Digital Literacy and Crop Productivity: Evidence from Cross-sectional Data in Hai and Moshi Districts, Kilimanjaro-Tanzania

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Abstract

Access to information through digital platforms particularly social media has the potential to improve agricultural productivity, henceimprovement of smallholder farmers' well-being. This is anticipated where farmers can significantly access, understand, evaluate and apply information obtained in agricultural-related activities. However, this depends, inter alia, on the extent to which farmers are digital literate, despite notable access and general use of digital platforms by farmers, there is a need to empirically understand how farmers digital literacy contributes to crop productivity . The study explored the use of social media and the Internet through digital platforms by smallholder farmers and determined the contribution of digital literacy to agricultural productivity. The study adopted a cross-sectional research design; data were collected using a structured questionnaire from 200 purposefully selected smallholder farmers. Focus group discussions and key informant interviews were used to collect complementary data. Descriptive statistical analysis was used to explore the use of the internet and social media, multiple linear regression analysis was used to determine the contribution of digital literacy to agricultural productivity. The results show that 70.5 per cent of smallholder farmers have access to social media. However, the majority (95%) lack awareness of agricultural information apps. Although digital literacy had a negative but significant effect on maize productivity, it nonetheless had a positive and significant effect on common beans' productivity. It is concluded that smallholder social media and the internet contribute to agricultural productivity. It is recommended that the agricultural and ICT departments in Hai and Moshi districts and other interested stakeholders should conduct awareness campaigns and training in rural areas on accessing information concerning agricultural activities through the use of digital platforms towards improved productivity.

Keywords: Digital literacy, internet, social media, agricultural productivity, smallholder farmers

Introduction

The agricultural sector is critical for the livelihoods of many rural households in many developing countries, including those in Africa (Mzomwe *et al.,* 2021). In addition, it can help in the reduction of poverty and food insecurity for 80% of the world's rural poor farming households. Globally, the agricultural sector accounts for 4 per cent of the global gross domestic product (GDP) and more than 25 per cent of the GDP in some least developing countries (World Bank, 2022).

In Tanzania, agriculture represents almost 30 per cent of the country's GDP with three-quarters of the country's workforce involved in this sector. Also, agriculture is the largest and most important sector of the Tanzanian economy (ITA, 2022). The sector is the main employer of the national labour force and the main contributor to the national income. Tanzania's agriculture is practised in seven agricultural zones where more than ninety food and cash crops are cultivated.

Maize and beans are the two food crops widely grown and consumed in Tanzania (Bashe, 2022; ITA, 2022). Maize is one of the important cereal crops grown worldwide (ITA, 2022) and its global production has increased from 205M

to 1,145 M tons (FAO, 2021). Across Tanzania, maize is the most widely planted cereal crop by smallholder farmers during the short rainy season (NBS, 2021). Access to new markets abroad has increased the sale of maize from 92,000 tons worth 58 billion in 2020 to 189,277 tons worth 72 billion shillings in 2021 (Bashe, 2022). Common bean is an important pulse crop for smallholder farmers in developing countries such as Tanzania and is both a source of food and cash income (Teshome et al., 2020; NBS, 2012). Tanzania is the largest common bean producer in Africa (Letaa *et al.,* 2015). In Tanzania, beans are often cultivated by smallholder farmers for food consumption without the use of fertilizers where a quarter to one-third of the households sell their beans.

In Kilimanjaro, agriculture is the main economic activity contributing over 75 per cent of employment to the rural population and about 60 per cent to the region's GDP (KRIG, 2017). Maize and common beans are the two main crops produced in the Kilimanjaro region (KRIG, 2017). Hai and Moshi Districts produce high-value crops such as maize and beans and the area has the potential for irrigation infrastructure (KRIG, 2017).

Despite the importance of the agricultural sector to Tanzania and Kilimanjaro region access to agricultural extension services is limited. According to Ringo *et al.* (2023), Tanzania like many other sub-Saharan African countries is faced with a low uptake of agricultural technologies consequently leading to low agricultural productivity. In Tanzania, the low uptake is caused by the declining role of public extension services (Muhanga, *et al.,* 2021), hence, the existence of a wide extension-farmers ratio which limits access to new agricultural technologies and the capacity to turn the information and knowledge into practices for actual development. Therefore, the need to use ICT (information communication technology) to bridge the gap. However, the use of ICT to access agricultural information requires the farmers to be digitally literate. Generally, digital literacy means having the skills you need to live, learn, and work in a society where communication and access to information are increasingly through digital technologies such as internet platforms, social media, and mobile devices (Western Sydney University, 2021). Digital literacy can be determined through technical skills, critical understanding and communicative abilities (Landmann *et al.,* 2021).

