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Factors Influencing Extension Workers' Behavioural Intentions Towards Digital Farm Technologies in Malawi

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FACTORS INFLUENCING EXTENSION WORKERS' BEHAVIOURAL INTENTIONS TOWARDS DIGITAL FARM TECHNOLOGIES IN MALAWI

Research paper

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Abstract

Information and Communication and digital farm technologies are vital in improving agriculture production. Despite introducing digital farm technologies in Malawi, the country continues to have low agriculture production. The country has a low uptake of technology, which is a major driving factor of agriculture productivity. Therefore, this research aims to examine factors that influence the behavioural intention of extension workers towards using digital farm technologies to improve agriculture production. The research covers 14 districts of Malawi, where the digital farm technology, National Agriculture Management Information System (NAMIS), is currently operational. Centring on the Theory of Planned Behaviour and the quantitative study approach showed that perceived behaviour control and subjective norms influence behaviour intention. At the same time, attitude is not a significant determinant of behaviour intention of using digital farm technologies.

Key Words: Information and Communication, Digital Farm Technology, Behaviour Intention, NAMIS, Theory of Planned Behaviour (TPB).

1 Introduction

The principal source of national income in Malawi and surrounding Sub-Saharan African economies continues to be agriculture (Davis et al., 2017; Giertz et al., 2015) with over 70 per cent of people in Africa depending on agriculture (Peralta, 2016). As such, agriculture is one of the development goals in Africa (Davis et al., 2017; Gulden, 2020) in not only improving nutrition and food safety (Dybdal, 2017) but also supporting national economies by providing job opportunities (Cheber, 2018). An estimated population increase to 1.3 billion by 2050, in addition to climate change, continues to pose food security threats in Africa (FAO, 2009). Thus, Dybdal (2017) report that there is a need for smallholder farmers in Africa to boost production by over 70 per cent to be able to feed the growing population and reduce malnutrition problems as food and nutritional security rises (Deichmann et al., 2021; Kudama et al., 2021).

These effects can be countervailed by adopting more vibrant and innovative strategies to ameliorate agricultural productivity. Over the years, Information and Communication Technologies (ICTs), merged with digital farm technologies, have played a vital role in improving agriculture production. Using relevant technologies in smart farming in developed countries largely depends on farmers' willingness to embrace modern productivity-boosting technologies (NPC, 2020). However, low technology uptake in some parts of Kenya and surrounding countries contributes to low agricultural production (Kavoi et al., 2014; Damba et al., 2020). Digital farm technologies (DFT) use specialised digital equipment, software, and Information Technology (IT) services guided by planting times and harvesting times ideal for farm management (Dybdal, 2017). According to Soma (2019), digital farming is shifting the traditional network of stakeholders in farming. As mentioned by Deichmann et al. (2021), in Africa and developing countries, embracing digital farming technologies overcomes problems that "information delays market access for many farmers that operate on small-scale, rise information through new ways proving farm supervisory skills, "and they provide novel ways for improving agricultural supply chain management" (Peralta, 2016). Further, Malawi's 2063 strategy document highlights the agriculture value chain in expounding the need to grow the agricultural sector and increase food security, people's prosperity, industrialisation and improve African trade, highlighting and bolstering Malawi's contribution to global trade (NPC, 2020).

Technology, according to Peralta (2016), "does not only talk about information communications technology (ICT) but any tool that makes work or life easier like mobile technology which is having a positive impact on smallholders' livelihoods: cell phones (Owolabi and Yekinni, 2022) allow them to carry out business without mediators "and access agriculture extension services and training that governments may no longer provide". Nevertheless, according to Peralta (2016) when it comes to introducing technology to the planting, harvesting and storage practices, farmers stick to the traditional approaches.

