Factors that influence agricultural technology adoption among commercial vegetable growers in Arusha District, Tanzania

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ABSTRACT

Vegetable farming is an alternative source of livelihood and an important agricultural practice for income generation and employment opportunities. Currently, agricultural technologies are promoted among commercial vegetable growers to improve their livelihood. However, in many cases, the commercial vegetable farmers' adoption rate of modern technologies is low. There is limited understanding of the technology's adoption and the determinants of insights. This paper aims to assess the factors affecting technology adoption among commercial vegetable growers in three wards of the Arusha District, Tanzania. It targeted vegetable growers in the study area. This study adopted a cross-sectional design and quantitative approach guided by the theory of diffusion of innovation. The multi-stage sampling method was used to select a sample of 150 households. Data were gathered by a questionnaire applied in a survey method. The study used descriptive statistics to analyse the factors affecting agricultural technology adoption in the study area. Findings indicated that the farmers' education, household income, farm size, access to extension services, and access to credit influence the adoption. These factors are fundamentally enclosed within the vicious cycle of poverty that limits growers from adopting innovative and adaptive strategies of effective agricultural technologies in the study area. It was concluded that agricultural adoption among vegetable commercial growers is determined by education, household income, farm size, access to extension services, and credit facilities in the study area. Hence, there is a need for purposive interventions to address these factors among agricultural and business actors.

Keywords: Arusha, Adoption, Agricultural Technology, Vegetable Growers

1. INTRODUCTION

In this paper, the term "agricultural technology" does not only mean agricultural machinery, but also new crops (for example hybrid seeds, high yielding varieties), farming systems (for example organic farming, sustainable agricultural practices), post–harvest practices (for example marketing channel choices, drying technology), innovative agricultural technologies (for example robots, sensors), and other agricultural innovation (for example information and communication technologies, fertiliser, crop insurance) (Jack & Tobias, 2017). Improved agricultural technologies are essential for achieving Tanzania Vision 2050 goals of transformation, such as poverty reduction and maintaining food security for impoverished farming households (Mtui, 2023). Adopting agricultural technologies enhances the transition from low productivity and subsistence to commercial agriculture (Antwi et al., 2025).

Previous empirical studies have examined the determinants of agricultural technology adoption. Characteristics of farmers, such as education level, age, and gender, are assumed to have some effects on the adoption of agricultural technologies (Ruzzante & Bilton, 2018). A higher education level of farmers could possibly increase knowledge and ability, making them more reasonable and open-minded, and better evaluate the gains of the improved technology (Meiguran & Basweti, 2016). This is the basis that stimulates an individual's rational thinking, integrated with other social and economic capacities for adoption.

As a result, farmers' education level usually has a positive impact on the decision to adopt new technology. Gender issues have also been investigated in many studies related to the adoption of agricultural technology, and different results on the roles of men and women have been found. Farm structure, including farm size, labour force, and household income, is also part of the determinants (Aduwo et al., 2017; Neway & Zegeye, 2022). In many studies, farm size or land holding of the farm household is considered an important determinant of the adoption of new agricultural technology (Norton & Alwang, 2020). The availability of the agricultural labour force within the household may facilitate the application of technology due to liquidity constraints; the majority of households cannot easily acquire hired labour (Utami et al., 2019). The impact of the farm household income on the adoption of agricultural technology has also been investigated, and it is usually reported that farms with higher income tend to

adopt new agricultural technology more than those with lower income (Vinholis et al., 2021). The studies also revealed that gender is important and positive in the adoption of agricultural technologies because of the comparison between male and female-headed households. Social and cultural norms and values give men more access and control over land and production resources.