Based on the above it is expected that digitally literate farmers can easily use social media and the internet to meet their agricultural needs, For example, the Internet is an important medium of communication since it helps to store different types of information about agriculture thus enabling Extension Officers to easily reach smallholder farmers and share agricultural information with them (Mabe, 2011). Furthermore, Mabe (2011) argues that through the use of the internet, documents can be sent by extension agents to internet groups for discussion and thereafter be published on a webpage for referencing purposes.

Further to the above, social media as part of digital technology can provide farmers with incredible resources such as providing them with updates on farm operations and responding to their questions about the signs of plant or livestock disease (Naruka *et al.,* 2017). Social media include Facebook, WhatsApp, Twitter, YouTube and Google groups (Farmers Weekly, 2016). According to literature (Kipkurgat *et al.,* 2016; Khumoetsile, 2021) agricultural extension officers, farmers, agricultural organizations/institutions and Non-Governmental institutions are making use of social media platforms to engage with the stakeholders in the agricultural sector and prompt them to participate in various activities by disseminating and exchanging agricultural information. In addition, stakeholders are allowed to express their views and opinions, and to make comments on agricultural services). Moreover, social media platforms educate and inform farmers on agricultural issues as well as facilitate the buying and selling of agricultural produce (Khumoetsile, 2021). Therefore, if properly used social media and the internet can help to improve the socio-economic well-being of smallholder farmers in rural areas through the increase of agricultural productivity (Lachapelle, 2011).

The National Information and Communications Technology Policy 2016

and the National Agriculture Policy 2013 jointly states the government's commitment of encouraging all productive sectors including agriculture to incorporate ICTs in their development plans as well as its commitment to promote and support the implementation of nation-wide ICT systems for rural development and agriculture sector development activities. Despite the Tanzanian government's efforts to promote the use of ICT in offering agricultural extension services (e-extension), the use of social media and the internet in the agricultural sector is still a problem (Eskia, 2019). In addition, the low use of ICT in accessing agricultural information could be because most smallholder farmers lack adequate knowledge and skills on how to use ICTs to transform their farming practices and also lack of awareness on the potential of ICT (Pye-Smith, 2018; URT, 2016).

A review of the literature has shown that some studies have been conducted in East Africa and other parts of Africa concerning the use of social media and the internet. For example, those conducted in East Africa include Kuria (2014) "Use of social media as a source of agricultural information by smallholder farmers, a case study of lower Kabete, Kiambu County," Kipkurgat *et al.* (2016) "Impact of social media on agricultural extension in Kenya: A Case of Kesses District", Pye-Smith (2018) "How farmers are making the most of digital technologies in East Africa: Stories from the field," Kimani (2019) "Assessment of Use of Social Media Among Smallholder Farmers In Kiambu Country," and Khumoetsile (2021). Effects of Social Media Platforms' Use on Youth Participation in Agriculture in Njoro Sub-Country, Kenya." In addition, a study conducted in other parts of Africa include Abuta *et al.* (2020) Social Media Used by Arable Crop Farmers for Communicating Climate Change Adaptation Strategies in Imo State, Nigeria." Studies conducted in Tanzania include Urassa and Mvena (2015) "The Use of Cell Phones in Market Information among Beef Cattle Smallholders in Mpwapwa District, Tanzania," Muange *et al.* (2015) "Effects of social networks on technical efficiency in smallholder agriculture: The case of cereal producers Tanzania;" Eskia's (2019) "Assessment of factors influencing the use of ICTs in accessing market information among smallholder rice farmers in Kilombero District, Tanzania;" Jotta (2021), the "Influence of Information and Communication Technologies usage on crop productivity among youths' agro-enterprises in Misungwi and Kilosa Districts, Tanzania" and Mzomwe *et al.* (2021) "ICT and Marketing for Agricultural Products: Determinants of Mobile Phone Usage to Small-Scale Orange Farmers in Tanzania." However, more information on the use of social media and the internet as well as the association between digital literacy and agricultural productivity is yet to be fully uncovered in Tanzania. Therefore, the study aimed at exploring the use of social media and the internet among smallholder farmers and determining the association between digital literacy and agricultural productivity using Hai and Moshi Districts as case studies.

