster and disease alerts (RII = 0.75703125) also ranked highly, demonstrating the system's effectiveness in providing essential and timely data. Although the collection of monitoring and experimentation data ranked lowest (RII = 0.70703125), it remains a valuable feature for timely data acquisition.

Customization: Customization is another area where PBDAEAS shows strong potential. The ability to facilitate better two-way communication with farmers was the most valued aspect (RII = 0.92734375). This highlights the importance of interactive and responsive communication channels in agricultural extension services. Leveraging data for continuous learning and impact (RII = 0.9171875) and generating customized recommendations (RII = 0.90625) also ranked highly, indicating the system's strength in providing tailored advice and learning from data. Improving the quality of customized advice, while still important, ranked lowest (RII = 0.82734375), suggesting an area for potential enhancement.

Utilization: The ease of access to agricultural information and advice provided by PBDAEAS is the most significant factor in its utilization (RII = 0.878125). This underscores the importance of making information readily accessible to farmers. Understanding the content (RII = 0.83359375) and adopting recommended practices (RII = 0.8078125) also play crucial roles in utilization, indicating that farmers find the information not only accessible but also comprehensible and actionable. Although farmers' preference for PBDAEAS over traditional methods ranked lowest (RII = 0.778125), it still highlights a positive shift towards modern agricultural extension methods.

Overall Effectiveness of PBDAEAS: When evaluating the overall effectiveness of PBDAEAS, its ability to deliver timely productivity, weather, disease, and disaster information at scale ranked highest (RII = 0.85390625). This indicates that timely information dissemination is crucial for supporting farmers effectively. The low-cost execution of extension services (RII = 0.8421875) and the utilization of delivered content (RII = 0.80625) also rank highly, demonstrating the system's efficiency and practical impact. While delivering customized recommendations at scale ranked lowest (RII = 0.78984375), it remains an important feature, suggesting the need for further refinement to maximize its effectiveness.

5.2 Conclusion

Based on the research objectives and the findings of the study, the following conclusions are drawn.

Cost-effectiveness emerged as a crucial factor, with stakeholders appreciating the low-cost dissemination of standardized information (C3). This indicates that PBDAEAS provides a viable economic solution for widespread information distribution, making it accessible to a broader range of smallholder farmers. The development of content (C1) and two-way communication (C2) were also valued, although the latter faces challenges related to infrastructure and higher costs. Monitoring and experimentation (C4) had the lowest RII, suggesting the need for further investment to enhance these aspects.

Time was another critical factor, with the delivery of seasonal agricultural information (T1) and weather updates (T2) being highly valued. This aligns with the Diffusion of Innovation Theory, emphasizing the importance of timely and relevant information for effective adoption. The ability to quickly disseminate disaster and disease information (T3) further underscores the importance of rapid communication in mitigating risks and protecting livelihoods.

Customization was highlighted as a key benefit of PBDAEAS, with better two-way communication (CU1) and leveraging data for continuous learning (CU4) being particularly important. This reflects the Theory of Planned Behavior and the Technology Acceptance Model, which stress the importance of perceived usefulness and ease of use in technology adoption. Tailored recommendations (CU2) and improved quality of advice (CU3) also contribute to the relevance and applicability of the services.

Utilization focused on ease of access (U2) and comprehension of information (U3), indicating that clear and accessible content is crucial for effective adoption. While traditional methods are still preferred by some farmers, the overall positive RII for all indicators suggests a growing acceptance of digital tools.

The overall effectiveness of PBDAEAS is demonstrated by its ability to deliver timely, cost-effective, and customized information at scale. The findings support the application of agricultural development theories, highlighting the potential of digital tools to enhance agricultural productivity and sustainability in Ethiopia. By addressing the identified challenges and focusing on continuous improvement, PBDAEAS can play a vital role in transforming the agricultural sector, benefiting policymakers, practitioners, and farmers alike.

5.3 Recommendation

Based on the findings of the study and the conclusion, the following recommendations are made.

1. Investment in PBDAEAS: Investing in PBDAEAS is highly recommended, given its positive effect on Cost, Time, Utilization, and Customization on Effectiveness. Service providers like government organizations, NGOs, and private sectors should prioritize PBDAEAS in their long-term policy and strategy. Investment in PBDAEAS can lead to reduced costs in agricultural extension services, timely information delivery, increased content utilization, improved customization, and ultimately, widespread adoption and productivity enhancement.