1.1 Statement of the Problem

In many cases, the adoption rate of agricultural technologies in vegetable production in Tanzania is lower than that of neighbouring countries (Ochieng et al., 2022). For example, a recent study in Kenya shows that there were relatively higher adoption rates (60%) of vegetable farmers in Kenya compared to Tanzania (Kirui et al., 2025). This means that the majority of vegetable farmers continue to rely on their traditional cropping patterns or farming practices. In general, hundreds of vegetable farmers in Tanzania also remain in the lack of use of improved technologies (Mtuguja et al., 2023). This raises an important question: why are vegetable farmers in Tanzania not improving productivity by adopting a greater number of improved technologies? On the other hand, vegetable farming remains a central subsector driving the agricultural sector's growth, and agricultural technologies are the key to agricultural growth. Vegetable farming is an important sector in Tanzania's agricultural economy, contributing to the country's food security and economic growth. The most cultivated vegetables grown in Tanzania include tomatoes, onions, green peppers, carrots, cabbage, eggplant, and okra (Mtuguja et al., 2023). This paper, therefore, considered an analysis of factors that influence a range of agricultural technologies, adoption, namely, drip irrigation, mobile application, improved seeds, fertiliser use, min tiller, electric water pump, and integrated pest management. In this article, the analysis focuses on bananas, potatoes, and cabbage. The findings of this article serve as valuable guidance for shaping agricultural development policies and strategies regarding uncovering the associated determinants for mitigation and enhancement measures by actors.

1.2 Research Objectives

i. To examine the types of vegetable crops grown by farmers in the study area.
ii. To examine the major types of agricultural technologies adopted in the study area
iii. To analyse the factors that influence agricultural technology adoption among farmers

II. LITERATURE REVIEW

2.1 Theoretical Review

This article is guided by the Diffusion of Innovation Theory by Rogers (1995). The theory attempts to predict that media and interpersonal communications give messages and have an influence on opinion and judgment. Actors involved form and share information from one person to another in order to realise mutual understanding. As regards the adoption, individuals differ in understanding, leading to varied levels of adoption of innovation. For that matter, there are early and late adopters of innovation informed by various factors that moderate individuals and communities at large. The theory, therefore, underscores the roles of influential factors in shaping the information and messages that are communicated among actors. These could be socio-economic, demographic, and cultural factors that may influence the understanding and action among participants. The theory is relevant due to its ability to articulate actors involved in innovation, and that information is placed as primary and at the centre of innovation, regardless of barriers existing among participants as secondary variables. Thus, the adoption of agricultural technologies among vegetable producers is a factor among many interacting factors that influence farmers positively or negatively.

2.2 Empirical Review

Globally, there are factors that influence vegetable growers, evident in the literature. These include various factors contributing to the input process in vegetable production. The intricacies and hurdles of vegetable production, particularly regarding material input factors, such as pesticides, fertilisers, agricultural films, irrigation, land, and seeds, crop productivity efficiency, and environmental harm, are widely recognised in the existing literature (Lu et al., 2023). In many Sub-Saharan African countries, farmers' uncertainty about market prices is usually high, and traders may take advantage of farmers' ignorance of the market price and extract rent from them by offering very low prices for their products (Yu et al., 2024). Despite the fact that the higher farm gate values and productivity of vegetable farming are important factors in agribusiness, there are challenging factors that deter the benefits of growers, particularly in developing countries (Verma & Sinha, 2018).

Vegetables can be grown in the field and under cover (greenhouse). In recent years, more than 80% of vegetable production is carried out in the field, while the rest is undercover (Kaya & Budak, 2021**).** Also, vegetables are grown both organically and in various countries in the world, like Turkey. In this context, the global organic

vegetable market is growing steadily to challenge the traditional naturally grown vegetable market. Vegetables are grown in low and large quantities in various countries, with some developed countries like China and the United States of America being among the top five growers in terms of large-scale production.