Theoretical framework

The study was guided by the theory of General-Purpose Technologies (GPTs) by Helpman (1998) which advocates productivity as an explanatory factor for the adoption of technology. The GPTs theory states that adoption is quicker when productivity growth is high concerning the old technology (Marra *et al.,* 2003). Several agricultural-related studies have been guided by the theory. For example, Chen *et al.* (2020) "Electronic agriculture, block chain and digital agricultural democratization" and Jotta (2021) "The influence of information and communication technologies on crop productivity among youths' agro-enterprises." The GPT theory suits the current study as it generally shows that the application of advanced technologies such as ICT can lead to increased productivity.

Moreover, the GPT covers issues that are both short-term (acceptance and adoption) and long-term (usage and productivity) and behaviours (Venkatesh *et al.,* 2003). Therefore, smallholder farmers can accept and adopt the use of ICT in their production due to its ease of use or lack of access to other forms of agricultural extension. In addition, their use of ICT, social media and the internet may lead to increased

productivity. The theory applies to the study since it examines how smallholder farmers find, judge, use and or apply agricultural information from the internet and social media to increase their productivity.

Methodology

Description of the Study Areas

The study was conducted in Hai and Moshi Districts in Kilimanjaro region. Hai and Moshi Districts were purposefully selected due to the high production of both food-cash crops and high-value horticultural products such as maize and beans (KRIG, 2017). In addition, the two districts are not very far from Kenya, which is a good importer of agricultural products such as maize and beans; hence, a readily available market for the product and therefore could be instrumental in farmers' use of ICT in seeking agricultural information to transform their productivity. Furthermore, the districts were in an area where staff from Sokoine University of Agriculture were conducting research titled "Digital literacy and misinformation among smallholder farmers in Tanzania" the project was under the sponsorship of Facebook Foundational Integrity Research (Under Facebook Inc.). In addition, the current research was sponsored by the above-mentioned project.

Research Design, Sampling and Sampling Techniques

The study adopted a cross-sectional research design whereby data were collected once. The design was preferred because it allowed the collection of data once through many ways such as surveys, observation and interviews (Setia, 2016). The design was best fit for the current study as it allows a high external validity while allowing the capture and control of a large number of variables (Setia, 2016). In addition, data collected using the design can be used to prove or disprove assumptions or can be analyzed to create new theories (Setia, 2016).

The study used the purposive sampling technique to select both the study areas and respondents. The two districts which were believed to provide useful information for this study were selected purposively, followed by a purposeful selection of four administrative wards from each district. In addition, the study involved the purposeful selection of smallholder farmers with Smartphones and access to the internet. A sample size of 200 respondents was determined using Cochran's formula (1963) when estimating sample size for an infinite population whereby;

$$n = \frac{z^2 * p * (1-p)}{(d)^2}$$

n = size of sample size,
z = 95% confidence interval (i.e., 1.96),
p = Assumed maximum variability of population proportion which is 15.4%, and
d= acceptable margin error (i.e., 0.05)
Hence n which is a sample size was:

$$n = \frac{1.96^2 x\ 0.154\ (1-0.154)}{(0.05)^2}$$

$$n = \frac{3.8416x\ 0.130284}{0.0025} = 200.1996058 = 200$$

Therefore, the study sample size was 200 respondents, 100 from each District.

Data Collection and Analysis

The study collected both quantitative and qualitative data whereby the former was through the use of a structured questionnaire and the latter was through focus group discussions (FGDs) and key informant interviews (KIIs). A total of four FGDs involving six to eight participants were conducted to provide room for them to present their general understanding of digital devices and how they are using them in their agricultural production activities. The FGDs were guided by an FGD guide. In addition, according to Nyumba et al. (2018), FGDs should not exceed ten participants because large groups are difficult to control and limit each person's opportunity to share insights and observations. Five KIIs were held with people believed to have an in-depth understanding and knowledge about smallholder farmers' ability to use the internet and social media to access agricultural information geared towards raising their productivity: this included the District and Ward Extension Officers. A semi-structured interview checklist was used to capture important information about respondents' main economic activities and sources of income, NGOs and