Malawi has introduced several digital farm technologies, notably, National Agricultural Management Information Systems (NAMIS), Extension Helper Applications (EHA) and ICT-based Value Chain Governance Platforms. Firstly, NAMIS, whose goal is to facilitate the development of the agricultural sector through the timely provision of high-quality data to all stakeholders. Each sector level provides quality data, including farmers, Extension Planning Area (EPA) staff, managers, policymakers, researchers, development partners, private sector players and the public. This system plays a pivotal role in enhancing transparency, reducing information gaps, and ultimately contributing to the growth and efficiency of the sector (Rivera and Moore, 2020) describe EHA as "an app developed to make extension services more accessible and extension systems more efficient for a more robust demand-driven approach.

Further, Peralta (2016) explains that the EHA is a multi-faceted ICT tool designed to firstly, improve extension workers' ability to teach farmers towards improved adoption of beneficial technologies and practices, secondly, improve data quality towards better and evidence-based planning and lastly, improve coordination, efficiency, and cost-effectiveness of services through mapping activities to determine areas of over-saturation and where access is low."

Then there is also ICT-based Value Chain Governance Platforms (IVCG). As explained by Rivera, (2021), IVCG aims at digitizing supply chains' automated order-to-cash and procure-to-pay processes, improving collaboration with key stakeholders across the digital ecosystem and increasing end-to-end supply chain visibility as well as improving business and creating efficient B2B operations that address current business needs and emerging risks. People can witness similar trends in most African countries, for instance, Kenya (Islam and Grönlund, 2012; Kavoi et al., 2014). That notwithstanding, Malawi and many other African countries continue to experience low agricultural production despite the introduction of digital farm technologies.

This research uses NAMIS as a case study. The system aims to facilitate the development of the agricultural sector by providing high-quality data to all stakeholders promptly. Stakeholders include Extension Planning Area staff, managers, policymakers, researchers' development partners, the private sector, and the public. Specifically, NAMIS provides the following objectives: firstly, facilitating real-time data, including reporting at community, district and national levels through computerized data collection mechanisms and tools; secondly, improving access to agricultural information through the development and operationalization of electronic data banks; dashboards, and websites to meet the needs of various stakeholders at all levels within the agriculture sector. Lastly, NAMIS aims to improve data utilization and facilitate evidence-based decision-making at the community, district, and national levels. At the community level, there are extension workers who are the experienced farmers selected and hired by the government to mentor and train local farmers. Extension workers have typical roles: educating farm producers so that the farmers or producers can help themselves and linking farmers with research-based information to improve agricultural productivity, processing and marketing of agricultural goods and services. This research, then, sets out to examine factors that influence the behavioural intention of extension workers towards using digital farm technologies in Malawi to enhance agriculture production.

2 Related Literature

Digital farming technology (DFT) is the adoption of innovative ways of doing things to improve the performance and enhance efficiency of systems with a view to increasing productivity (Victoria, 2020). Hall and Khan (2002) define the concept of adoption of technology as “the choice to acquire and use a new invention or innovation”. With DFTs farmer’s efficiency is improved on one hand and the environmental impact of agriculture reduced on the other Wan (2023). Furthermore, farmers can reach a wider audience and provide transparent information on their products’ sources and characteristics, enhancing trust in the agricultural value chain.

In agriculture, technologies play an essential role in reducing poverty in developing countries. Further, Mwangi and Kariuki (2015) report that the technology adoption rate remains very low in most developing countries and that technological, economical, institutional, and human specifications are the main determinants of agricultural technology adoption. They went on to recommend that future studies on adoption widen the range of variables used and suggest farmers’ perceptions towards new technology. This recommendation consequently follows from the realisation that farmers’ willingness to access and adopt digital farm technologies is a crucial factor in the quest to increase agricultural productivity both in developed and developing countries (Kavoi et al., 2014; Shee et al., 2020; Smidt and Jokonya, 2021a).