Table 1

Top Five Countries' Distribution of Fresh Vegetables Globally, 2017

S/N	Country	Area (ha)	Index	Production (per ton)	Index
1	China	23.821.615	2925	554.290.578	2223
2	India	8.590.690	1055	127.144.323	510
3	USA	955.768	117	32.623.212	131
4	Turkey	814.360	100	24.933.078	100
5	Russia	650.877	80	16.405.843	66

Source: FAOSTAT, (2019), in Kaya and Budak (2021)

Table 1 presents the top five countries that produce vegetables globally. The production of vegetables globally is led by China, with the capacity to produce 554.290.578 tons in 23.821.615 ha. The second world producing country is India, having a land area of 8.590.690 ha with a production capacity of 127.144.323 tons. The third world producer of vegetables is the United States of America, with 955.768ha producing 32.623.212 tons. The fourth world producer is Turkey, with a land area of 814.360 ha and a production capacity of 24.933.073 tons. Russia ranks fifth in vegetable production. It owns 650.877 ha and a production capacity of 16.405.843 tons. The most grown fresh vegetables are found in China, the USA, India, and Turkey, among others. These include tomatoes being the first in ranking to be grown in large quantities, and eggplant being the last.

Table 2 presents the world's fresh vegetables grown in some countries. It is indicated that tomato is the topmost vegetable mostly grown globally, with a share of production of 32.6 % grown in China. India possesses a production share of 11.4% of 182.301.400 tons produced. Turkey has 7% share. The second most grown vegetable crop is onion. In China, it occupies a 24.8% share while in India it occupies 22,9 % share. In the USA, it has a 3.8% share. The third, fourth, and fifth vegetable crops involve cucumber, cabbage, and eggplant, respectively.

Table 2

World's Most Grown Fresh Vegetables, 2017

S/N	Product	Country	Share in Production (%)	Production (ton)	Area (ha)
1	Tomato	China	32.6		
		India	11.4	182.301.400	4.848.384
		Turkey	7		
2	Onion	China	24.8		
		India	22.9	97.862.931	5.201.590
		USA	3.8		
3	Cucumber	China	77.4		
		Iranian	2.4	83.753.861	2.271.263
		Russia	2.3		
4	Cabbage	China	46.8		
		India	**12.3**	**71.451.137**	**2.513.709**
		Russia	4.9		
5	Eggplant	China	62.9		
		India	23.9	52.309.122	1.858.251
		Egypt	2.5		
Total				**1,094.343.724**	**58.172.273**

Source: FAOSTAT, 2019 (Edited by DOGAKA) in Kaya and Budaki, 2021

In Tanzania, vegetable exports have grown in the past few years, becoming a leading sub-sector driving the agricultural sector's growth. Vegetable farming has become an important part of agriculture in the surrounding cities (Utami et al., 2019). It has supported the livelihood of farmers from household subsistence farming to commercial farming. International buyers are increasingly looking for Tanzanian vegetables. This offers local farmers and exporters new markets and opportunities. Vegetable production in Tanzania was 2.77 million metric tons in 2020. The rising awareness targeting the export to demanding markets helps the farmers increase the quality standards of their vegetables and makes them highly profitable (Mariyono, 2017). However, commercial vegetable farming in Tanzania has recently faced many challenges to productivity and severe impacts of climate change. To overcome these

challenges, the government of Tanzania has made great efforts to promote the adoption of modern technologies. To what extent these technologies are adopted remains the subject of attention of this work to examine the influential factors for action.

III. METHODOLOGY

The article is an output of the study that was done in the Arusha district, one of the seven districts of the Arusha region. The district is bordered to the North by Longido district, to the East by Meru district, to the South by Kilimanjaro region, and to the West by Monduli. Arusha District Council has a total of 78350 hectares of arable land. Maize, beans, pyrethrum, round potatoes, sweet potatoes, bananas, and legumes are among the food and cash crops farmed in the district. The cross-sectional design was employed in the study process. This was employed in order to analyse the status of technological adoption among farmers in the study area at that particular moment of study. It applied the quantitative approach so as to dig down into the extent of adoption using the multi-stage sampling method. The study area was purposely selected because it has more areas of commercial vegetable growers compared to other districts. Then three wards were selected purposely using the same criteria, with each ward, and simple random sampling techniques were used to select household vegetable growers.