Table 1: Description of variables used in the model

Variable	Type of variable	Expected sign
Farming experience (X1)	Continuous	+/-
Distance from the market (X2)	Continuous	+/-
Use of fertilizer (X3)	Dummy (1=Yes, 0=No)	+
Access to credit (X4)	Dummy (1=Yes, 0=No)	+
Digital literacy (X5)	Dummy (1=Yes, 0=No)	+/-
Use of labour (X6)	Dummy (1=Yes, 0=No)	+/-
Access to extension agents (X7)	Dummy (1=Yes, 0=No)	+/-
Land size (X8)	Continuous	+
Improved seed (X9)	Dummy (1=Yes, 0=No)	+

the local government efforts of promoting the use of the internet and social media, challenges faced by smallholder farmers in the use of the internet and social media and whether they seek help from experts once they experience those challenges, including for example, agricultural misinformation.

Quantitative data were analysed using IBM-SPSS (version 20) whereby descriptive statistics (frequencies, means, standard deviations and percentages) were determined. In estimating productivity, the study used reported output per unit area (kg/acre) for both maize and common beans as used by Severian, (2019); Habte *et al.* (2021). Furthermore, multiple linear regression was used to determine the contribution of digital literacy to agricultural productivity whereby the independent variables were digital literacy, the use of labour, the use of fertilizer, land size, access to extension agents, the use of improved seeds, distance from the market, farming experience and access to credit while the dependent variable was agricultural productivity (maize and beans). According to Uyanik and Güler (2013), the multiple linear regression model was specified as follows;

$$Y= b_0 +b_1X_1+b_2X_2+...+b_nX_n+\varepsilon_i,$$

Whereby:

Y = expected value of the dependent variable (productivity)

b_0 = the value of Y when all of the independent variables (X_i through X_n) are equal to zero

b_i-b_n = estimated regression coefficients, i.e. change in the outcome variable resulting from a unit change in the predictor variable, holding all other independent variables constant (i.e. when the remaining independent variables are held at the same value or are fixed)

X_i-X_n = predictor variables entered in the linear regression model (digital literacy, land size, improved seed, distance from the market, farming experience, use of labour, use of fertilizer, access to extension agents and access to credit) table 1 presents details on the variable analysed on the study.

ε_i = An error term representing a proportion of the variance in the dependent variable that was unexplained by the regression equation (due to inherent errors in the model and other variables which were not entered in the model)

Content analysis was also used to analyse the qualitative data from key informant interviews and the FGDs which were taken in the form of notes. These were transcribed, coded and analysed to establish themes based on the study's specific objectives and research questions.

Findings and Discussion

Use of social media and the internet among smallholder farmers

Findings in Table 2 show that over two-thirds (70.5%) of the surveyed smallholder farmers have access to social media which they use for general purposes while 29.5 per cent did not due to many factors. For example, not knowing how to use them and not knowing the benefits of social media; as a result, they see the usage of social media as a waste of time. This observation conforms to the findings by Khumoetsile (2021) who revealed that the

majority of smallholder farmers have access to social media and use social media platforms to obtain information on various subjects such as health, politics, agriculture, education, sports and fashion. Also, this observation conforms to the observation by Kimani (2019) who found that the majority of smallholder farmers have access and others do not have access to social media due to different factors such as low levels of social media awareness.

Study findings in Table 2 also show that over a third (38.2%) of smallholder farmers use WhatsApp for accessing agricultural information followed by Facebook (35.8%). Generally, smallholder farmers prefer WhatsApp and Facebook because they provide updated (current) information. Farmers also used many other groups hence enriching their knowledge, which in turn, helps to improve their productivity. For example, through social media, smallholder farmers can be able to share and get different agricultural information and once they get a problem on their farms, they can take a picture and share it with their fellows in various groups formulated on social media platforms such as WhatsApp group and get a solution on how to overcome that problem. The study's observation conforms to what has been reported by Kimani (2019) that the majority of smallholder farmers prefer WhatsApp followed by Facebook and that WhatsApp and Facebook are the most popular social media platforms to deploy agriculture information. However, the observation differs from what others have reported in the literature (Khumoetsile, 2021; Kuria, 2014: Abuta *et al.,* 2020) that the majority of smallholder farmers use Facebook as the main social media platform when looking for agricultural information.

