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Factors influencing the adoption of Internet of Things in the agricultural sector in Limpopo province

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Background: The Internet of Things (IoT) interconnects humans to things, things to things, and humans to humans, streamlining routine activities via the Internet for time and cost savings, and heightened productivity. Despite a global uptick in IoT adoption, Limpopo province's agricultural sector faces a significant lag in embracing and utilizing IoT technologies.

Objectives: The goal of the study was to determine the factors that may determine the adoption and use of IoT within the agricultural sector in Limpopo province.

Method: A qualitative study was carried out using Unified Theory Acceptance and Usage of Technology (UTAUT) as the theoretical lens. Data were collected using interviews, observations, and document reviews from the Limpopo agricultural sector participants. Analysis was performed by means of thematic analysis.

Results: Priori themes for this study namely, organisational support, cost, knowledge gap, security and policy were confirmed as significant in the adoption of IoT in the Limpopo agricultural sector. Monitoring, control, perceived value, and risk emerged as new themes in the adoption of IoT.

Conclusion: For Limpopo agricultural sector to be transformed from manual methods of conducting agricultural activities to the automated method, they will need support enshrined in policies dealing with cost, knowledge transfers as well as security assurances about the use of modern technology such as IoT.

Contribution: A study exploring IoT adoption in Limpopo's agricultural sector promises regional transformation. The Internet of Things can revolutionise practices with real-time monitoring, data-driven decision-making, boosting crop yields, resource efficiency, and sustainability. It empowers smallholder farmers, stimulates rural development, offers valuable data for policymakers, and enhances economic viability in addressing challenges like water scarcity, climate change, and market competitiveness, ultimately improving livelihoods in Limpopo province.

Keywords: Internet of Things; IoT; agriculture, Unified Theory Acceptance and Usage of Technology; UTAUT; adoption factors; rural development.

Introduction

The agriculture sector is the key driver for food security and food production. Agriculture plays a vital role in the development of the economy. It is one of the drivers of job creation. The human population is estimated to rise to 10 billion by 2050. In South Africa, the population increases nearly by 1% annually and is estimated to reach 64.46 million by 2030. In order for agriculture to cope with this growing population, it must develop efficient means of food production to secure food security. Manual labour-intensive agricultural systems result in low productivity (Yoon et al. 2018). Agricultural output can be boosted by the introduction of technology. Internet of Things (IoT) is a shared network of objects and things that can interact with each other through an internet connection. It extends the Internet beyond traditional modes of connectivity. This has created a range of benefits that are transforming how people execute traditional activities. Internet of Things is widely used in connecting devices and collecting information. The agricultural sector has also witnessed some IoT-based innovations that have conferred a range of benefits to farmers. These include the use of Global Positioning System (GPS) in planting, harvesting through telemetry and unmanned aerial vehicles. These IoT adoptions have led to time saving and reduction in production costs. The adoption of IoT by farmers may lessen the production costs, enable effective and efficient use of both physical and human resources, and lessen environmental impact (Li, Chen, & Zhu 2013).

Smart Farming (SF) refers to farming with the application of modern technologies. It uses systems and computers to keep the temperature at the ideal level, using humidity controllers, water spray systems, water flow control, and more. Smart Farming optimises conditions in order to maximise growth and harvest capacity. Wireless Sensor Networks can lead to agricultural modernisation. However, despite the proliferation of IoTs in developed countries the rate of adoption in these countries has been very slow. In most developing countries, farmers are still using traditional methods of farming. Therefore, there is an urgent need to find a solution that can help the agricultural domain with the effective use of modern tools and technologies. This study focussed on the factors that may influence the adoption of IoT in the agricultural sector in Limpopo Province. We also established how ease of use of IoT systems may lead to its adoption by identifying the conditions that may facilitate the adoption and use within the agricultural sector. We also sought to determine the role of social influence on the adoption and use of IoT in the agricultural sector in Limpopo Province. The rest of the article is organised as follows: literature review, conceptual framework, research methods, data analysis, results, discussion and conclusion.