In this study, commercial vegetable growers were the target population involved. These are defined as those who grow vegetables for at least two seasons within a year, covering an area of more than 2 acres, and contribute at least 50 per cent to the annual household income. The total number of households involved in commercial vegetable farming in Ilkidinga, Sambasha, and Olturoto was used to make a sample of 150 households; 50 households from each ward were selected equally using the simple random sampling technique. The survey was done between January to March 2024. Respondents were interviewed face-to-face by administering a semi-structured questionnaire for gathering the necessary data on the adoption of modern agriculture technology and related factors among vegetable farmers, such as characteristics of the farm householders, the farmers' access to credit, and to extension services. The collected data were analysed by descriptive statistics using the Statistical Package for the Social Sciences. These involved frequencies, percentages, and summation. The results were presented using tables as well as explanations.

IV. FINDINGS & DISCUSSIONS

4.1 Types of Vegetable Crops Grown by Farmers in the Study Area

Table 3 presents the results of major vegetable-producing wards in the study area. The study revealed that the majority of the respondents, 64(42.66%), grow potatoes, 32(22%) grow onions, and 31(20.66%) grow cabbage. It was found that fewer than 20 deal with other vegetables like carrots, tomatoes, and cucumbers.

Table 3

Major Vegetables Producing Wards in Arusha District (N=150)

Vegetable Crops grown	**Ilkidinga N(%) N= 50**	**Sambasha N(%)N=50**	**Olturoto N(%)N=50**	**Total N=150**
Potatoes	20(40)	22(44)	22(44)	64(42.66)
Carrot	2(4)	3(6)	3(6)	8(5.33)
Cabbage	13(26)	8(16)	10(26)	31(20.66)
Tomatoes	3(6)	4(8)	2(4)	9(6)
Cucumber	2(4)	1(2)	2(4)	5(3.33)
Onions	10(20)	12(24)	11(22)	33(22)
Total	**50**	**50**	**50**	**150**

These results indicate that the study area produces a number of vegetable crops. However, potatoes and onions are grown by all wards more than other crops in the Arusha District. This has influential factors among producers in the study area. The area contributes to the development of the country's sub-sector. These results are in line with those of Mtuguja et al (2023**),** who found that vegetable exports from Tanzania have been grown in the past few years, becoming a leading sub-sector driving the agricultural sector's growth. According to the diffusion of innovation theory, media and interpersonal communication are the sources of innovation and, therefore, technological transfer and adoption, where individuals come to know and are influenced to adopt. In this way, the potatoes and onions were adopted by the majority of farmers.

4.2 Major Types of Agricultural Technologies Adopted in the Study Area

This section presents and discusses the number of adopters and the categories of technologies adopted. It begins by presenting and discussing the number of agricultural technologies adopted and then ends by presenting and discussing the categories of major agricultural technologies adopted in the study area.

4.2.1 Number of Adopters

Table 4 presents the results of a number of technologies adopted by vegetable farmers in the study area. The results show that the majority of the respondents have been using improved seeds, chemical fertiliser, and drip irrigation. However, the mini tiller was used by 6(4%), the electricity water pump by3(2%) and integrated post management by 5(3.33%).

Table 4

Number of Adopters and Types of Major Agricultural Technology

Agriculture technologies	**Ilkidinga Ward N (%) N= 50**	**Sambasha Ward N(%) N=50**	**Olturoto Ward N(%)N=50**	**Total N=150**
Improved seed	20(40)	19(38)	25(50)	64(42.66)
Chemical fertilizer	15(30)	17(34)	15(30)	47(31.33)
Drip irrigation	9(18)	5(10)	5(10)	21(14)
Electricity water pump	1(2)	2(4)	1(2)	3(2)
Mini tiller	2(4)	2(4)	2(4)	6(4)
Integrated pest management	2(4)	2(4)	1(2)	5(3.33)
Rainwater harvesting	1(2)	3(6)	1(2)	5(10)
				150
Categories of Adopters of AT	**Ilkidinga N= 50**	**Sambasha N=50**	**Olturoto N=50**	**Total N=150**
Low adopters	18(36)	15(30)	16(32)	49(32.66)
Medium Adopters	30(60)	34(68)	29(58)	93(62)
High Adopters	2(4)	1(2)	5(10)	88(58.66)