Findings in Table 2 show that 13 per cent of smallholder farmers prefer WhatsApp as opposed to other types of social media platforms. They prefer WhatsApp because it makes communication easy, it joins many people at a time and also it allows information sharing through video and pictures. This means that apart from having different types of social media platform, smallholder farmers have the social medium that they believed is rich in information and help them to obtain useful information that helps to improve their agricultural performance.

Findings in Table 2 show that the majority (95%) of smallholder farmers do not know any App which provides agricultural information

Table 2: Smallholder farmers' access and type of social media platform accessed (n=200)

Characteristic	Frequency	Per cent	
Access to social media	Yes	141	70.5
	No	59	29.5
Type of social media platform	WhatsApp	47	38.2
	Facebook	44	35.8
	Instagram	14	11.4
	YouTube	10	8.1
	Twitter	6	4.9
	Google	1	0.8
	Telegram	1	0.8
Preferable social medium	None	147	73.5
	WhatsApp	26	13
	YouTube	2	1
	Facebook	22	11
	Instagram	3	1.5
Awareness of agriculture information Apps	Yes	10	5
	No	190	95

while only 5 per cent know Apps which provide agricultural information. This means despite there being many applications (Apps) that can help smallholder farmers obtain different types of agricultural information to possibly improve their performance most are unaware of their existence. And this could be because, no one of those Apps, especially related to agricultural activities. In addition, this makes it difficult for them to use their smartphones to search for information to help them transform their agricultural production.

Agricultural information apps prefered by smallholder farmers

Findings in Table 3 show that 1.5 per cent of smallholder farmers use Plantix App followed by Mkulima Smart App, used by 1 per cent. Farmers prefer the use of the Plantix App because it helps them to get advice on how to take care of their crops, especially in their fight against pests and diseases for higher productivity. This observation is supported by what was pointed out during the FGDs as shown in the quote below;

The plantix App helps me a lot because if the plants are affected, I can take a picture and it helps me identify the problem. Some diseases have similar characteristics so through the plantix App I can find a solution. (FGD Participant, Masama South, July 2022).

The observation conforms to the findings by Eichler Inwood & Dale (2019) that most of the smallholder farmers use Plantix App since it is very useful in fighting against pests hence food product security. However, the observation differs from what others have reported in the literature (Costopoulou *et al.,* 2016; Nyinondi & Sospeter, 2022: Zhang *et al.,* 2016) that the majority of smallholder farmers use Kilimo na Ufugaji App, E-Price App as well as Farm Management App to access all of their farm information in real-time.

Availability of Required Agricultural Information on the Internet and Social media

Findings in Table 4 show that the majority (94.5%) of smallholder farmers reported not having missed their required agricultural information on the internet and social media while 5.5 per cent did miss it. Despite the above observation, it may be that the majority did not miss the information not because they got everything that they were looking for but, it is because they were not looking for agricultural information either on the internet or social media. This observation is supported by a participant during FGDs who said;

"...I am not missing any information concerning agricultural activities because I have enough experience in agriculture: I have engaged in agriculture since I was young. So, I know what I can do to get high production without depending on social media and the internet therefore, I am not missing any information because I am not searching for any agricultural information on social media and the internet..." (FGD Participant, Masama South, July 2022).

The observation conforms to what others have reported in the literature (Kanjina, 2021; Moris & James, 2017: Zheng *et al.,* 2022) that the majority of smallholder farmers do not look for agricultural-related information on the

Table 3: Agricultural information apps prefered by smallholder farmers (n=200)

Agricultural information Apps	Frequency	Per cent
Not using App	190	95.0
Kilimo Africa App	1	0.5
Mkulima Smart App	2	1.0
Plantix App	3	1.5
Yara CheckIT App	1	0.5
FarmCare App	1	0.5
Kilimo and Ufugaji App	1	0.5
WeFarm App	1	0.5

internet and social media, this could be due to different reasons including the effect of age, education as well as the lack of understanding of the tangible benefits social media and internet can provide.

