

Perceived Effectiveness of AgriTech in Disseminating Oil Palm Production Technologies in Western Tanzania

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Abstract

Dissemination of agricultural technology is vital to increasing sustainability and productivity; hence it is vital to assess how well it reaches and helps farmers. This study aimed at evaluating farmers' perceived effectiveness of AgriTech in the dissemination of improved oil palm production technologies in Tabora and Katavi regions in the Western zone of Tanzania. The study employed a cross-sectional mixed-methods research design involving quantitative and qualitative methodologies. A semi structured questionnaire was used to collect quantitative data from a sample of 120 respondents while focus group discussions and key informant interviews were employed to obtain qualitative data. Quantitative data were analysed using a Statistical Package for Social Sciences (SPSS) programme while content analysis was used to analyse qualitative data. The study found that overall, farmers' perception about AgriTech's effectiveness was positive with a mean score of 4.11 ± 0.03 suggesting that they perceived AgriTech as effective in the dissemination of improved oil palm production technologies. Reliability was specifically perceived as the most effective indicator of oil palm production technologies with a mean score of 4.13 ± 0.03 while tangibility was the least perceived effective indicator scored 3.96 ± 0.04 . The study concludes that while AgriTech supports farmers with services that are accessible, responsive, and reliable; however, improvements in the physical infrastructure and upholding high standards in service delivery are necessary for effective extension delivery.

Keywords: *Perceived Effectiveness, AgriTech, Dissemination, Oil palm, Production Technologies*

Introduction

Agricultural Technology Transfer Hub (AgriTech) is an organized facility that facilitates the dissemination of improved agricultural technologies to farmers, extension workers and other agricultural stakeholders (TARI, 2020). The facility was established by the Tanzania Agricultural Research Institute (TARI) to transfer improved agricultural technologies developed from its centres and other research or academic institutions. It plays a key role in disseminating knowledge, technologies, and agricultural information, and in linking farmers with other stakeholders in the agricultural sector. Agricultural technology transfer plays a significant role in transforming agricultural productivity by facilitating movements of soft and hard skills which are essential for improving farm production (Mgendi and Cheng, 2019; Azumah et al, 2018). Recently, there are eight AgriTechs located in each Zonal Agricultural show grounds in Tanzania. They operate throughout the year, providing opportunity to farmers and other agricultural stakeholders to learn various improved agricultural technologies which contributes to increased productivity resulting in raising farm incomes and ensuring food security (Rutasitara & Selejo, 2008).

AgriTech is not a Tanzanian invention; it has been effectively used in many different ways all around the world. Similar services are provided by the Agricultural Technology Information

Centre (ATIC) in India to farmers with a single point of access to better agricultural techniques (Dar *et al.*, 2014; Singh *et al.*, 2013; Kumar and Singh, 2007). Also, China's Science and Technology Backyards (STB) have played a crucial role in increasing agricultural output (LI *et al.*, 2022) while Mexico's MasAgro Hubs have been vital in encouraging conservation agriculture among smallholder farmers (Camacho-Villa *et al.*, 2016; Schutet *et al.*, 2015; Kilelu and Leeuwis, 2016). Furthermore, Chinese Agricultural Technology Demonstration Centres (ATDCs) have been established in different 23 countries in Africa to disseminate improved agricultural technologies aiming at increasing agricultural productivity and food security (Nalwimba & Mudimu, 2019; Mgendiet *et al.*, 2019)¹.

At the same time, although there is a large body of literature on AgriTechs (Sherka, 2021; Wordofa & Sassi, 2017; Wonde *et al.* 2022; Pandey & Solanki, 2012; Sankanagoudar & Nagnur, 2015; Dutta *et al.*, 2021; Singh & Kalra, 2019; Kumar *et al.* 2020; Eshetu, 2018; Narayana *et al.*, 2015; Ombati *et al.*, 2014; Worku, 2010; Mekuria, 2014; Omer *et al.*, 2021; Setu *et al.*, 2022; Khan *et al.*, 2017), however only a limited number of them have reported on the effectiveness of AgriTechs in the dissemination of improved agricultural technologies (Ombati *et al.*, 2014; Worku, 2010; Mekuria, 2014; Omer *et al.*, 2021; Setu *et al.*, 2022; Khan *et al.*, 2017).

Furthermore, most of the latter have limited their assessments to a single or a few components of the AgriTechs, thus limiting the comprehensive understanding of the effectiveness of the Hub as a tool of disseminating technologies. Thus, drawing on the empirical study, this article presents a comprehensive assessment of farmer's perceived effectiveness of AgriTech on the dissemination of improved oil palm production technologies in Western Zone of Tanzania. The article is organized in five sections; the first is the introduction, which is followed by the background to the article. The third section is on the conceptual framework adopted for the study, followed by the description of the study methodology. The fourth section presents results and discussion followed by the conclusions in the fifth and last section.

Background

TARI is mandated to develop different improved agricultural crop technologies and disseminate them to the end users using different dissemination pathways including Agricultural Technology Transfer Hub (AgriTech). AgriTech is a contemporary means of disseminating agricultural innovations including the use of improved seeds/seedlings, soil and water management methods, pests and diseases control and post-harvest technologies. The AgriTechs facilitate information transfer from researchers to farmers (TARI, 2020). They serve as a one-stop shop where various agricultural technologies are available.

AgriTechs were established with the mission of facilitating the continuous dissemination of improved agricultural technologies to end users, including farmers, extension workers, and other stakeholders. According to TARI (2020), AgriTechs seek to achieve the following objectives: (i) To ensure that the dissemination of agricultural technologies and innovations extends beyond one Agricultural show event; (ii) To establish one stop centre for training and accessing agricultural technologies and innovations to end users; (iii) To enhance collaboration with public and private stakeholders in technology dissemination; and (iv) To establish shops for sale of seeds and value-added products and by-products.

¹Similar other initiatives have been reported (see for example, Alemu, 2021; Njine, 2014; Ombati *et al.*, 2014; Wonde *et al.*, 2022)

FatumaMwasaAgriTech, which is the focus of this study, is one of the eight AgriTechs established under TARI in the country. The Hub is located in FatumaMwasa Agricultural show grounds at Ipuli in Tabora Municipality. It has been designated as a centre for technology dissemination in the Western Zone of Tanzania (TARI, 2021). The centre is administered jointly by the two TARI centres, namely, TARI Tumbi and TARI Kihinga. TARI Tumbi has a national mandate for conducting and coordinating agroforestry research. To cope with climate change and farmer's demands, the centre conducts research in various crops including oil palm, cereals, root and tubers, legumes, and horticulture. On the other hand, TARI Kihinga has a national mandate for conducting and coordinating research on oil palm. These centres provide personnel, capacity development, and improved technologies, which are important resources for the AgriTech's operations. Apart from oil palm and agroforestry technologies, AgriTech provides value-added products, good agronomic practices, and improved seeds/seedlings of various crops from other TARI centres. The centre is open all year round, as such, it is an important resource for farmers, extension agents, and other stakeholders to access and implement cutting-edge agricultural innovations.