2.1 Influences of ICT and Digital Technologies in Agriculture

Using digital technologies in agriculture transforms farmers' agricultural decision-making and productivity (Fountas et al., 2020). These DFTs comprise networks, mobile devices, services, and applications assisting in processing, managing, and exchanging data, information, or Knowledge with a target audience (morc, 2022). According to (morc, 2022) digital farm technologies include various linking technologies, including traditional telecommunications, television and video, radio, cell phones and smart devices, computers and the internet, sensors, geographic information systems, and satellites. As explained by (Vassilakopoulou and Hustad, 2023) closing the remaining digital divide is essential for ensuring a broad influence in rural regions of developing nations like Malawi. The effective use of ICT is crucial for promoting growth and development in the agriculture sector. ICT has played a significant role in fostering economic progress and societal advancement, particularly in countries that have harnessed digital farm technologies effectively (Ayim et al., 2022)

While integration of ICT in the agriculture sector in developed countries has led to tremendous improvement in agriculture value chain efficiency and productivity, it has been sluggish in sub-Saharan Africa (Damba et al., 2020) and the major transformation of the sector has yet to take place. The researcher acknowledges ICT as a decision support system for farmers to stay updated with all recent information through ICT's assistance, including more advanced ways of enhancing crop quality and production (CropIn, n.d.). The tremendous adoption of ICTs can make it possible to facilitate better communication and ensure the delivery of services and information to people who previously had no access, like agriculture extension workers and rural farmers in developing countries (CropIn, n.d.; Das, 2014). Furthermore, the infusion of modern advanced technologies like remote sensing, artificial intelligence and robotic systems have bolstered the growth of DFTs (Fountas et al., 2020) as well as transforming the way producers cultivate, harvest, and distribute agricultural commodities (Holzinger et al., 2022). As mentioned earlier, people experience the benefits of DFTs in France, the United States, Greece, and Kenya (Anastasios et al., 2010; N. Kingiri, 2021). However, there is a widened digital divide, which leaves many with little understanding of DFT and its potential application in agriculture.

2.2 Behaviour and Intention towards the use of the technology

As mentioned already farmers' willingness to access and adopt digital farm technologies is crucial in increasing agricultural productivity in developed and developing countries (Kavoi et al., 2014; Smidt and Jokonya, 2021b) There is already flourishing evidence that emerging technologies give rise to new ways of behaving, for example, socially relating to others, engaging the world, and experiencing reality (Olson and Olson, 2003; Richardson, 2001). A person can hypothesis the acceptance of the technology to be determined by their intention to accept it (Davis et al., 1989). The intention, in turn, is determined by the person's attitude toward the Information System (IS) and the person's perceptions concerning its usefulness. Beliefs a person holds about the IS form attitude. The beliefs in a particular technology consist of the targeted IS user's perceptions of its usefulness and ease of use. External variables, such as the task, user characteristics, political influences, organizational factors, and the development process, are expected to influence technology acceptance behaviour indirectly by affecting beliefs, attitudes, or intentions (Teo and Zhou, 2014). Intention to use technology is used in this research as the outcome variable because it is a reliable predictor of technology usage (Ajzen, 1991; Turner et al., 2010). Technology Acceptance, authored by Davis in the late eighties, enabled the measurement of behavioural intention, meaning a person's intention to use technology (Brookes, 2022).

2.3 Theoretical Framework

Information systems theories are classified by (Gregor, 2006) as falling into the main goals of analysis, explanation, prediction, and description. This research aligns itself with the theory for explaining and predicting (EP theory) found within the theory of analysis. Theory of Explaining and predicting is the type of theory which, according to (Brookes, 2022) says what is, how, why, when, and what will be, and corresponds to commonly held views of theory in both the natural and social sciences employing "intention to use" the technology. This theory is used to help understand how information systems can better be used as an off-the-shelf artefact applied and utilized in digital farming where an existing technology is being used, in this case, the National Agricultural Management Information System (Prakash et al., 2023).This researcher will use the EP theory to explain and analyse the behavioural intention of extension workers based on the responses provided.