On the other hand, those smallholder farmers missing agriculture information on the internet and social was because they did not know how to properly search for the same. The observation is supported by the quote from an FGD participant who said:

"…Sometimes you can find it difficult to get the information that you are looking for on the internet and social media because first you may ask a question in the group either WhatsApp or Facebook group and many people will respond and give out their view others might answer well others not. But, at the end of the day, no one will conclude that this is the correct answer and this is not, and sometimes you may find you are in the same group with Agricultural Extension Officers but, they may respond quite late or not responding at all. Therefore, you may end up not getting the correct answers you are looking for. On the other hand, you may search for something on the internet but, many answers will appear sometimes from the wrong source and you will end up losing interest because you do not know a good source for the correct agricultural information…" (FGD Participant, Masama South, July 2022).

The study's observation conforms with what has been reported by Darshan & Meena (2017) that the major constraints that face smallholder farmers in using the internet and social media during accessing agricultural information and made them miss some of the important information include difficulty to find relevant information and this is because of the large number of sources, inadequate technical knowledge/ skill of using internet and social media tools and the last constraint is the majority of farmers are not trained on how to use a particular tool.

Findings in Table 4 show that 2 per cent of smallholder farmers miss pest and disease management information as well as weather information and this affects their agricultural performance. The observation conforms to what others have reported in the literature (Kante *et al.,* 2017; Mwenda *et al.,* 2022: Mtambanengwe *et al.,* 2012) that small holder farmers experience inadequacy of weather information as well as pest and disease management information services due to lack of reliability, timing, up-to-date and frequency of dissemination of this important information on the internet and social media which can result to low productivity.

Findings in Table 4 show further that 97 per cent of smallholder farmers were not using

Table 4: Smallholder farmers' access to agricultural information on the internet and social media and alternatives (n=200)

Characteristic		Frequency	Per cent
Missing agricultural information on the internet and social media	No	189	94.5
	Yes	11	5.5
Missed agricultural information	None	189	94.5
	Weather	4	2
	Pests and disease management	4	2
	Good agricultural practices	2	4
	Marketing	1	0.5
Alternative ways used by smallholder farmers to access information	None	194	97
	Extension agents	6	3

any alternative ways after missing agricultural information on the internet and social media while only 3 per cent use extension agents. This means that after missing agricultural-related information, most of the smallholder farmers do not use alternatives while others use extension agents to access important information which is missed on the internet and social media. The observation differs from what others have reported in the literature (Churi *et al.,* 2012; Phiri *et al.,* 2019: Rahman *et al.,* 2020) that the majority of smallholder farmers use extension workers at district and village levels, family members, friends and fellow farmers as an alternative for communicating information which could not be accessed in the internet and social media.

The contribution of smallholder farmers digital literacy on maize productivity

Table 5 presents the results of the Multiple linear regression analysis on the contribution of digital literacy on maize productivity. According to Table 5, the coefficient of determination (R^2) for maize productivity was 0.689 suggesting that the model explains 68.9 per cent of how the dependent variable is associated or influenced by the independent variables included in it. in addition, Table 5 shows that factors associated with maize productivity in Moshi and Hai Districts were farming experience, the use of fertilizer, farmers' digital literacy, land size and the use of improved maize seeds; these were significant at $p \leq 0.001$ and 0.05 levels (Table 5). On the other hand, the influence of distance to the market, access to credit, the use of labour and extension services was statistically insignificant.

Table 5 shows that the coefficient for farming experience was negative and statistically significant ($p \leq 0.05$). The result suggests that with an increase in 1 year of farming experience, maize productivity decreased by 0.372 units. Therefore, having long experience in farming activities does not guarantee an increase in productivity. However, the finding differs from what has been reported in the literature (Kolapo *et al.,* 2022; Agboola *et al.,* 2015) whereby farming experience has been reported to have a positive and significant effect on maize productivity, that means the more years of experience maize farmers have, the higher their maize productivity. Nonetheless, the study's observation is to some extent in line with Nyamekye *et al.* (2016) who reported farming experience had no positive effect on maize productivity.

Table 5 also shows that the coefficient for use of fertilizer was positive and significantly ($p \leq 0.05$) associated with high maize productivity whereby those using fertilizers produced 0.181 more units of maize compared to those who did not. The result suggests that the use of fertilizer helps to increase productivity among smallholder farmers. This result is not supported by the result in a study by Severian (2019) who found that farmers who applied fertilizer had lower productivity, holding everything else fixed and this might probably be because the farmers who reported having applied fertilizer on their farms did not have adequate skills on the proper use of fertilizer. However, the observation conforms to what others have reported in the literature (Abate *et al.,* 2015; Arif *et al.,* 2021: Urassa 2010) that the adoption of improved technologies such as fertilizers by smallholder farmers will improve their productivity.