Literature review

A study by Bucci, Bentivoglio and Finco (2019) revealed that attempts to adopt agricultural technologies by Italian farms encountered several obstacles linked to the cultural barriers which we refer to as social influence in this study The farmers faced the difficulty of investing in and appreciating the benefits of precision technologies. After the initial resistance, Italy started to embrace precision farming techniques, and several research activities are being carried out (Braun & Clarke, 2006). The study indicated that the level of farm computerisation is directly related to the socio-economic characteristics of the farmer. These are the conditions which facilitate the process of adoption. It is also influenced by the level of education and age which are moderating factors. According to the study by Lima et al. (2018), the United Kingdom (UK) was the largest lamb meat producer in Europe at the time when the study was conducted. However, the low profitability of the sheep farming sector suggested that the production efficiency can be improved. The study aimed to assess the uptake of Electronic identification systems (EID) technology and explore drivers and barriers of adoption of related tools among English and Welsh farmers. Electronic identification systems are a key technology for the automation of processes. Their implementation is targeted to improve the quality, economy and/or environmental impact of animal production. A total of 2000 questionnaires were sent, with a response rate of 22%. Among the respondents, 87 had adopted EID tools for recording assembled information, 97 intended to embrace it in the future, and 222 neither had adopted it nor intended to adopt it. Agrawal and Vieira (2013) revealed that IoT is taking root because it enhances the value of life by connecting many smart devices, technologies, and applications.

Xiaojing and Yuanguai (2012) contend that smart agriculture is one of the applications of the IoT, which has a wide application and bright future. The implementation and deployment of IoT also assist ranchers in tracking the whereabouts of their animals by labelling each animal with Radio-Frequency Identification (RFID) or nanotechnology, to prevent theft of animals (Shinde & Prasad 2017). People tend to adopt a technology if they experience its benefits which is sometimes referred to as performance expectancy. The agricultural sector in Brazil has been modernised since the 1960s. Brazil managed effective change from a net distributor of food to a global manufacturer of agricultural goods by 2014. The SF market in Brazil has invested more in farming technologies than in stock farming (Ridker et al. 2017). Tools such as robotic milking for the livestock are used by several European farmers (Rodenburg, 2017).

Conceptual framework

Adopting Infrastructure as a Service (IaaS) is similar to outsourcing services to an external provider. An appropriate reference theory employed in the research guides the research design (Mokwena 2011). There are 67 known theories to explore information technology (IT) outsourcing. A transaction cost theory was opted for this article because of its strength in counting the actual cost of outsourcing production of products or services including transaction costs, contracting costs, coordination costs, and search costs (Williamson, 1981). The inclusion of all costs is considered when making a decision and not just the market prices. Essentially this theory illustrates the make-versus-buy decision for companies.

Transaction Costs Theory (TCT) is regarded as the most influential, powerful, and parsimonious theory for understanding IoT decisions and outcomes, and it is the most often used theory. Transaction Costs Theory was founded by Williamson (1981) and is one of the fundamental theoretical underpinnings that researchers have utilised to simplify the outsourcing choice (Aubert, Rivard & Patry 1996; Bahli & Rivard 2003). Transaction Costs Theory aids in the definition of an organisation's boundaries by considering production and transaction costs. Transaction costs, according to Williamson (1981), are the expenses connected with the exchange of commodities or services, and incurred in overcoming market inefficiencies.

Various research studies have applied qualitative analysis in line with the observed incapability of quantitative analysis to achieve the aim of the study, or if the sampling size is insufficient to carry out appropriate quantitative analysis (Dwivedi et al. 2011). For example, Saravani and Haddow (2011) in studying the technology needs of Australian and New Zealand library staff members used Unified Theory Acceptance and Usage of Technology (UTAUT) in a qualitative study. Rempel and Mellinger (2015) in a qualitative study investigated the bibliographic management tool in academic libraries, utilised UTAUT as conceptual framework. Moreover, Collier et al. (2015) qualitative study on the adoption of virtual desktop infrastructure in the South African banking sector, employed Rogers' Diffusion of Innovation Theory (DIT), deviating from the theory's quantitative convention, therefore offering a novel perspective. Through in-depth interviews and content analysis, the present study delved into the nuanced socio-cultural and organisational elements influencing the adoption process. This qualitative adaptation of DIT underscores its flexibility and applicability beyond quantitative realms. Figure 1 depicts the conceptual model of this study.