In this research, issues of behavioural intention and people's attitudes towards technology are tackled in the Theory of Planned Behaviour (TPB) developed by (Ajzen, 1991), displayed in *Figure **1***. The theory of Planned Behaviour is an extension of the Theory of Reasonable Action. The theory of Planned Behaviour discusses one factor determining the behavioural intention of the person's attitudes toward that behaviour (Brookes, 2022). The first two factors of attitude and subjective norm are the same as the

Theory of Reasonable Action (Ajzen, 1991). The third factor, perceived behaviour control, is the control users perceive that may limit their behaviour.

3 Methods

The research adopted the Theory of Planned Behaviour (TPB) (Ajzen, 1991) to include the behavioural intention to use digital farm technology, as depicted in *Figure **1***.. Consistent with this theory, it can be predicted that behavioural factors can influence extension workers' intentions to use digital farm technologies in Malawi to achieve food production and sustainability. This current research considered the use of variables in the form of attitude, subjective norms, and perceived behavioural control influenced by age and experience on NAMIS as a digital farm technology tool.

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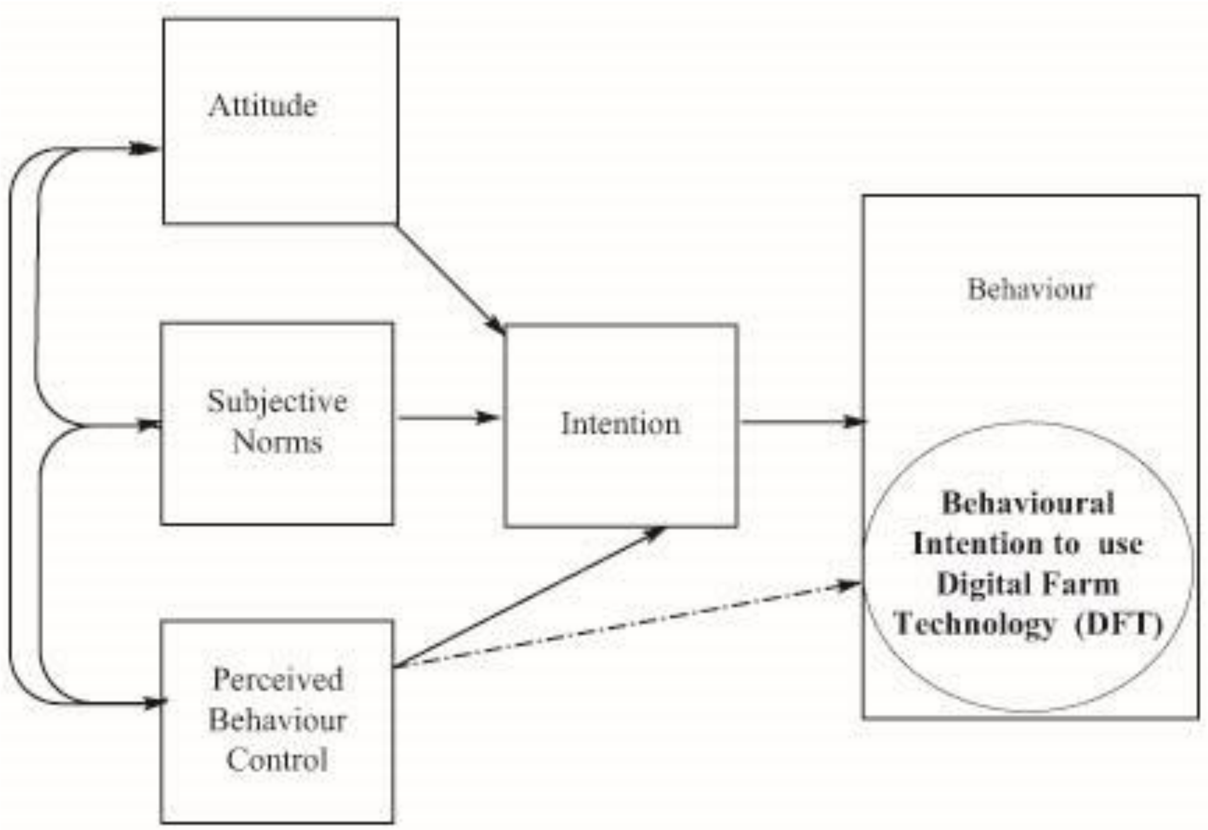