In addition to acquiring, storing, and distributing technologies from TARI centres, FatumaMwasaAgriTech also established commercial channel for certified seeds/seedlings and goods, and uses demonstration plots to highlight crop success. Additionally, it distributes promotional materials, commercializes value-added products, and conducts training sessions to stakeholders on improved agricultural technologies. In order to broaden its influence and improve dissemination of improved technologies, FatumaMwasaAgriTech works with private agricultural enterprises, education institutions, and local governments. Furthermore, to guarantee efficient technology transfer to farmers, Agricultural Extension Officers, students and other stakeholders in the agricultural value chain, FatumaMwasaAgriTech uses various extension methods, including exhibitions, farmer field days, demonstration plots and mass media.

Conceptual framework

Effectiveness of an organization refers to how well an organization performs its activities to attain the predetermined objectives (Mukherjee et al., 2011). Perceived effectiveness is used to describe the subjective evaluation of how effectively goods or services satisfy the requirements and expectations of users. Farmers' perceived effectiveness of AgriTech in the dissemination of improved oil palm production technologies refers to how farmers believe that the AgriTech is effective at transferring improved oil palm production technologies. This study draws on Service Quality Model (SERVQUAL) to assess farmer's perceived effectiveness of AgriTech's in the dissemination of improved oil palm production technologies. SERVQUAL is a framework for assessing service quality. It was initially developed by Parasuraman, Zeithaml, and Berry in 1985 and further modified by Rana in 2013 (Parasuraman et al., 1988; Rana et al., 2013). In principle, the model constitutes several dimensions including access, assurance, empathy, reliability, responsiveness, tangibility and timeliness as indicators to measure the service quality of an organization. The SERVQUAL model has been employed by various scholars such as Sajesh and Padaria (2019) and Rana et al. (2013) to measure the effectiveness of extension agencies in the provision of extension services.

The conceptual framework in Figure 1 depicts the perceived effectiveness of AgriTech as a multifaceted construct, with several indicators grouped in concentric rings around the idea of

overall effectiveness at the centre. Seven essential aspects of service quality such as timeliness, tangibility, responsiveness, empathy, reliability, assurance, and accessibility may have an effect on the effectiveness of AgriTechH. All of these factors work independently to influence the main outcome variable, which is the perceived effectiveness of AgriTechH. Accessibility refers to how simple it is for users to utilize the platform. Assurance is the confidence of farmers that AgriTechH has the required skills, expertise, resource and infrastructure to meet farmers' requirements. Empathy is the measure of the interest and concern of the AgriTechH in addressing needs of individual farmers and within their context. Reliability is the ability to provide relevant and quality services in an accurate and cost-effective manner. Responsiveness is the measure of concern and supportive service of the AgriTechH. Tangibility implies physical facilities and materials for the benefit of farmers. Timeliness is the measure of timely provision of response and service.

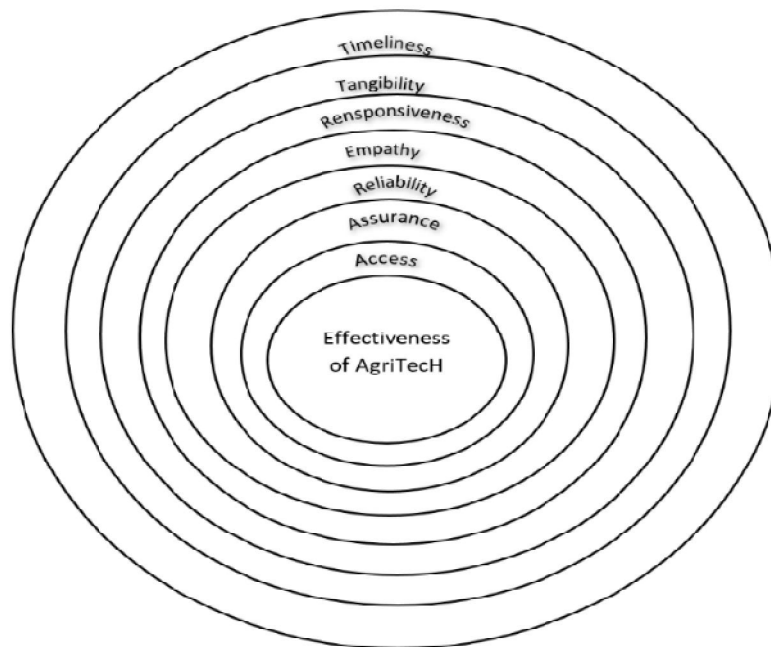


Figure 1: SERVQUAL Dimension

METHODOLOGY

The study was conducted in Tabora Municipality, Urambo and Kaliua districts in Tabora region and in Tanganyika district in Katavi region located in the western zone of Tanzania. Tabora and Katavi regions were chosen because they are ecologically suitable for oil palm production and are among the regions which are served by Fatuma Mwasa AgriTechH. According to the 2022 National Census, the populations of Katavi and Tabora Regions are 1,152,958 and 3,391,679 respectively. Katavi Region is situated between Latitudes 5° 15' and 7° 03' South and Longitudes 30° and 33° east. The region receives between 700 and 1,300 millimetres of rainfall annually. On the other hand, Tabora Region lies between latitudes 4° and 7° south of the Equator and receives an average of 1,010 millimetres of precipitation annually.