Research methods and design

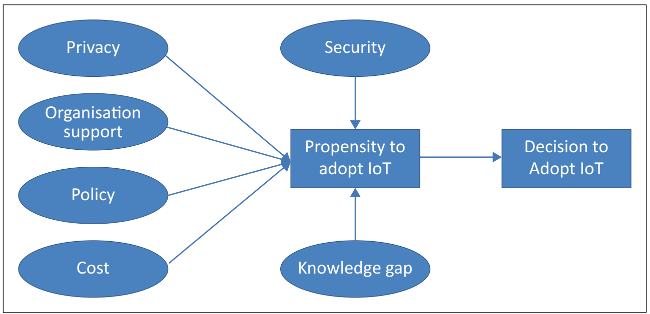
Qualitative approach was adopted for this study. Qualitative research involves collecting data through interviews, observation of events, and personal experiences (Robert 2003). This is a phenomenological study that focussed on the factors which might influence the adoption of IoT in the agricultural sector in the Limpopo province. The study followed purposive sampling method for collection of the data. The process of data collection included interviews with 11 participants (supervisors, extension officers and farmers), document analysis and observations. A total number of 12 questions approved by the University Ethics Committee were used during interviews. The researcher also observed the farmers in their everyday setting to gain some insight into the work. Documents from the department of agriculture were made available for the research.

Data collection

The qualitative techniques best used in measurement can be characterised into three different types: interviews, observation, and documentation.

Data analysis

The focus of this research was to identify the elements that may influence the adoption and use of IoT in the Limpopo agriculture industry. Thematic analysis was chosen as the data analysis method for this study. The use of codes in thematic analysis contributes to the emphasis on transcription



Source: Williamson, O.E., 1981, 'The economics of organization: The transaction cost approach', *American Journal of Sociology* 87(3), 548–577. https://doi.org/10.1086/227496

IoT, internet of things.

FIGURE 1: Conceptual transaction cost theory model.

accuracy. Figure 2 shows examples of data extracts coded multiple times.

Ethical considerations

Participants of the research were given details and intentions of the study and were assured about the confidentiality of their information in the study. Information of the participants was anonymous and not published to the public. All the data collected for the study from the participants were securely saved to ensure the safety of the participants' information. Ethical approval was taken from the Faculty of Information and Communication Technology at Tshwane University of Technology to conduct the study. Data collected for this article is purely for academic purpose; privacy and confidentiality were considered for all the participants according to Tshwane University of Technology ethical policy or guidelines. FCR/ ICT/2019/10/006.

Background of participants

In this study, 11 stakeholders from the agriculture and farming industries were interviewed. The participants were specifically chosen since they worked in the agricultural industry. Extension officers, supervisors, assisted in

Data extracts	Codes
We do not have any monitoring system in place to monitor the farms, we are using manual. IoT technologies will assist in environmental sustainability by using sensors to get through the practice of pesticides and fertilizers. There are legislation policies in place to assist. As the agricultural officials (extension officers and supervisors) have the monitoring tool that we are using smart pens to capture farmers information when visiting the fields. Accessing data through the manual system is a little bit slow or takes longer, need more labour and time-consuming.	• IoT systems consideration. • Support for the monitoring system. • Growing of population consideration. • Support of policies for IoT.
We are not familiar with any IoT technologies. We do not use any technologies to monitor the farms, we rely on a manual system that needs human intervention. Most people who are important to the farmers often hear people talking about Iot in the agricultural sector. Farmers are expected to use IoT technologies such as Facebook, WhatsApp, and Instagram in the agricultural sector regularly. Most farmers discover the importance of using social platforms in the agricultural sector which may increase competitiveness, increase net exports, produce trade as a part of world trade and advance its structure.	• Familiarisation with IoT • Manual operation • The use of the social platform is a concern. • The competitiveness in a market
The technology makes farm to work easier. Easy to retrieve data from the system. We	• Concern on interoperability of IoT.

IoT, internet of things.

FIGURE 2: Data extracts.

TABLE 1: Participants according to their positions.