The results revealed that economically viable technologies with low technical difficulties, like improved seeds, electricity, water pumps, mini tillers, and improved pest management, were mostly adopted. Currently, technologies like plastic mulching, mobile applications, and rainwater harvesting have been adopted less. According to the diffusion of innovation theory, media and interpersonal communication are the sources of knowledge and adoption among farmers. The results provide evidence that the adoption of improved seed and chemical fertilisers is the most adopted agricultural technology in the vegetable crops (Kirui et al., 2025). This can be linked to the influence of media and interpersonal communication, as well as other socio-economic and demographic features that influence farmers' knowledge and practice. For that matter, there are early and late adopters as per the diffusion of innovation theory.

4.2.2 Categories of Adopters

Table 4 presents the results of the categories of technology adopted. The results show that the majority of the respondents, 9 (63 %), were medium adopters,49 (32.66%) of the respondents were low adopters, and 5(10%) of the respondents were high adopters. The results imply that most of the respondents have adopted agricultural technologies at the moderate level, while a small percentage adopted technologies at either a lower or higher level. The results are linked to the fact that farmers' education level usually has a positive impact on the decision to adopt new technology argued by Meiguran and Basweti (2017).

4.3 Factors that Influence Agricultural Technology Adoption among Farmers

This section presents and discusses the factors influencing agricultural technology adoption among vegetable farmers in the study area. These factors are social, such as education and training. Others are demographic factors like age and household size, while others are economic factors, including farm size and access to credit facilities. These altogether tend to influence vegetable farmers in the study area at a varying pace of influence. Table 5 presents the results of factors that influence agricultural technology adoption in the study area.

Table 5

Factors Influencing Agricultural Technology Adoption (N=150)

Variables	**Wards in the Study Area**			**Total**
1. Age	**N(%)**	**N(%)**	**N(%)**	**N (%)**
	Ilkiding'a	**Sambasha**	**Oltroto**	
30-35	11(22)	8(16)	7(14)	26(17.33)
40-45	20(40)	22(44)	25(50)	67(44.66)
50-55	13(26)	11(22)	12(24)	36(24)
60-65	4(8)	6(12)	3(6)	13(8.66)
70-75	2(4)	3(6)	3(6)	8(5.33)
2. Education level				
Non formal	7(14)	9(18)	6(12)	22(14.66)
Primary Education	30(60)	22(44)	32(64)	82(54.66)
Secondary education	10(20)	15(30)	10(20)	35(23.33)
Tertiary	3(6)	4(8)	2(4)	9(6)
Household size				
2-4	7(14)	4(8)	6(12)	17(13.33)
5-9	16(32)	20(40)	20(40)	56(37)
10-12	20(40)	22(44)	21(42)	63(42)
13-16	5(10)	4(8)	3(6)	12(8)
Farm size in hectares				
0.5-1.0	32(64)	29(58)	28(56)	89(59.33)
1.1-1.5	11(22)	15(30)	19(38)	45(30)
1.6-2.0	7(14)	6(12)	3(6)	16(10.66)
Farming experience				
1-10	17(34)	18(36)	12(24)	47(31.33)
11-20	30(60)	24(48)	31(62)	83(55.33)
21-30	4(8)	5(10)	5(10)	14(9.33)
31-40	1(2)	3(6)	2(4)	6(4)
Access to credit				
Yes	12(24)	9(18)	7(14)	28(18.66)
No	38(76)	41(82)	43(86)	122(81.33)
Membership in a farmer's group				
Yes	42(84)	38(76)	46(92)	126(84)
No	8(16)	12(24)	4(8)	24(16)
Training received				
Yes	44(88)	36(72)	45(90)	125(83.33)
No	6(12)	14(28)	5(10)	25(16.66)
Credit received				
Yes	12(24)	8(16)	5(10)	25(16.66)
No	38(76)	42(84)	45(90)	125(83.33)
Extension visit				
Yes	43(86)	46(92)	39(78)	128(85.33)
No	7(14)	4(8)	11(22)	22(14.66)