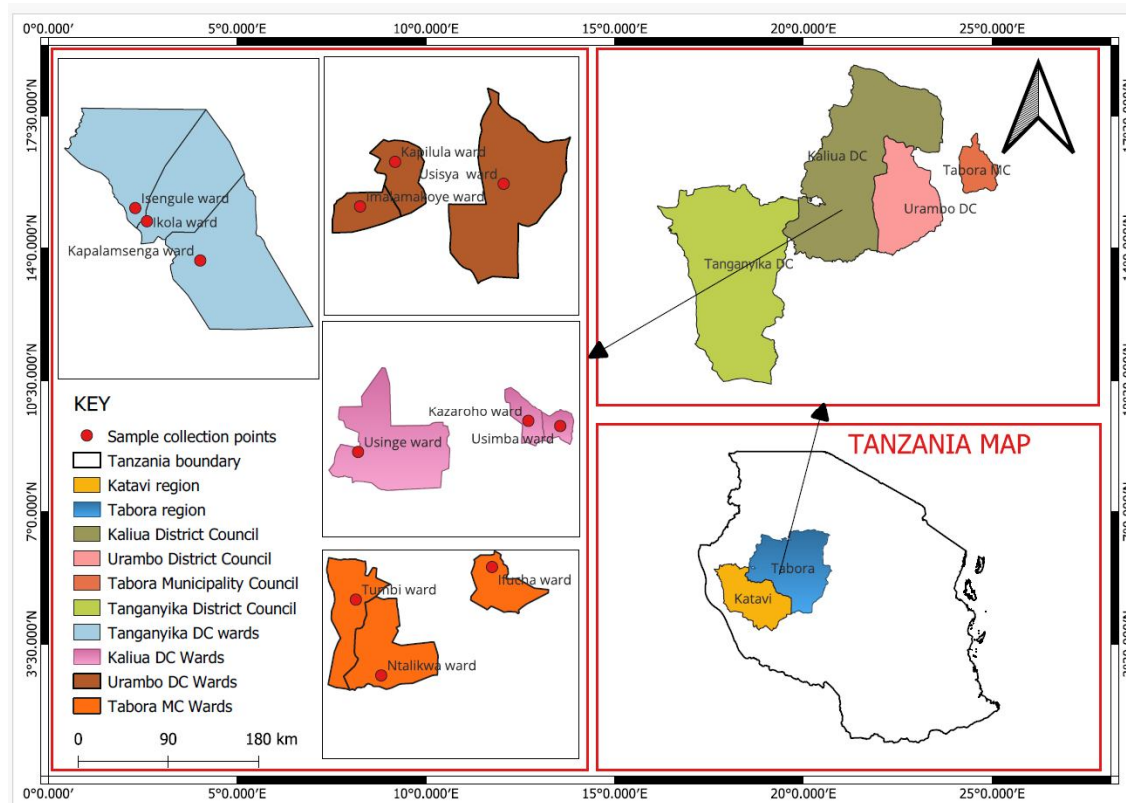


Figure 2: A map showing the study area

The study employed mixed methods research design involving both qualitative and quantitative research methods. The use of mixed research method facilitates triangulation, which improves validity and depth of the results. Oil palm farmers were the population of interest in this study. Both men and women farmers were included in the study to determine gender contribution in the oil palm production. Purposive sampling technique was used to select thirty farmers from each district making a total of 120 oil palm farmers. Literature revealed that a sample size of 80-120 respondents is sufficient for conducting socio-economic studies in sub-Saharan African countries, including Tanzania (Gbawoquiya, 2019; Iddi et al., 2022; Masanja et al., 2023). Farmers who actively participated in AgriTech activities such as attending training sessions, asking for guidance on oil palm production, and putting the disseminated technologies into practice were the main focus of the selection process. This strategy made sure that the sample included people who were knowledgeable about the disseminated technologies and had relevant experience, which matched the objectives of the research.

Furthermore, the District Agriculture, Livestock, and Fisheries Officer (DALFO), AgriTech Staffs, and Ward Agricultural Extension Officers (WAEO) served as Key Informants in this study. These officials were selected as Key Informants because of their knowledge and experience in the dissemination of improved agricultural technologies. Eight KIIs were conducted involving the DALFO and the WAEO from each district. Further, four Focus Group Discussions (FGDs) were conducted with the oil palm farmers, one FGD from each district were conducted in the study area. Participants who were not participated in the survey were included in FGDs to prevent overlap with the questionnaire survey. Six people participated in each FGD; they were purposefully chosen to guarantee variety, including women, men,

seniors, and young people, in order to collect a range of viewpoints. These FGDs participants were chosen based on their involvement in oil palm cultivation and their experiences with AgriTech dissemination initiatives.

The FGDs were moderated by a trained facilitator familiar with the study objectives, ensuring a neutral and productive discussion environment. The conversations were facilitated by a standardized checklist that focused on important subjects specifically the perceived effectiveness of AgriTech in dissemination of oil palm production technologies.

The primary data were collected from 120 respondents using a semi structured questionnaire with the KOBO Collect v2022.3.6 software, which enable responses to be entered directly into a digital format. This minimizes errors resulting from manual data entry, thereby streamlining data administration and guaranteeing data accuracy.

Further, a five-point Likert scale covering seven dimensions (accessibility, assurance, reliability, empathy, responsiveness, tangibility, and timeliness) was used to measure farmer's perceived effectiveness of AgriTech. To assess respondent's perception, mean scores for each indicator were computed and a cut off score of 3.0 as suggested by Wanjohi and Syokau (2021) was used, with the above 3.0 indicating positive perception and below 3.0 indicating negative perception.

The calculation of the mean score was as follows:

$$\text{Mean score} = \frac{\sum_{i=1}^n \text{Score}_i}{n}$$

Where:

$\sum_{i=1}^n \text{Score}_i$ Represents the sum of all scores for a particular indicator, n represents the total number of respondents who rated that particular measure.

Data analysis was conducted using MS excel and statistical package for social sciences. The collected quantitative data were arranged, coded, and cleaned in MS excel and then imported into SPSS 27 for further analysis. Descriptive statistics such as mean, and standard error was used to analyse quantitative data. Content analysis was used to analyse qualitative data from KIs and FGDs. The data were coded and similar patterns were categorized to cast experiences and perspectives of farmers. The categories developed were then validated by an expert review to make sure they appropriately reflected farmers' experiences and viewpoints. Content analysis was utilized to delve into particular issues, recommendations for improvement, and comprehensive input about the effectiveness of AgriTech (Xu & Zammit, 2020).

Results and Discussion

Socio-Economic Characteristics of Respondent

Results in Table 1 show that the majority (83.3%) of the respondents were males; similarly, the majority (95.8%) of the respondents were married. Moreover, a large proportion (59.2%) of the respondents had primary education, and that about 96.7 per cent of them, which is the majority, were involved in agriculture as their main occupation with about 72.5 per cent of them having more than ten years of farming experience. Furthermore, results in Table 1 revealed that apart from oil palm, the majority (91.7%) of the respondents produced maize. This is in line with the report by FAO, (2015) indicating that over 80% of smallholder farmers in Tanzania produce maize as staple crop.

Table 1: Socioeconomic characteristics of the respondents

| Socioeconomic characteristics | Category | Frequency | Percent % |
|--|--|-------------------|-----------|
| Sex | Female | 20 | 16.7 |
| | Male | 100 | 83.3 |
| Marital status | Single | 5 | 4.2 |
| | Married | 115 | 95.8 |
| Level of education | No formal education | 2 | 1.7 |
| | Primary Education | 71 | 59.2 |
| | Secondary education | 25 | 20.8 |
| | Tertiary/college education | 22 | 18.3 |
| Occupation | Government employee | 14 | 11.7 |
| | Farmer | 116 | 96.7 |
| | Local leader | 6 | 5.0 |
| | Business/trade | 18 | 15.0 |
| | Others (religious leader, plumber, carpenter) | 4 | 3.3 |
| | How many years have you been engaged in agricultural activities? | Less than 3 years | 10 |
| | 3 to 5 years | 8 | 6.7 |
| | 6 to 10 years | 15 | 12.5 |
| | More than 10 years | 87 | 72.5 |
| For how long have you been growing oil palm? | Less than 3 years | 82 | 68.3 |
| | 3 to 5 years | 12 | 10.0 |
| | 6 to 10 years | 5 | 4.2 |
| | More than 10 years | 21 | 17.5 |
| Crops other than oil palm | Maize | 110 | 91.7 |
| | Tobacco | 40 | 33.3 |
| | Sweet potatoes | 17 | 14.2 |
| | Rice | 64 | 53.3 |
| | Others such as beans | 55 | 45.8 |

Farmer's Perceived Effectiveness of AgriTech in the Dissemination of Improved Oil palm Production Technologies

According to AgriTech reports, various improved oil palm production technologies have been disseminated to the farmers through the AgriTech. These include improved oil palm seedlings (Tenera), the criteria for selecting oil palm field, land preparation methods, nursery management practices, transplanting techniques, irrigation methods, pruning techniques, fertilizer application methods and pest control methods.