The coefficient for digital literacy was negative and significantly ($p \leq 0.05$) associated with maize productivity (Table 5). The result shows that smallholder farmers with digital literacy had lower maize productivity than was the case with farmers with no digital literacy by 0.358 units. The result suggests that having digital literacy does not guarantee an increase in productivity. This observation is supported by what was pointed out by a participant during one of the FGDs as shown in the quote below:

"...Productivity depends on many things such as the best care of crops especially spraying when needed as well as capital. For example, someone may get all the information related to agriculture but, if he/she lacks capital this will become a problem because productivity will be low..." (FGD Participant, Masama South, July 2022).

However, the study's observation contradicts the study of Quandt *et al.* (2020) who found a positive association between digital literacy and maize productivity though

the association was not statistically significant. Nonetheless, their finding suggests that an increase in digital literacy leads to an increase in productivity. Another study conducted by Onsomu *et al.* (2022) established a positive association between digital literacy and maize productivity.

The coefficient for maize land size was positive and statistically significant at 1 per cent. The result indicates that an increase in 1 acre of maize land size would lead to an increase in maize productivity by 0.224 units. This finding is supported by findings in other studies (i.e., Kolapo *et al.,* 2022; Jara-Rojas *et al.,* 2013; Severian, 2019; Nyamekye *et al.,* 2016) revealing that farm size had a positive and significant effect on maize productivity indicating that an increase in farm size leads to an increase in maize productivity.

Table 5 shows that the coefficient for use of improved maize seed was positive and significant ($p \leq 0.001$) with maize productivity. The result suggests that smallholder farmers who used improved maize seed had higher maize productivity by 0.292 units compared to their counterparts who did not use the same. The observation conforms to what has been reported by Ngango and Hong (2021) that the use of improved maize seeds was positively and significantly associated with maize productivity.

The contribution of farmers digital literacy on common beans productivity

Table 6 presents the results of the Multiple linear regression analysis on the association of digital literacy with common beans productivity. As shown in Table 6 the coefficient of determination (R^2) for common beans productivity was 0.708 which means that the independent variables entered in the model explained 70.8 per cent of the causes of farmers reported common beans productivity levels. The results in Table 6 further show that the factors associated with common beans productivity in Hai and Moshi districts were farming experience, distance to the market, digital literacy, land size and the use of improved beans' seed and the association was significant at the $p \leq 0.001$ and 0.005 levels respectively. On the other hand, the use of fertilizer, access to credit, the use of labour and extension services were not significantly associated with common beans productivity.

Table 6 shows the coefficient for farming experience was positive and significantly ($p \leq 0.05$) associated with common beans productivity. The observation suggests that a one-year increase in a farmer's experience in common beans farming leads to an increase in

Table 5: Multiple linear regression analysis on the contribution of digital literacy on maize productivity (kg/acre)

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
Farming experience	-0.313	0.135	-0.372	-2.323	0.026**	0.938	1.066
Distance to market (km)	0.102	0.095	0.071	1.081	0.281	0.934	1.071
Use fertilizer	0.197	0.093	0.181	2.12	0.036**	0.868	1.152
Access to credit	-0.941	1.157	-0.054	-0.813	0.417	0.924	1.082
Digital literacy	-1.522	1.607	-0.358	-2.345	0.024**	0.877	1.141
Use of labour	0.372	1.142	0.022	0.326	0.745	0.873	1.146
Maize land size	0.986	0.331	0.224	2.975	0.003***	0.718	1.393
Improved maize seed	4.013	1.003	0.292	4.002	0.000***	0.763	1.311
Extension services	-0.211	0.865	-0.017	-0.244	0.808	0.811	1.232

$R = 0.830$, Unstandardised $R^2 = 0.689$ and Standardized $R^2 = 0.0202$
*NB: **, is significant at 5% and *** is significant at 1%*

productivity by 0.146 units. This observation is supported by what was reported during the FGDs as shown in the quote:

I have a lot of experience in agriculture, and I know what to do to get a lot of crops. If I get low production, it is probably because I was late to spray the insecticide in time (FGD Participant, Masama South, July 2022).