4.3.1 Age of Farmers

The results in Table 5 show that the majority of the respondents, 67 (44.66%), were between the ages of 40 and 45 years. This means that they are still active in productive and reproductive life. The implication is that at this age, they are likely to be more responsive to the vegetable production improvement programme in the study area. As a group, older adults tend to be slower than younger adults in adopting new technology. Age is seen to be a serious factor in the adoption of new technology. Older Farmers are assumed to have gained knowledge and experience over time and are better able to evaluate technology information than younger farmers. Understanding these individuals and age-related differences provide guidance for the introduction of new technologies that may benefit users.

The results in Table 5 show that the age of farmers is a positive and important determinant of the adoption of agricultural technologies, as found by Ruzzante & Bilton (2021). The farmers who are younger have a higher chance of employing new technologies than older farmers. From this, the younger farmers are seen as easier to embrace modern technologies because of their level of education, their desire to take up potential risks, and the foreseeable long-term plans that they may have, compared to the older generation.

4.3.2 Education Level

Table 5 presents the results of the education level of respondents. The results further revealed that the majority of the respondents, 84(56%), were literate. A high level of literacy among respondents may facilitate better adoption of improved vegetable production practices, including the ability to teach others effectively. This result is in support of the findings of Venma & Sinha (2018), which revealed that the adoption of education, as literate farmers can easily understand the technology effects of the extension agents and their implications better than illiterate farmers.

The respondents' education level is significant, and a high level of literacy among household heads may facilitate better adoption of agricultural technologies. This is consistent with the findings of Emerick and Dar (2021), who find that the farmers adopting the new technologies had at least a formal education. They reported that the acquisition of knowledge through education nurtures a constructive mindset and facilitates the adoption of new techniques, especially those involving complex information and management.

4.3.3 Farm Size

Table 5 presents the results of farm size in the study area. The size of the farm cultivated is a function of population pressure, family size and the financial background of the farmers. One major characteristic of the farmers was fragmented land holding. Results in Table 1 show that 89(59.33%) % had 0.5 to 1.0 hectares of land. It then implies that all the respondents were small-scale farmers. They revealed that farm size is important and positively influences the adoption. When the farm size increases, the chances of falling into high technology adoption increase. This is in agreement with the work of Ugochukwu and Philips (2017), who state that the utilisation of agricultural technology is more likely among farmers who own large farms.

4.3.4 Access to Extension Services

Table 5 presents the results of access to extension services in the study area. The study revealed that respondents visited by an extension officer have a higher chance of falling into the high adoption category compared to those not visited by an extension officer. This finding agrees with the work of Utami et al. (2019), who reported that accessing information through extension services eliminates the confusion about a technology's performance, allowing individuals to have subjective assessments to shift the objective over time, promoting adoption.