Figure 1. The Theory of Planned Behaviour adapted from (Ajzen, 1991)

Attitude is the degree to which an individual favourably or unfavourably assesses the behaviour being examined". In this case, the attitude of respondents affects their mindset/psychology to use digital farm technology. Subjective norm is the social pressure that makes a person perform a particular behaviour. As noted by (Ham et al., 2015) subjective norms could positively influence a person's intention to behave in a particular setting. In this current research, the following are subjective norms: peer pressure from other extension workers/staff, farmers, opinion leaders, and family members to use or not to use digital farm technologies. Lastly, perceived behavioural control is an individual's perceptions of ease or difficulty in performing that behaviour (Ajzen, 1991). Respondents' intention would be high when they perceive themselves as self-efficient and competent in using digital farm technology. Attitudes towards digital farm technology use, subjective norms and perceived behavioural control were considered independent variables and behavioural intention to use digital farm technology was dependent variable hypothesised accordingly.

3.1 Study Units

This research mainly focused on agricultural extension workers in the Extension Planning Areas where National Agriculture Management Information Systems (NAMIS) is implemented. Two hundred and ninety-nine (299) participants were planned to answer the questionnaire. The participants were statistically sampled from 14 districts with a population of 1088 extension workers. Again, ten (10) extension workers were drawn from Extension Planning Areas using the Extension Helper Application to pre-test the study questionnaire. Pretesting was used to identify and correct any problems or issues with the instrument before the full-scale study.

3.2 Data collection technique

With the help of enumerators (Extension Planning Officers), the researcher collected data from Extension Planning Areas (EPAs) through questionnaires distributed to their respective extension workers as participants or respondents. Some of the questionnaires for participants were hand-delivered by the researcher to extension planning officers, mainly for those extension planning officer near the researcher's working area; some were sent through courier, and others were sent through emails. Email addresses for all extension panning officers were obtained from the Local government office of Malawi. The questions were adapted from the Theory of Planned Behaviour (TPB). The questions asked and responses were explained based on TPB predicting constructs framed on a Likert scale of 1 to 5. During data collection, the codes 1 to 5 were used in Likert scale variables. During linear regression of the Likert outcomes, dummy coding was done using categorical independent variables, where each category was a binary indicator. With dummy coding, the codes 0 and 1 were used for each category of the categorical variable, where 1 meant that category, and 0 meant not that category or otherwise.

3.3 Sample size determination

The research purposively involved 108 EPAs from 14 NAMIS implementing districts in Malawi listed in the table together with their sections and districts: Chitipa, Mzimba North and Mzimba South districts in the northern region of Malawi, Kasungu, Lilongwe East, Lilongwe West, Mchinji, Ntchisi, Dedza and Ntcheu districts in the Central Region and then Phalombe, Thyolo and Zomba districts in the Southern Region of the country. These formed a sampling frame of 1088 Units (N). The sample size was determined statistically using a stratified sampling method with the EPAs as data sets. The formula in Equation 1 is applied, where the population is already known and the desired confidence level,

$$\boldsymbol{n} = \boldsymbol{z}^{\boldsymbol{2(1-p)p}}/\boldsymbol{e}^{\boldsymbol{2}}=96 \qquad \text{Equation 1}$$

Z = 1.96, an estimate of prevalence, P = 0.5, and the desired level of sampling error, e = ±0.1. Adjusting for non-response by 10%, n = 108.