Access

The findings in Table 2 show that respondents perceived AgriTech as being very accessible. In particular, the highest mean score of 4.21 ± 0.06 shows that the respondents perceived that it is easy to get in touch with AgriTech staff and that the information from the AgriTech is easily accessible. However, the approachability of AgriTech staff had the lowest mean score of 4.18 ± 0.06 , which is nevertheless still good. Both results show that farmers had a positive perception about effectiveness of AgriTech services despite their variation in the mean

score. During key informant interview with Ward Agricultural Field Officer, the following observation was made,

“...When we encounter any production challenge like crop pest it is easy to approach and contact the AgriTech staffs for assistance; and they usually attend the reported cases on time...”(KII with Ward Agricultural Field Officer at Ikola Ward on July 11, 2024)

These findings, however, are in contrast with the findings in a study by Andersen (2017) who reported of famers' low access to extension services (17%) in Dodoma, Tanzania.

Table 2: Perceived Effectiveness of AgriTech on SERVQUAL Indicators

| Indicators | Description | Mean | Std. Error |
|-----------------------|--|-------------|-------------------|
| Accessibility | AgriTech personnel are easily approachable | 4.18 | 0.06 |
| | AgriTech staff are easy to contact | 4.21 | 0.06 |
| | AgriTech information are easily accessible | 4.21 | 0.06 |
| | AgriTech have quick feedback mechanisms | 4.20 | 0.06 |
| Assurance | Extension services and products are highly useful to farmers | 4.15 | 0.04 |
| | AgriTech has enough capital resources | 4.06 | 0.06 |
| | AgriTech staff have the necessary expertise | 4.06 | 0.06 |
| Empathy | AgriTech offers regular interaction | 4.09 | 0.06 |
| | AgriTech provides localized solutions | 4.15 | 0.06 |
| Reliability | Extension services and products provided by AgriTech are reliable | 4.13 | 0.04 |
| | AgriTech provides cost-effective services and products | 4.13 | 0.05 |
| | Extension services and products provided by AgriTech are of high quality | 4.08 | 0.04 |
| | AgriTech provides accurate information | 4.16 | 0.04 |
| Responsiveness | AgriTech personnel are highly service-minded and supportive | 4.17 | 0.05 |
| | AgriTech demonstrates concern for farmers' well-being | 4.19 | 0.06 |
| | AgriTech has all the required physical facilities for effective operations | 3.98 | 0.05 |
| Tangibility | AgriTech uses good communication materials | 3.70 | 0.05 |
| | AgriTech facilities and materials are well maintained | 4.20 | 0.06 |
| | AgriTech provides consistent response within promised timeframe | 4.18 | 0.05 |
| Timeliness | AgriTech provides timely responses to farmers' inquiries | 4.02 | 0.07 |

The findings in Table 2 imply that the provision of friendly services to farmers by AgriTech and ease accessibility of AgriTech staff, might be contributing to the closing of the services gap and an increase of accessibility to contemporary agricultural technologies by a broader range of smallholder farmers. This has the potential of significantly increasing agricultural output, especially among smallholder farmers who may not get the same level of assistance from conventional support channels.

According to Figure 3, the majority of the respondents agreed that AgriTech was effective in terms of accessibility particularly the rapid feedback mechanisms, information accessibility, and easy access to staff contacts. The fact that fewer respondents disagreed suggests that their perceptions were mostly positive. The disagreement about AgriTech's accessibility, however slight, is attributed to the fact that the services are located far from the clientele as a male oil palm farmer during FGD remarks,

“...AgriTech is very useful but what limits our regular visits to the Hub is the distance from our homes to the AgriTech. We are requesting TARI and the government to find possibilities of bringing these services more closely to our places...” (Male Oil palm farmer during FGD at Ikola village on July 11, 2024)

These remarks are in line with the findings from a study by Alemu (2021) who reported that farmers who are relatively far from the Farmer Training Centres (FTC) are less participating in FTC based extension because it takes their time, energy and additional cost to travel there.

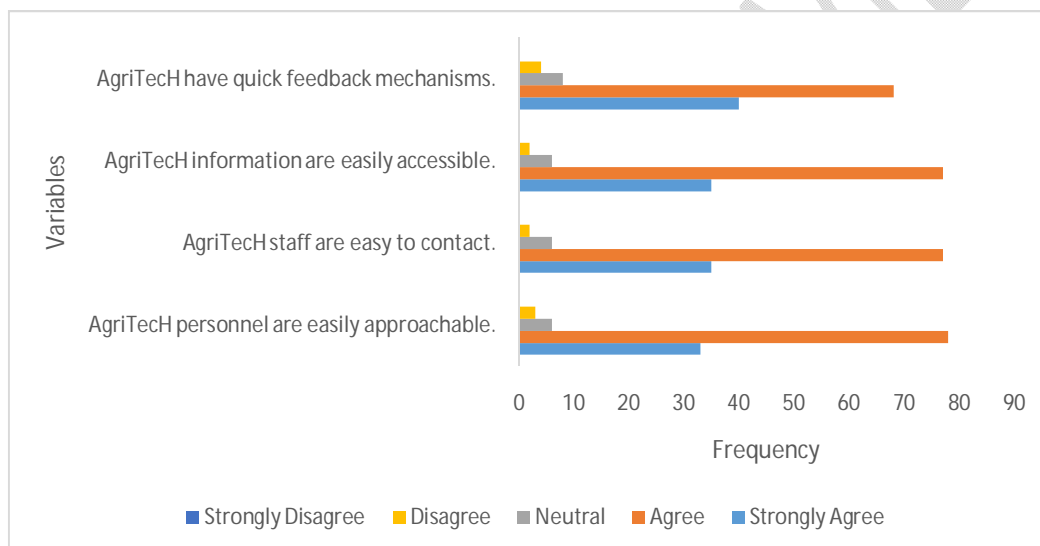


Figure 3: Distribution of respondents based on their perceived effectiveness of AgriTech regarding accessibility