4.3.5 Farming Experience

Table 5 presents the results of farming experience among respondents in the study area. Experience is gained with age and specific practice in an area, considering the majority occupation of the respondents, which is farming. The length of time spent in farming can be linked to the age of the farmers. The result revealed that 85 (56.66%) of the respondents had been in farming for 11-20 years. With the respondents' farming experience, it is expected that they are able to make sound decisions regarding resource allocation and farm management. Experience gained by farmers in agricultural production activities helps them to bear the risks and uncertainties associated with farming. These results concur with other scholars' like Ruzzante and Bilton (2021), who underscore the effect of age as an indicator of experience given the time spent by vegetable farmers in undertaking their activities in the study area. This has an effect on the adoption of agricultural technologies. According to Kaya and Budak (2021), vegetable farming is mostly experienced by five leading countries globally, namely China, India, the United States of America, Turkey, and Russia. This indicates the endowed experience of technological adoption in these countries, such that they have a long period of learning by practice that leads them to continuously improve the existing knowledge through technological innovation and advancement. Locally, there are also diverse experiences in adopting agricultural technologies that distinguish one society from another.

4.3.6 Membership in Social Groups

Table 5 presents the results of respondents' membership in social groups in the study area. The study revealed that the study area experiences membership with different social groups, indicating that membership in different social groups raises the possibility of adopting an agricultural bond. Membership in social groups bridges the information asymmetry and reduces the costs of searching for information concerning new technology. Contrary to these results, Ahmed and Anang (2019) in Ghana found that membership in farmer groups is associated with lower adoption of improved Maize varieties. This is contrary to the generally held view that farmer groups promote adoption by farmers. Adoption is higher for married farmers with access to agricultural extension, but it decreases with the size of the herd and the cultivated land. The results underscore challenges confronting farmer-based organisations, such as increasing politicisation, decreasing effectiveness, and limited support from both public and private institutions. Incentivising

farmer groups, including the apex body responsible for supervising these groups, will enhance the effectiveness of farmer groups.

4.3.7 Access to Training

Table 5 presents the results of access to training among study respondents. The study found that the majority of vegetable farmers received farming training in the study area. 44(88%) in Ilkiding'a ward, 36 (72%) in Sambasha ward, and 45 (90%) in Oltroto ward villages, making a total of 125 (83.33%) of the receivers of training in the study area. These results indicate that training is one of the important considerations among vegetable farmers in Arusha District. These results imply that farmers in the study area have basic knowledge about vegetable farming. These results indicate variations in the level of adoption of agricultural technologies in relation to the diffusion of innovation theory that promotes media and interpersonal communication as the basis for adoption of technology. According to Mkuki et al. (2025), revealed that training programs offered in Ward Agricultural Research Centres (WARCs) focused mainly on crop production and relied heavily on private stakeholder support to offer training to smallholder farmers. The study concluded based on training areas that crops receive more priority in WARC training programs over entrepreneurship, livestock, record keeping, and fisheries.

4.3.8 Household Size

Table 5 presents the results of household size among the families of respondents. The results show that most of the respondents had a household size between 10 and 12 people. Household size is simply used to measure labour availability and enhances farm labour participation. Large households are expected to adopt technology as it relaxes the labour constraint required during the introduction of new technologies. These findings imply that more family labour for vegetable production would be readily available since a relatively large household size is an obvious advantage in terms of labour supply. However, the findings are contrary to Akello and Mwesigwa's (2023) study, which found that large family size puts an extra burden on food consumption and is more likely to experience food insecurity than households with a small and average family size in Uganda.

4.3.9 Access to Credits

Table 5 presents the results of access to credit facilities among respondents in the study area. Findings indicated that 122(81.33%) of the respondents did not have access to credit, while 28(18.66%) did. Credit is a very important factor that is needed to acquire or develop a farm enterprise. Its availability could determine the extent of production capacity. These results imply that negative factors influence the farmer's decision to take credit. According to the diffusion of innovation theory, media and interpersonal communication are important elements in the diffusion of technology from one farmer to another. However, given the proximity of the study area to the Arusha City and township, media and communication relations to agricultural technology are not a big challenge. The results are relevant to other studies. For instance, according to Kirui et al. (2025), the estimation shows that agricultural credit access improves farm performance. Obtaining credit from institutions increases productivity and technical efficiency more effectively than from informal sources. Therefore, this and other challenges negatively influence farmers' decisions to adopt agricultural technologies in the study area.