This suggests the need for a sample size of 284.106474, as depicted in Table 1, which is 285 units and a desired sampling error of 14, making a sample size of 299 study participants. Thereafter, a proportionate stratification was calculated to ensure that the number of units selected for the sample from each stratum is proportionate to the number of units for the EPA to the population, as shown in Table 1. The proportionate calculation was aimed at a fair representation of the number of units and extension workers to be studied to have a balanced view after the study.

No.	District	EPA	Section	Maned	Sampled	284	Sorting
1	Chitipa	6	51	27	2.48%	7.05	1
2	Dedza	10	169	100	9.19%	26.10	9
3	Kasungu	8	64	51	4.69%	13.31	4
4	Lilongwe East	7	123	119	10.94%	31.06	8
5	Lilongwe West	12	197	154	14.15%	40.20	7
6	Mchinji	6	90	64	5.88%	16.71	6
7	Mulanje	5	57	40	3.68%	10.44	13
8	Mzimba North	9	65	54	4.96%	14.10	2
9	Mzimba South	13	100	63	5.79%	16.44	3
10	Ntcheu	7	107	77	7.08%	20.10	10
11	Ntchisi	4	70	52	4.78%	13.57	5
12	Phalombe	6	70	140	12.87%	36.54	12
13	Thyolo	6	63	47	4.32%	12.27	14
14	Zomba	9	150	100	9.19%	26.10	11
	Total	**108**	**1376**	**1088**	**100.00%**	**284**	

Table 1. Sample size determination table.

3.4 Data Analysis

The research used multiple regression analysis to analyse the attitude (AT), subjective norms (SN) and perceived behaviour control (PBC) factors to reveal the behavioural intention to use DFTs by extension workers. Reliability analysis was carried out to express the degree to which measurements are free from error and yield consistent results using a threshold value of 0.70. The correlation between the independent variables was also measured with the convergent and discriminant validity Pearson correlation assessed. *Attitude (*perceptions of its usefulness and ease of use, as discussed earlier), *Subjective norms (*peer pressure) and *perceived behavioural control* (influenced by age and experience) were considered independent variables and *behavioural intention (BI) to use digital farm technology was considered* as dependent variable.

Hypothesis 1: Attitude positively affects extension workers' intention to use Digital Farm Technology.

Hypothesis 2: Subjective norms positively influence extension workers' intention to use Digital Farm Technology.

Hypothesis 3: Perceived behavioural control positively affects extension workers' intention to use Digital Farm Technology.

4 Results and discussion

231 of the 299 questionnaires sent out were responded to, representing a response rate of 77.25 per cent. 46.8 per cent of those who responded were females. Seventy-one per cent of all the respondents were aged between 30 and 39 years. Table 2 provides a summary of the responses. VIF values were all below five at 1.018, 1.018 and 1.000 for perceived behaviour control (PBC), subjective norms (SN) and attitude

(AT), respectively, indicating that they are not multi-collinear. *Table **3*** shows the linear regression results of behaviour intention (bi) on PBC, SN and AT. The results show that pbc and sn are statistically significant determinants of behaviour intention (bi) with p-values of less than 0.05. They both have a positive association with behaviour intention, such that for a unit increase in PBC and SN, there is a 0.042 and 0.377 unit increase in behaviour intention, respectively. On the other hand, attitude is not statistically significant in determining behaviour intention with a negative association.