2. Future Research Recommendation – evidence from end-users

This study targeted supply side (as indicated in the title 'evidence from expert service providers') for its research input. It is recommended that future researchers could target farmers and conduct similar studies. Variables to consider in these studies may include, but not limited to, ease of access, understanding of content, willingness to adopt, and actual adoption rates. This approach would provide a more comprehensive understanding of the effectiveness of PBDAEAS from the perspective of end-users, the smallholder farmers themselves.

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ANNEX

Annex 1: Data Collection Instrument

INSTRUCTION: Please respond to the following questions by ticking inside the appropriate box and by writing your response in the space provided.

Part 1: Demographic Questions

Gender: ☐ Male ☐ Female

Age: ☐ 25 or below ☐ 26-40 ☐ 41 or above

Institution type:

☐ Government ☐ Non-government ☐ Development partner (donor)

☐ Private Sector ☐ Other

Level of education

☐ BA/BSC Degree ☐ MA/MSC Degree ☐ PhD

Position level

☐ Top management ☐ Mid-level management ☐ Expert level ☐ Other

Your experience in the type of Digital Agricultural Extension & Advisory

☐ Phone/Mobile ☐ Video ☐ Radio ☐ Other

Your experience in Digital Agricultural Extension & Advisory service provision

☐ Content development ☐ Content dissemination ☐ Research/Monitoring ☐ Other

Years of Experience in Digital Agricultural Extension & Advisory

☐ 7 years or less ☐ 8-15 years ☐ 16 years or above

Part 2: Effectiveness Questions

The following questions will be used to collect data on the variables under study in this research.

i. Cost

To what extent do you agree with the following statements of **COST (C)** in explaining the effectiveness of phone-based digital agricultural extension and advisory service (PBDAEAS) provision.

No.	Statement/Question	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
C1	Unlike conventional methods, PBDAEAS is low cost means to develop content.					
C2	Unlike conventional methods, PBDAEAS is low cost mean to access farmer profile data and have two-way communication with farmers.					
C3	Unlike conventional methods, PBDAEAS low cost means to disseminate standardized information to smallholder farmers.					
C4	Unlike conventional methods, PBDAEAS low cost means to do monitoring and experimentation.					

ii. Time

To what extent do you agree with the following statements of **TIME (T)** in explaining the effectiveness of phone-based digital agricultural extension and advisory service (PBDAEAS) provision.

No.	Statement/Question	Strongly Disagree (1)	Disagree (2)	Neither Agree nor Disagree (3)	Agree (4)	Strongly Agree (5)
T1	Unlike conventional methods, PBDAEAS can timely deliver seasonal agriculture information to farmers.					
T2	Unlike conventional methods, PBDAEAS can timely deliver					

	weather information to farmers.					
T3	Unlike conventional methods, PBDAEAS can timely deliver disaster and disease information to farmers.					
T4	Unlike conventional methods, PBDAEAS can facilitate timely collection of monitoring and experimentation data.					

iii. Customization

To what extent do you agree with the following statements of **CUSTOMIZATION (CU)** in explaining the effectiveness of phone-based digital agricultural extension and advisory service (PBDAEAS).

No.	**Statement/Question**	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**	**Strongly Agree (5)**
CU 1	Unlike conventional methods, PBDAEAS allow a better two-way communication with farmers.					
CU 2	Unlike conventional methods, PBDAEAS can generate customized recommendations using the data it generates.					
CU 3	Unlike conventional methods, PBDAEAS can improve the quality of customized advice using the data it generates.					
CU 4	Unlike conventional methods, PBDAEAS can leverage the data it generates to derive impact through constant learning.					

iv. Utilization

To what extent do you agree with the following statements of **UTILIZATION (U)** in explaining the effectiveness of phone-based digital agricultural extension and advisory service (PBDAEAS).

No.	**Statement/Question**	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**	**Strongly Agree (5)**
U1	Farmers prefer using PBDAEAS over traditional agricultural extension methods.					
U2	PBDAEAS is easy for farmers to access agricultural information and advice.					
U3	Farmers understand the content provided through PBDAEAS.					
U4	Farmers adopt the recommended agricultural practices delivered through PBDAEAS.					

v. Effective provision of phone-based digital agricultural extension and advisory service

To what extent do you agree with the following statements of **EFFECTIVE PROVISION OF PHONE-BASED DIGITAL AGRICULTURAL EXTENSION AND ADVISORY SERVICE (E)**.