4.3.10 Theoretical Linkage of Results

These results are linked to the diffusion of innovation theory in various contexts. Due to age, the majority of growers are in the middle-aged category of around 40 years. This is the age featured by innovative ideas and social interaction that provides an opportunity for the diffusion of agricultural technology among farmers. The majority of growers are literate farmers and therefore have a recommendable understanding of farming practices due to their ability to acquire, analyse, and make use of technological information. They understand the various types of seeds and their requirements; hence they make rational decisions on growing practices. The study is featured by smallholder growers of vegetables, with half to one hectare in the majority. This is an indicator of innovative ideas through the intensification of vegetable crops. Having such small areas of farming by the majority requires innovation. However, factors like poverty may hinder this innovation. The study area holds extension services visits by technical agricultural staff, which is a source of innovation and technological interaction. They have an opportunity to innovate ideas, inputs, and services. It was found that the vegetable growers in the majority have a long period of experience in farming, ranging from 11 to 20 years. This indicates their long period of interactive experiences in the practice of vegetable farming, during which proven knowledge and skills are built. The majority of growers are members of social groups. These groups are usually regarded as self-help providers in social and economic contexts. They share a range of information intended to serve members in their livelihood strategies of vegetable farming. There is training done in the study area about good practices, where the majority of members have access. These are the sources of

skills, knowledge, and awareness about growing vegetables. They contribute to the acquisition of innovations as well as their adoption. The majority of families in the study area have many members, from ten to twelve.

This indicates the existence of many sources of innovation at the household level, where members interact with the outside community members in various ways. This can be through the education system, social groups, and social media. It was found that the majority of growers have no access to credit facilities in the study area. This can be connected to the low living standards of the majority of members in the study area. This is to argue that these factors invariably influence vegetable growers in the study area to acquire and adopt agricultural technologies. At the centre of the interaction of these factors is the central factor of poverty and the level of education inherent within the majority of members of communities in the study area. These have a fundamental influence in enabling the capacity to innovate and adopt various effective agricultural technologies. This is due to the fact that technological innovations are costly to acquire; above all, technical education is the primary factor for innovation acquisition and adoption. One requires a certain technical level of education or knowledge exposure to be effectively innovative. However, all these are not acquired easily as they require investment. With poverty, one cannot get access to technical or high-level education and effective vegetable technologies.

V. CONCLUSION & RECOMMENDATIONS

5.1 Conclusion

This study assessed the determinants of the adoption of agricultural technology among commercial vegetable growers in Arusha District, Arusha Region in Tanzania. The major types of vegetables grown in the study area include potatoes, carrots, cabbage, cucumber, and onions. The most adopted agricultural technologies were improved seeds, chemical fertiliser, drip irrigation, at least one electricity water pump, mini tillers, rain water harvesting, and integrated pest management simulation. Most of the respondents have adopted agricultural technologies at a low level. Age, education level, farm size, and access to extension services were important determinants of technology adoption in the study area. It was therefore concluded that agricultural technology adoption is very low, being influenced by social and technical factors for the types of vegetables grown in the study area.

5.2 Recommendations

The findings of this study carry crucial policy implications for accelerating the adoption of agricultural technology in the Arusha District**.** It is recommended to increase access to education programs for such farmers, encouraging them to adopt agricultural technologies. Different extension services must be promoted for improving the behaviour as well as the attitude of the farmers towards the adoption of agricultural technology. Also, different organisations must be formed to support farmers by providing them with initial capital for an effective outcome. This will not only help in improving the productivity of the crops, but also it will help in the betterment of the household of the farmers by increasing their incomes. Poverty reduction measures are required to be sustained in an attempt to help communities move out of poverty, which is the major source of poor technological innovation among vegetable growers. Technical education measures are also part of these efforts for enhancing the farmers' capacity to innovate and adopt technologies.

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