Assurance

The results in Table 2 and Figure 4 show that farmers have positive perception about AgriTech's effectiveness in terms of assurance. AgriTech's extension services and products, personnel knowledge, and financial resources were all scored over 4.0 by the respondents, indicating a high degree of trust in these areas. According to the findings, AgriTech is well trusted for its dependability and capacity to satisfy farmer's needs; dependability and capacity satisfy farmer's needs are essential elements of assurance. During FGD a female oil palm farmer was quoted saying,

“... AgriTech has enough capital resources and sufficient number of staff with varied expertise who are capable of delivering the services and products at the required quality to facilitate our agricultural production activities...” (Female Oil palm farmer during FGD at Imalamakoye village on 02 July, 2024)

Generally, the findings from this study are supported by the findings in a study by Kannur et al. (2020) who reported that more than a half (51.11%) of the respondents had more favourable attitude followed by favourable attitude (28.89%) towards agricultural extension services provided by Agricultural Technology Information Centre of UAS, Bangalore. These findings, however are in contrast with the findings in a study by Meja and Geta (2015) who reported skills and attitudinal problems of some of the development agents in Farmer Training Centres in Damote Gale District in Ethiopia. The findings from this study have important ramifications because they emphasize how crucial assurance of service availability is to the uptake and ongoing usage of AgriTech services (Bewonget *al.*, 2023). Farmers are more inclined to trust and depend on a service when they believe that the provider has the needed resources and knowledge (Jakkue *et al.*, 2019). Because agricultural tasks are typically very important and involve high risks, the farmers' perceived confidence to AgriTech may increase farmer's involvement and the possibility of integrating recommended practices into regular routines. Moreover, better results in terms of agricultural production and sustainability might result in positive perception regarding the assurance of AgriTech services.

The study by Antwi-Agyei and Stringer (2021) pointed out that smallholder farmers perceive extension services and products as useful when efficiently fulfil their requirements especially when providing them with workable solutions that improve their operations. As reported by Davis et al. (2019), robust financial resources might guarantee the ongoing development and enhancement of these extension services, which increase customer trust even further. Another important consideration is the expertise of the AgriTech workforce. According to Dunne et al. (2019), professionals with good expertise and experience are better able to provide insightful counsel and assistance, which helps farmers feel more assured. This was supported by remarks by AgriTech supervisor during the Key Informant Interview when he said,

“...The AgriTech has the sufficient number of qualified and experienced scientists in various specialization for effective operation...” (KII with Supervisor at FatumaMwasaAgriTech on July 30, 2024).

Research has repeatedly shown that people are more inclined to accept and utilize technology frequently when they believe in the assurance of the service provider (Brown *et al.*, 2018; Kassem *et al.*, 2021; Taylor and Bhasme, 2018).

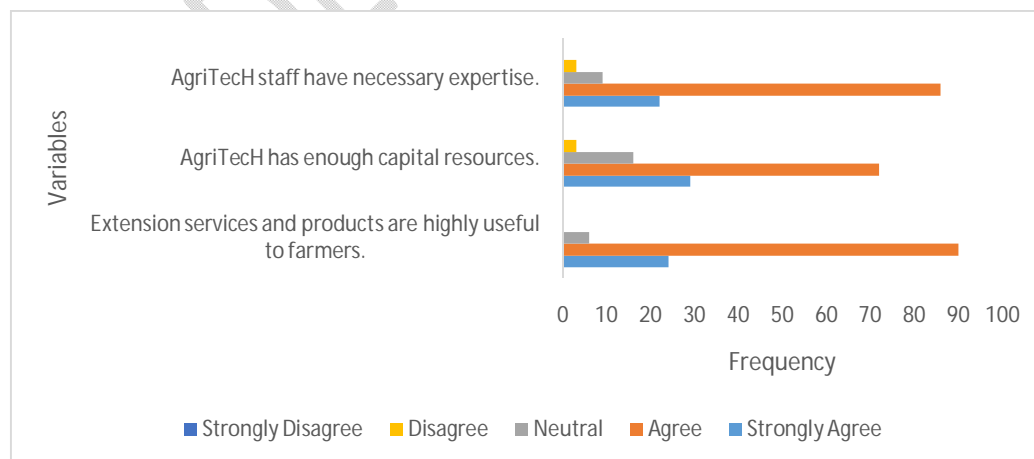


Figure 4: Distribution of the respondents based on their perceived effectiveness of AgriTech regarding assurance

Empathy

In this study, respondents rated high the regular interactions and localized solutions provided by AgriTech. The findings in Table 2 show that the perceived effectiveness of AgriTech regarding empathy was high with a mean score of 4.15 ± 0.06 . This is somehow higher given the fact that AgriTech provides localized solutions than the 4.09 ± 0.06 for regular interaction offered. The high mean scores indicate that farmers place high importance on regular interaction and solution customization which are the two essential components of empathy in service delivery (Bahadur *et al.*, 2018). The findings from this study are in line with the findings in a study by Wonde *et al.* (2022) who reported that close supervision, special attention and follow-up of the programme by experts in Farmers Training Centres motivated trainees into seriously attending training programmes and develop the necessary technical skills required for modern wheat and maize production, which further lead them to an increase in the yield and in annual net income.

Through individualized care and targeted local solutions, AgriTech probably makes its services more relevant and efficient (Duncan *et al.*, 2021). Farmers may therefore accept AgriTech solutions at a faster rate as a result of feeling more supported and understood in their particular circumstances. Offering customized solutions shows that Fatma Mwasa AgriTech is cognizant of the many agricultural contexts in which farmers work, reaffirming the AgriTech's dedication to tackling specific problems. According to the findings in Figure 5, most respondents perceive AgriTech as compassionate in general, especially when it comes to offering solutions that are localized and personalized for specific local circumstances. These findings emphasize how crucial empathy is for successful dissemination and adoption of agricultural technology. This is because understanding farmers' particular demands and issues requires empathy which increases the applicability and adoption of technical solutions. Providers of agricultural technology that exhibit empathy are more likely to interact personally with farmers, which enables the latter to customize solutions that take into account particular regional circumstances and customs (Kaimowitz *et al.*, 2019).