The study's observation is supported by other researchers (Teshome *et al.,* 2020; Okam *et al.,* 2016) who reported a positive and significant relationship between one's farming experience and productivity of common beans and that an increase in years of farmers' experience leads to digital literacy were more likely to report higher productivity of common beans than the none-digital literate by 0.245 units. The observation is in line with what Nsabimana and Funjika (2019) have reported that digital literacy had a positive and significant effect on common beans productivity. Similar observations have been made by Venkatesh *et al.* (2003).

Land size dedicated to common beans production was positively and significantly ($p \leq 0.001$) associated with the crop's productivity (Table 6). The observation suggests that a unit increase in land allocated for beans production led to an increase in its productivity by 0.456

Table 6: Multiple linear regression analysis on the contribution of digital literacy on common beans productivity

Independent variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	β	Std. Error	Beta			Tolerance	VIF
Farming experience	0.032	0.016	0.146	1.995	0.047**	0.929	1.076
Distance to market (km)	0.347	0.155	0.730	2.240	0.049**	0.732	1.410
Use of fertilizer	-0.496	0.716	-0.052	-0.692	0.49	0.89	1.124
Access to credit	0.121	0.552	0.016	0.219	0.827	0.966	1.035
Digital literacy	0.463	0.527	0.245	2.029	0.046**	0.756	1.323
Use of labour	-0.449	0.547	-0.061	-0.821	0.413	0.906	1.104
Extension services	-0.181	0.41	-0.034	-0.442	0.659	0.851	1.175
Beans' land size	1.372	0.196	0.456	7.014	0.000***	0.947	1.056
Improved beans seed	0.822	0.408	0.144	2.017	0.045**	0.982	1.018

$R = 0.842$, Unstandardized $R^2 = 0.708$ and Standardized R^2
*NB: * is significant at 10% **, is significant at 5% and *** is significant at 1%*

increased common beans productivity.

Further to the above, Table 6 shows the coefficient for the distance to the market was positive and significantly ($p \leq 0.05$) associated with common beans productivity. The above suggests that a unit increase in the distance to the market increases the productivity of common beans by 0.730 units. however, the observation contradicts what has been reported by Teshome *et al.* (2020) that distance to the market had a negative and significant effect on common bean productivity in Ethiopia.

Table 6 further shows that the coefficient for digital literacy was positive and significantly ($p \leq 0.05$) associated with bean productivity. Thus, suggesting that smallholder farmers with units. The study's observation is supported by literature (Narcisse and Chrysostome, 2019; Baruwa & Oke, 2012) whereby land size has been reported to be positively and significantly associated with high productivity of common beans.

Findings in Table 6 also show that the use of improved bean seeds was positively and significantly ($p \leq 0.05$) associated with increased productivity of common beans by the surveyed farmers. Generally, farmers who use improved beans seeds had higher productivity of common beans reported higher productivity compared to those who did not use by 0.144 units. The study's observation conforms to what has been reported by Letaa *et al.* (2020) that the use of

improved bean seed varieties was positively and significantly associated with the crop's high productivity in the southern highlands of Tanzania.

Conclusions and recommendations

The study aimed at exploring the use of digital platforms through of social media and the internet among smallholder farmers and investigated the contribution of digital literacy on maize and common beans productivity using Hai and Moshi districts as case studies. It can thus be concluded that access to social media and the internet does not determine a farmer's use of information provided on social media and the internet. It has also been observed that a significant proportion of farmers who participated in this study had low awareness on agriculture information Apps. It is also concluded that digital literacy has contributed to agricultural productivity. Moreover, the majority of smallholder farmers do not have ideas of the existence of various applications (Apps) that can enable them to obtain agricultural information, for those who use those Apps, some encounter problems such as less information, outdated information as well hardships in finding agricultural related information within the Apps.

Based on the study's findings and conclusions, it is hereby recommended that the agricultural and ICT departments in Hai and Moshi districts and other interested stakeholders should collaborate and conduct awareness campaigns and training of smallholder farmers on the use of social media and the internet in meeting their agricultural information need. Doing so will enable smallholder farmers to access valuable information hence, the possibility of transforming their agricultural production and ultimately improving their general well-being. In addition, education concerning the use of applications (Apps) which provide agricultural information should be given so that smallholder farmers can use the same to obtain agricultural-related information thus, thus minimising their dependency on extension officers. Furthermore, developers of the Apps should make sure that information are contented, updated and can easily be used by the farmers.

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