No.	**Statement/Question**	**Strongly Disagree (1)**	**Disagree (2)**	**Neither Agree nor Disagree (3)**	**Agree (4)**	**Strongly Agree (5)**
E1	PBDAEAS is a low cost means to execute extension service to smallholder farmers at scale.					
E2	PBDAEAS can timely deliver productivity, weather, disease, and disaster information to farmer at scale					
E3	PBDAEAS can deliver customized recommendations using the data it generates to farmers at scale.					
E4	Farmers utilize the contents delivered through PBDAEAS.					

Annex 2: Response Frequency Graph

a) Response Frequency of the Variable COST

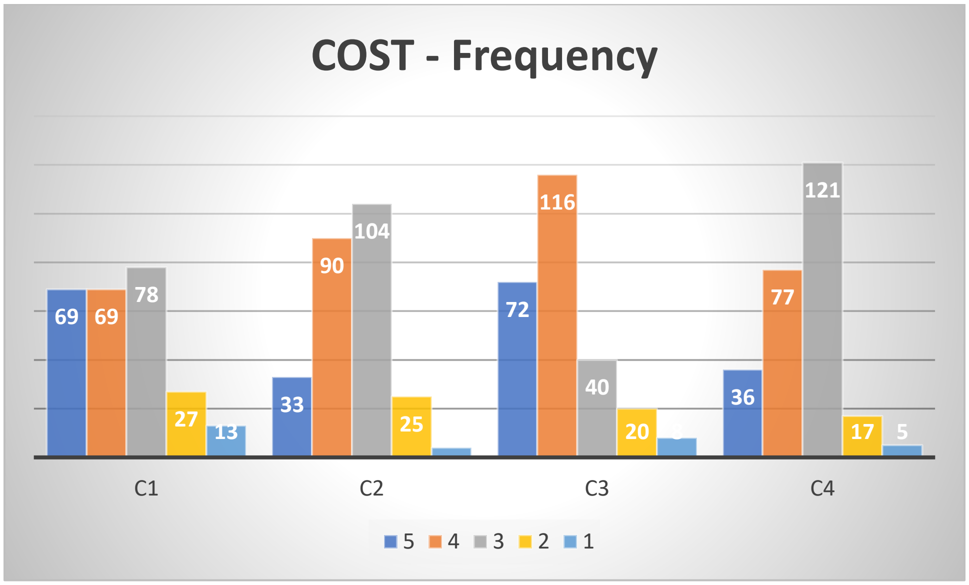

Figure A1. 1: Cost response frequency

Source: Own survey, 2024

b) Response Frequency of the Variable TIME

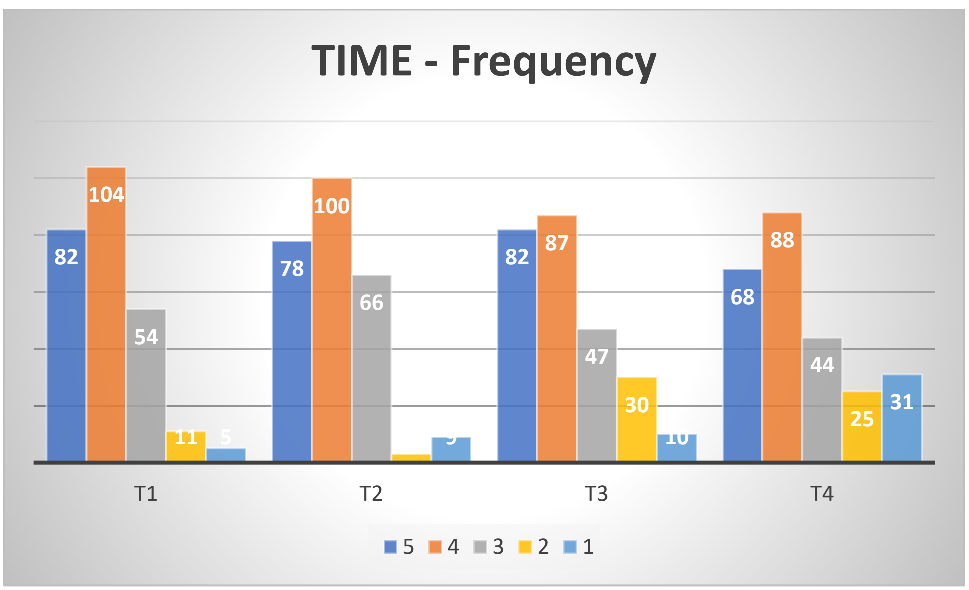

Figure A1. 2: Time response frequency

Source: Own survey, 2024

c) Response Frequency of the Variable CUSTOMIZATION

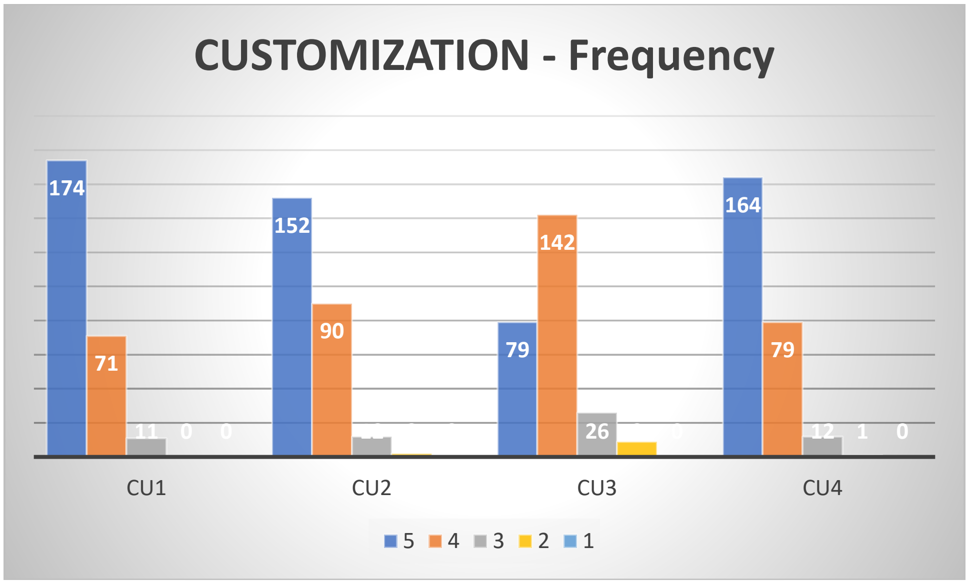

Figure A1. 3: Customization response frequency

Source: Own survey, 2024

d) Response Frequency of the Variable UTILIZATION

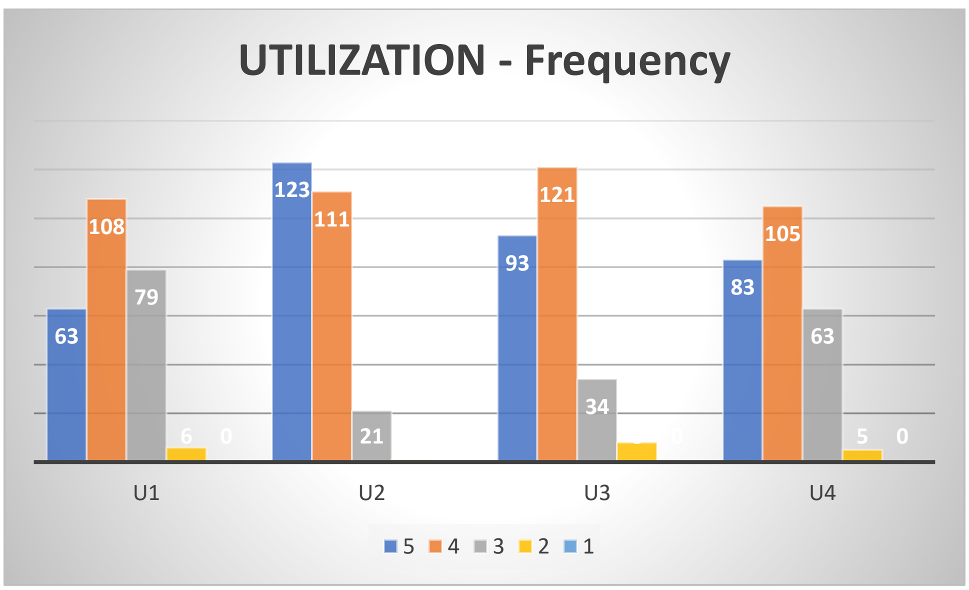

Figure A1. 4: Utilization response frequency

Source: Own survey, 2024

e) Response Frequency of the Variable EFFECTIVENESS OF PBDAEAS