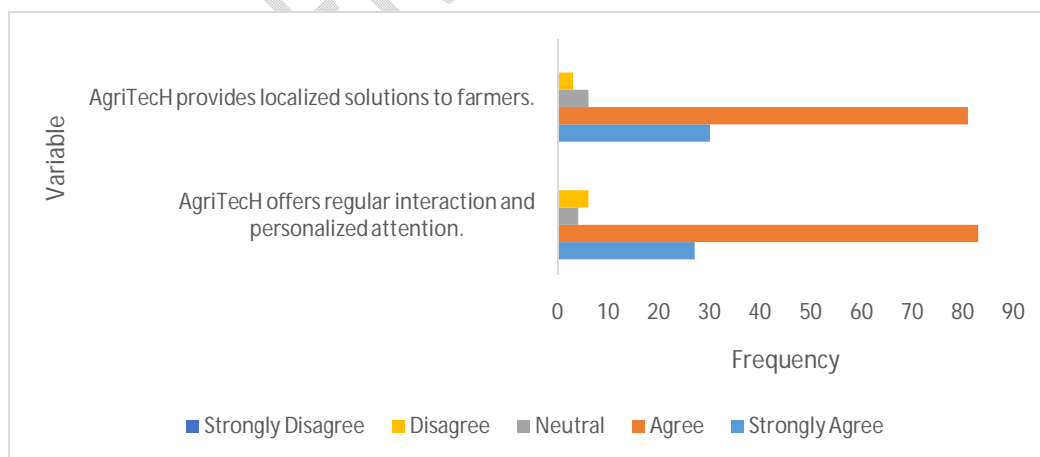


Figure 5: Distribution of the respondents based on their perceived effectiveness of AgriTech regarding empathy

Reliability

The results in Table 2 illustrate how reliability about AgriTech is perceived by farmers, with mean ratings of over 4.0 for a number of factors including cost-effectiveness, accuracy of information, quality of services, and dependability of extension services. In particular, the correctness of AgriTech's information and the dependability of its extension services had mean ratings of 4.16 ± 0.04 and 4.13 ± 0.04 , respectively. These high ratings show that respondents see AgriTech as very dependable overall, especially when it comes to providing correct information and consistently high-quality services. This finding aligns well with the finding in a study by Sajesh and Padaria (2019) who reported the highest score in reliability dimension for Farm Science Centre called Krishi Vigyan Kendra (KVK) in Akola, India. Despite their positive perception toward this indicator, one male oil palm farmer during FGD provided a different observation regarding the availability and the cost of the improved oil palm planting material. He reported,

“... The improved oil palm planting materials are not adequately available; they are sold at high cost due to increased demand. To ensure sufficient availability of improved oil palm planting materials, the government should increase support to TARI Tumbi and TARI Kihinga as the major sources of improved oil palm planting material (tenera) in Western zone as well as support and capacitate other public and private organizations which will be ready to engage in oil palm seedlings development. Also, to encourage more farmers to adopt improved planting materials they should be subsidized or sold at a relative lower price so as farmers can afford ...” (Male Oil palm farmer during FGD at Ifucha Village on July 30, 2024).

The results in Figure 6 show that most respondents agreed with every item indicating AgriTech's reliability. Furthermore, the results suggest that extension service provider's long-term viability and sustainability depend heavily on its reliability. Being seen as trustworthy by farmers indicates that they value the services and knowledge AgriTech offers, which is crucial for attracting repeat farmers and promoting the ongoing use of AgriTech products. Indeed, a study by Kietiet *al.* (2021) found that the provision of services through any channel is affected by reliability and trust. Reliable services guarantee that farmers can rely on AgriTech to assist their farming operations, which improve results and enhance AgriTech's image.

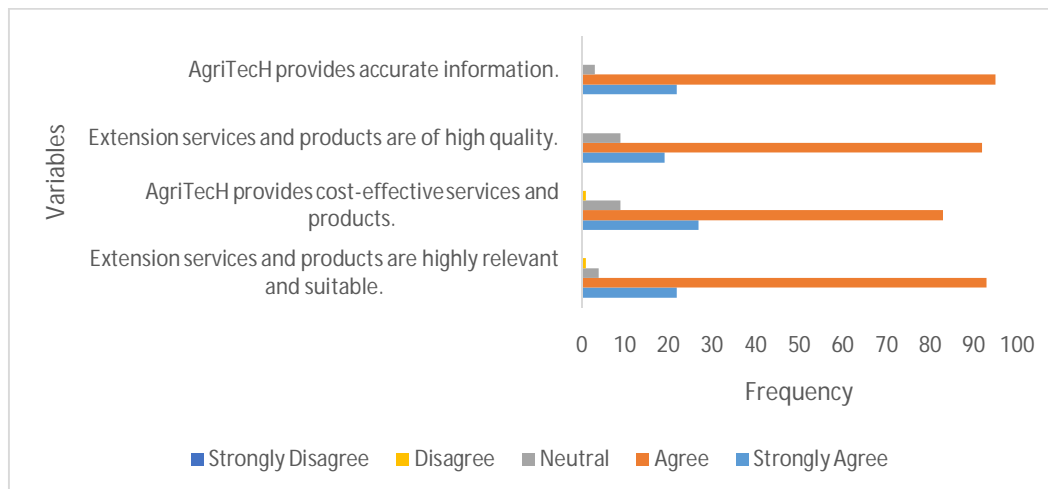


Figure 6: Distribution of the respondents based on their perceived effectiveness of AgriTech regarding reliability

The sense of reliability is probably much influenced by the regular provision of excellent services (Van Lierop *et al.*, 2018). When farmers consistently use AgriTech's services and obtain great outcomes, they are more inclined to perceive AgriTech's services positively (Fox *et al.*, 2021). Furthermore, it is critical to provide correct information since false or misleading information may damage credibility and have a detrimental effect on agricultural operations (Visser *et al.*, 2021). AgriTech's dedication to the precision and excellence probably plays a part in the positive impression of reliability.

Responsiveness

Farmers' opinions regarding responsiveness on AgriTech's effectiveness are shown in Table 2. The respondents' overall perception about AgriTech staff is good, as seen by high mean ratings (4.17 ± 0.05), which imply a very supportive and service-minded attitude. Furthermore, as shown by somewhat higher mean score (4.19 ± 0.06), farmers equally recognize AgriTech's proven care of their well-being. The excellent response ratings might be attributed to the customized manner in which AgriTech employees engage with farmers. Farmers feel appreciated and understood in this setting, which is probably more engaging and encouraging (Kassem *et al.*, 2021). A similar observation is made by Tefera *et al.* (2011) who reported that responsiveness to farmer's interest, which was demonstrated by the majority (62%) of Development Agents in Farmer Training Centres in Ethiopia called for a need for additional training to improve effectiveness of such agents in the delivery of extension services. This might be attributed to their service-minded behaviour and concern about farmer's well-being. These findings are in contrast with findings in a study by Meja and Geta (2015) in Ethiopia who reported poor concern of Farmer Training Centre to farmers' wellbeing due to the longer duration of classroom session as opposed to practical and training sessions during summer season with no consideration of farmers' working times.

The data in Figure 7 demonstrate that most respondents believed that AgriTech was beneficial in improving responsiveness in all of the statements. These results imply that AgriTech has been effective in creating a service culture that meets the expectations of farmers, that is likely to increase mutual trust and collaboration. These observed positive perceptions regarding responsiveness indicated in Table 2 have important ramifications for future development of AgriTech. Sustaining and enhancing responsiveness is attributed to

increased farmers satisfaction (Kassem *et al.*, 2021), which is essential for AgriTech solutions to be adopted over time.