	Using NAMIS services enables me to accomplish farming tasks more quickly	Using NAMIS will improve the effective use of my time.	I find using NAMIS useful for carrying out farming tasks	How often do you use the NAMIS daily for the service?	How many hours per week do you use NAMIS?
Mean	3.8658	4.1861	4.1948	2.57	2.91
Median	4.0000	4.0000	4.0000	3.00	3.00
Mode	4.00	4.00	4.00	3	3
Std. Deviation	6.39254	6.34069	6.33357	1.052	0.940

Table 2. Responses

This is true and supported by other studies like (Zeweld et al., 2017), who found that willingness to adopt seems to be limited by negative attitudes and weak normative issues. Further, just like other studies, this research found that not all independent variables in the theory of planned behaviour have a positive effect on behaviour intention, and even those that have an influence on behavioural intention do not exert the same strength of influencing behavioural intention (Arnold et al., 2006). In addition, this research found that perceived behaviour control and subjective norms variables influence behaviour intention while attitude is not a significant determinant of behaviour intention of using digital farm technologies.

Despite seemingly having almost the same outcomes, the context of the studies is different (Ajzen, 1991). For instance, (Brookes, 2022)explains that TBP assumes the person has all the resources required to perform the expected behaviour in a way that includes monetary resources. This research was done in the context of the financially challenged country, Malawi, and the remote areas with internet challenges; it was even difficult to send questionnaires where people struggled to send the responses in time. Furthermore, we live in a technology and digital paradigm era where people mainly tend to be absorbed in using digital technology work. Experiences of the digital divide can be noted between the elderly and the youth. Since most of the extension workers are in the youth age group range, it looks exciting for them to work with digital tools as they do their work digitally, thereby demonstrating information and Communication for development. This creates social pressure for others to follow suit, friends, and families after seeing that their fellow youths and friends are doing well with farming. Given the government's deliberate publicity to digitalise the economy towards achieving the 2063 strategic vision (NPC, 2020), it is not surprising that perceived behaviour control influences the behaviour of the extension workers. On the other hand, with more than 70 per cent of the respondents between 30 and 39 years of age, technology adoption for such a young age is not difficult, thus generating a positive perceived social pressure as the control users perceive that may limit their behaviour.

Coefficients[a]

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.	95.0% Confidence Interval for B Lower Bound	95.0% Confidence Interval for B Upper Bound
1	(Constant)	2.893	0.511		5.661	0.000	1.886	3.900
	(PBC)	0.042	0.014	0.162	2.880	0.004	0.013	0.070
	(SN)	0.377	0.042	0.501	8.928	0.000	0.294	0.461
	(AT)	0.002	0.005	0.025	0.447	0.655	-0.008	0.012

a. Dependent Variable: bi

Table 3. Coefficient table

5 Conclusion and Implications

Based on the Theory of Planned Behaviour and factors influencing the behavioural intention of extension workers towards using DFTs to boost agricultural production were examined. For the study area, perceived behavioural control and subjective norms do influence the behaviour of the extension workers.

Following the study and the results, attitude is not a significant determinant of behaviour intention of using digital farm technologies. And as explained earlier attitudes are formed from beliefs a person holds about the Information System (Teo and Zhou, 2014). The beliefs in a certain technology consist of the targeted Information System user's perceptions of its usefulness and ease of use. External variables such as the tasks, user characteristics, political influences, organisational factors, and the development process, are expected to influence behaviour indirectly by affecting beliefs, attitudes, or intentions.

This research, therefore, recommends the involvement of the users, the extension workers, in the system development process to appreciate the tasks and characteristics of the system premised on the national drive to digitalise extension services following the youthfulness of the respondents. That notwithstanding, the study recommends an examination of the behavioural intention to use DFTs on the actual farmers to triangulate the findings on one hand and agricultural production output on the other. The study was only looking at the intention to use digital farm technologies in 14 districts out of the 28 districts in Malawi. This research further suggests upscaling the study to all districts and extension planning areas in Malawi. The researcher further recommends extending the research to the actual use of the technology and not only looking at the intention to use.

In this paper, the researcher has tried o contribute to literature regarding the adoption of digital farm technologies in farming in the context of low-income countries experienced with digital divide mainly regarding internet infrastructure challenges. Furthermore, the research contributes to the digital farm technology adoption phenomenon to increase agriculture production.

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