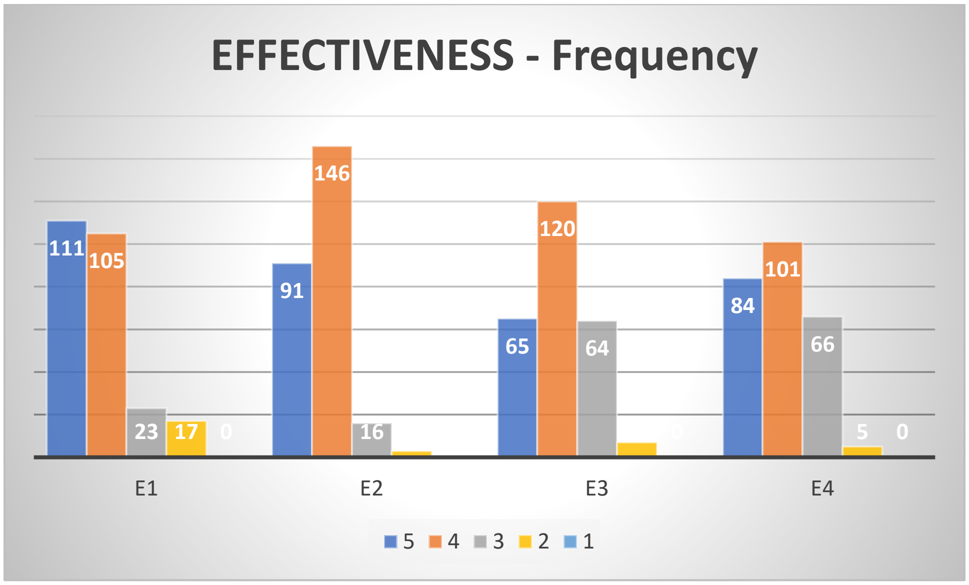

Figure A1. 5: Effectiveness response frequency

Source: Own survey, 2024

Annex 3: Research Proposal Approval Form

THESIS RESEARCH PROPOSAL APROVAL FORM

DETERMINANTS OF THE EFFECTIVENESS OF PHONE-BASED DIGITAL AGRICULTURAL EXTENSION AND ADVISORY IN ETHIOPIA: EVIDENCE FROM EXPERT SERVICE PROVIDERS

This thesis proposal is prepared and submitted to the Center for Regional and Local Development Studies in partial fulfillment of the requirements for the Master of Art in Regional and Local Development Studies.

NAME	SIGNATURE	DATE
Messay Sintayehu		**Feb 25, 2024**

We have examined and approved the thesis research proposal prepared and submitted to the Center for Regional and Local Development Studies by Messay Sintayehu.

NAME	SIGNATURE	DATE
ADVISOR **Dr. Kumela Gudeta**		**Feb 25, 2024**
EXAMINER **Dr. Filmon Hadaro**		**25 February 2024**

Annex 4: Ethical Clearance Certificate

Addis Ababa University
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College of Development Studies (CoDS)
Institutional Review Board (IRB-CoDS)

MA/MSc Proposal Ethical Clearance Certificate **(No 004/2024)**

1. Student's name:...... **Messay Sintayehu**....Gender:...**Male** Age:......
   Id.No:...... **GSR/7533/15** ....e-mail:......... ***messaysb@gmail.com...***
   Center/Dep't:...CRLDS.. Stream:...**Regional and Local Development Studies** *(RLDS)*
2. Title of the Proposal: **Determinants of Effectiveness of Phone-Based Digital Agricultural Extension and Advisory in Ethiopia: Evidence from Expert Service Providers.**
3. Proposal No:......**04**......Date accepted:.........**March 18, 2024**........
   Amendment No (if any):...**01/2024**...Date:......... **March 25, 2024...**
4. A clear statement of the decision: ....**APPROVED**...............
5. The Research Ethics Committee of ......**CRLDS**.........affirms that this proposal fulfills the standard requirements described in IRB-CoDS Standard operation Procedure (SoP) and all protocols are observed.
6. This certificated is issued upon approval of the IRB-CoDS on ..**26/.03/ 2024**

Chairperson of the REC
Name:..................**Dr Belew Dagnew**...
Designation:.........**Asst. Professor**.........
E-mail:......**belew.dagnew@aau.edu.et**

Signature:......
Date:.........**26 March, 2024.**.....

CC: IRB-CoDS Office, ***Addis Ababa University***
(copy of the approved proposal is attached here with)