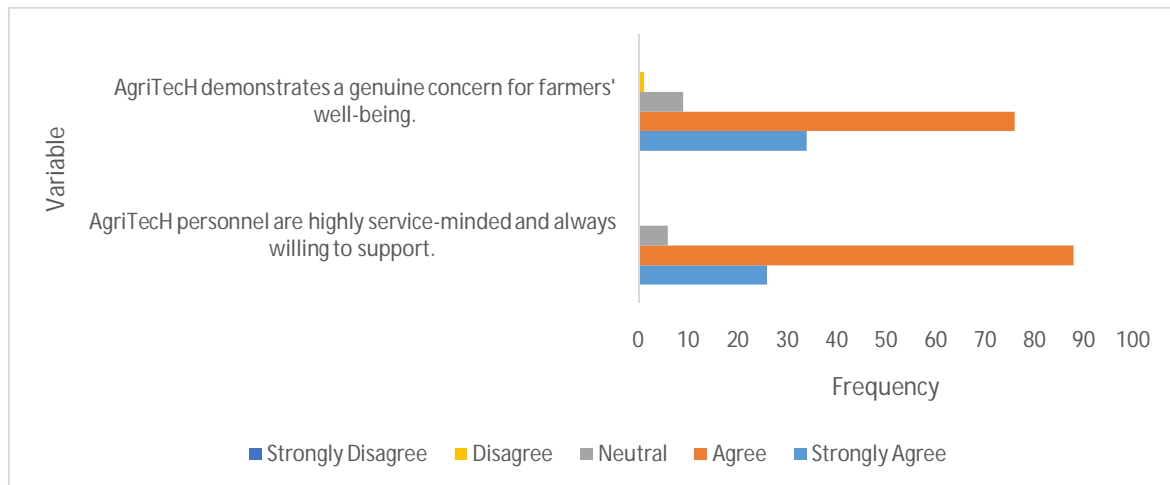


Figure 7: Distribution of the respondents based on their perceived effectiveness of AgriTech regarding responsiveness

Tangibility

Results in Table 2 present farmers' perceptions regarding AgriTech's effectiveness on tangibility indicator, with particular reference to the actual facilities and resources. The average ratings, which vary from 3.70 ± 0.05 to 4.20 ± 0.06 , show that farmers perceive AgriTech as generally effective in terms of availability and preservation of the physical infrastructures required for operations. The fact that, maintenance of materials and facilities received the highest score indicates that farmers place a high value to AgriTech in terms of preservation and repair of their available resources. Figure 8 further emphasizes this observation by demonstrating that most respondents agreed with all AgriTech tangibility assertion. Farmers' positive perception about AgriTech's demonstrable physical facilities and communication materials can be credited to the organisation's strategic investment in infrastructure.

Even though tangibility was shown to be generally good, it is crucial to take into account the lower mean score of 3.70 ± 0.05 and 3.98 ± 0.05 in communication materials and required physical facilities respectively. These lower rankings on the two aspects indicate that while physical facilities are kept up well, there should be some improvement to increasing AgriTech effectiveness in communication materials and the required physical facilities. The findings of the current study align with the findings in a study by Sajesh and Padaria (2019) who reported the highest score in tangibility dimension for Farm Science Centre called Krishi Vigyan Kendra (KVK) in Akola, India. The highest score of AgriTech in tangibility dimension shows that farmers are satisfied with the available physical facilities and communication materials and how these facilities are maintained. These findings however, are in contrast with the findings in a study by Meja and Geta (2015) who reported unavailability of some physical facilities including living houses for development agents, electricity, television, appropriate teaching materials, metrology, workshop and field equipment in the Farmer's Training Centres in Damote Gale District in Ethiopia. The remark given by AgriTech Supervisor during the key informant interview revealed the following,

“...Despite that the AgriTech has important physical facilities and training materials for continuing with its operations, some of the physical facilities are not available including living houses for resident supervisor, storage facilities, shop, fencing as well as officespace and their facilities. We also have insufficient water supply for irrigation especially during dry season because AgriTech operates throughout the year as well as insufficient communication materials including printed materials such as posters, leaflets, booklets, brochures, banners for communicating improved technologies and audio-visual aids such as Public Address System, LCD projectors, Video camera, Laptops, printers, photocopy machine for preparing and disseminating improved technologies....” (KII with Supervisor at FatumaMwasaAgriTech on July 30, 2024)

On the other hand, during the FGD one female oil palm farmer had this to say,

“...There is a limited availability of the communication materials in the AgriTech especially leaflets containing information about improved oil palm production technologies. Leaflets are good at reminding learners of what has been learnt after getting back to their homes” (Female Oil palm farmer during FGD at Usinge Village on July 3, 2024).

The findings have two major implications for the AgriTech. Firstly, keeping physical infrastructure updated is crucial to preserving farmers' confidence and contentment. Secondly, there is an opportunity to improve effectiveness and calibre of physical and communication materials, making sure that farmers can easily access and comprehend them in addition to being instructive.

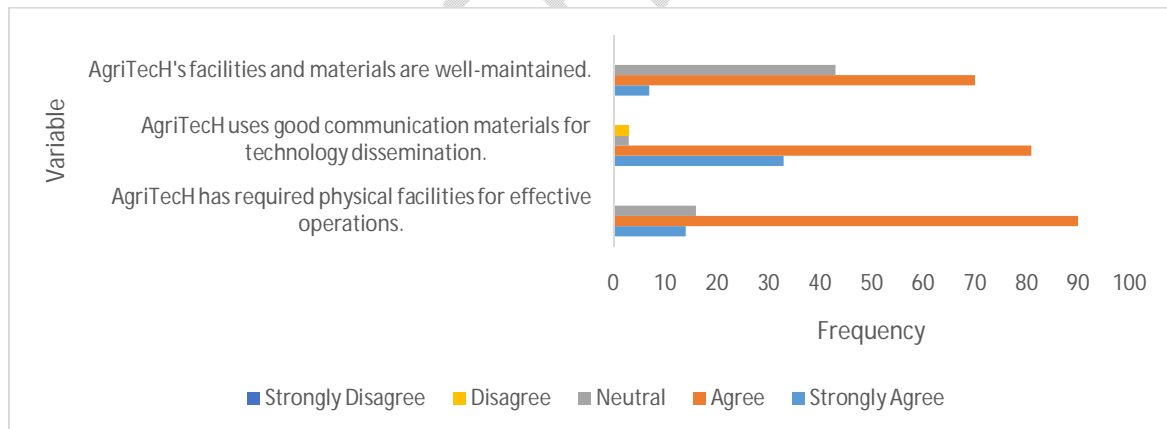


Figure 8: Distribution of the respondents based on their perceived effectiveness of AgriTech regarding tangibility

Timeliness

The findings in Table 2 present farmers' assessments of AgriTech's timeliness, with particular emphasis on the promptness and consistency of the response. The average ratings, which vary from 4.02 ± 0.07 to 4.18 ± 0.05 , show that farmer's perceptions were positive. AgriTech's capacity to provide replies within the specified period received the highest rating. This shows that AgriTech can generally be relied upon to fulfil its promises to farmers on schedule. Moreover, results in Figure 9 show that every farmer agreed with every statement about how quickly AgriTech delivers its services. This effectiveness probably

boosts farmers' general contentment and motivates them to keep using AgriTech services. These findings are in line with findings in a study by Agholor et al. (2013) who reported that a good percentage of women (18.14%) were satisfied with timeliness of the delivery of extension services as compared to (14%) of men. As commented by Mabofu and Elia (2017), access to timely and reliable agricultural information has the potential of improving agricultural production. Furthermore Elia (2014) and Gue'ye (2010) revealed that the provision of timely agricultural research information to stakeholders is important in influencing agricultural development.

However, despite the higher scores, there is still potential for improvement, especially in terms of guaranteeing timely response to farmer's inquiries. The findings in Table 2 emphasize the need for consistency in the provision of agricultural services. For AgriTech to continue serving farmers with confidence and pleasure, it is imperative that all contacts be completed in the timeframes that have been promised. Furthermore, by recognizing and resolving any delays, AgriTech's services further increase efficacy by improving the general sense of timeliness.

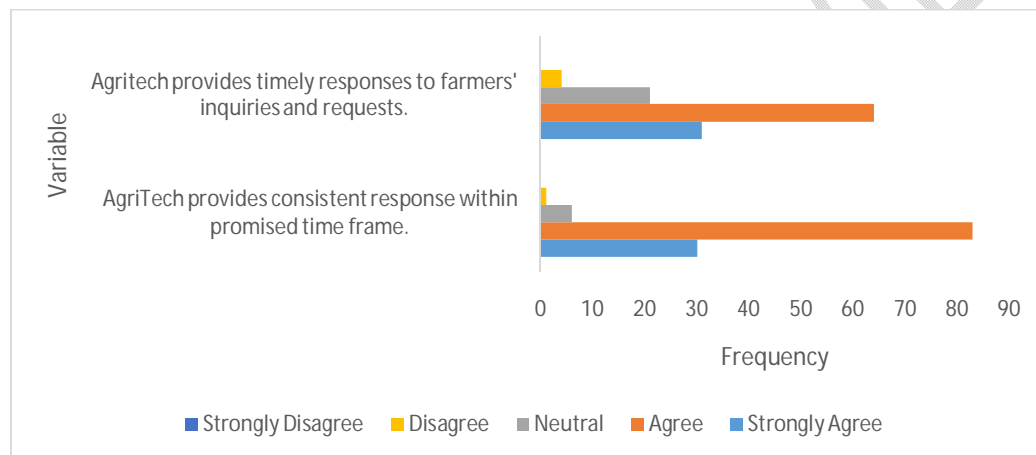


Figure 9: Distribution of the respondents based on their perceived effectiveness of AgriTech regarding timeliness

Overall perceived effectiveness

The study findings in Table 3 show that AgriTech was perceived well by all measures, with the mean score ranging from 3.96 ± 0.04 to 4.20 ± 0.05 . Access to AgriTech scored higher mean score (4.20 ± 0.05), while tangibility indicator scored low mean score (3.96 ± 0.04). This implies that farmers have perceived positively the effectiveness of AgriTech's in disseminating improved oil palm production technologies. Somewhat lower score on tangibility suggests that the provision of services in some areas should be enhanced. This includes but not limited to increasing infrastructure spending or providing greater upkeep for the already-existing infrastructures. The findings confirm the SERVQUAL model of the theoretical framework, which holds that indicators such as access, assurance, reliability, empathy, responsiveness, tangibility, and timeliness are essential for the total service quality and overall effectiveness. This is reflected in high ratings in almost all the indicators under investigation. The observation regarding tangibility emphasizes the necessity for the ongoing enhancements of the tangible components of service delivery in order to sustain farmer's satisfaction over time. The lower score for tangibility within the context of SERVQUAL model

underscores the need for continuous improvement of the physical aspects of service delivery, such as investing in infrastructure and maintaining the existing ones.

Table 3: Overall farmers perceived effectiveness of AgriTech

| Indicator | Mean | Std. Error |
|----------------|------|------------|
| Access | 4.20 | 0.05 |
| Assurance | 4.09 | 0.04 |
| Empathy | 4.12 | 0.05 |
| Reliability | 4.13 | 0.03 |
| Responsiveness | 4.12 | 0.04 |
| Tangibility | 3.96 | 0.04 |
| Timeliness | 4.10 | 0.05 |
| Overall | 4.11 | 0.03 |

Limitation of the study

There are some limitations to this study that might influence how the results are interpreted and used generally. The findings are descriptive and given in a generalized manner and do not go into deep detail about the actual conditions of oil palm farming, such as the level of production at the moment, the degree of technology adoption, or the particular extension strategies and contacts that are used in the research region. Furthermore, since the research primarily looks at farmers in certain districts, it has a narrow geographical emphasis and could not adequately represent the dynamics of oil palm production and technology diffusion in other regions. Moreover, the study did not establish a causal relationship between AgriTech activities and the observed results due to the research design and analysis. Future research on this subject should be more comprehensive in order to give a more complete picture of how effectively AgriTech disseminates technology for oil palm production.

Conclusion and recommendations

Overall, the article shows that farmers' perceived effectiveness about AgriTech in the dissemination of improved oil palm production technologies was good across all measures such as access, assurance, empathy, reliability, responsiveness, timeliness and tangibility. However, tangibility indicator has the low mean score as compared to other indicators. Although it is good because of being above the cut-off point, it implies that there is a need of improving tangibility component to raise farmers' perception about AgriTech's effectiveness. Addressing this weakness while maintaining the strengths highlighted by other indicators such as access, reliability, responsiveness, and assurance can ensure a more holistic and impactful performance of AgriTech.

The improvement in tangibility aspect can be done by renovating the available physical infrastructures such as training room and constructing unavailable physical infrastructures including house for resident supervisor, shop for products, fencing, storage facilities as well as offices. This will improve the working and learning environment for both AgriTech staffs and farmers respectively. Furthermore, there should be improvement in water supply system for irrigation and the availability of communication resources both printed materials and audio-visual aids that can be utilized to disseminate improved agricultural technologies to farmers, extension staffs and other stakeholders. Additionally, there is a need of ensuring that these physical resources are not only well cared for but also meet the changing demands of farmers to improve the overall efficacy of the services provided by the AgriTech.

Disclaimer (Artificial intelligence)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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