Participants	Department	Position
PA1	Agriculture	Extension officer (Animal Production)
PA2	Agriculture	Extension officer (Animal Production)
PA3	Agriculture	Extension officer (Animal Production)
PA4	Agriculture	Extension officer (Crop production)
PA5	Agriculture	Extension officer (Crop production)
PA6	Agriculture	Extension officer (Crop production)
PA7	Agriculture	Supervisor
PA8	Agriculture	Supervisor
PF9	Farming	Farmer
PF10	Farming	Farmer
PF11	Farming	Farmer

recruiting the participants. Each interviewee was given a unique code to ensure that their privacy was protected. These codes started from PA1 to PA11 (see Table 1 for details) in order to maintain anonymity of the participants.

According to the information provided in Table 1, all the participants worked in the Limpopo agriculture sector and were therefore entitled to participate in the data collection process. All the participants had more than 2 years of experience in their respective jobs, which reflected the experience they had obtained, which was required for this study.

The researcher was able to understand what is preventing the adoption of IoT in agriculture in Limpopo province through discussions with individuals involved in the agricultural sector. As a result, we were able to triangulate the data.

Process of analysis

Thematic analysis was used to analyse the data gathered in this study. While there is a substantial difference between theory and data-driven analysis (Braun & Clarke 2006), the researchers discovered that when these two methodologies are used together, the value of analysis increases significantly. As a result, all the topics identified during the thematic analysis process were submitted to further interpretation, with the exception of those relating to the adoption of IoT.

According to Braun and Clarke (2006), 'data are not coded in an epistemic vacuum'. This became apparent when the initial interviews were being transcribed and interpreted. During the early stages of analysis, however, the researcher used a more data-driven approach. The researcher was able to tie important themes from the raw data to literature after identifying them. The researcher was also able to contextualise the data after collecting these inductive-based roles, which resulted in the abstraction of themes not found in the literature as well as the interview questions.

The researcher has produced a guiding structure consisting of six steps based on study done by Braun and Clarke (2006).

TABLE 2: Data extracts coded multiple times.

Data extracts	Codes	Line in transcript
We do not have any monitoring system in place to monitor the farms, we are using manual. IoT technologies will assist in environmental sustainability by using sensors to get through the practice of pesticides and fertilisers. There are legislation policies in place to assist. As the agricultural officials (extension officers and supervisors) have the monitoring tool that we are using smart pens to capture farmers information when visiting the fields. Accessing data through the manual system is a little bit slow or takes longer, need more labour and time-consuming.	• IoT systems consideration. • Support for the monitoring system. • Growing of population consideration. • Support of policies for IoT.	1–15
We are not familiar with any IoT technologies. We do not use any technologies to monitor the farms, we rely on a manual system that needs human intervention. Most people who are important to the farmers often hear people talking about IoT in the agricultural sector. Farmers are expected to use IoT technologies such as Facebook, WhatsApp, and Instagram in the agricultural sector regularly. Most farmers discover the importance of using social platforms in the agricultural sector which may increase competitiveness, increase net exports, produce trade as a part of world trade and advance its structure.	• Familiarisation with IoT • Manual operation • The use of the social platform is a concern. • The competitiveness in a market	16–22
The technology makes farm to work easier. Easy to retrieve data from the system. We would recommend IoT technologies to someone else. The cost might have an impact on IoT adoption. Concerns are about internet connections, data security and privacy. The lack of education is another concern. IoT applications and systems are the way to go. The problem IoT is facing is creating full interoperability between connected devices possible. Limpopo department of agriculture currently has IoT initiatives ongoing. Even though in Limpopo province they are still farmers who are resistant to change.	• Concern on interoperability of IoT. • Concerned about the cost. • Lack of education or knowledge. • Concerned about the age of farmers. • Concerned about Internet connectivity, security, and privacy. • Department support is important. • The resistance to change is a concern.	23–29

IoT, internet of things.

Phase one

This phase is a highly significant component of the analysis process since it enabled the researcher to develop and become familiarised with the entire data gathered from the interviews, and finalise initial concepts for codes to define the subject. Transcribing of all the interviews was done, which helped the researcher in this familiarisation process. The researcher got used to the information at this phase and this, in turn, helped in the execution of Phase Two. Since the study is exploratory, recordings included everything that was stated during the interviews.

Phase two

This phase necessitated coding the full data corpus, which resulted in information being contained in a coding system that went beyond the study's basic themes. This approach was taken into consideration when creating the list in phase one. The first coding was more data-based than theory-

TABLE 3: Data extracts classified under the same code.

Data extract	Code	Line in transcript
• The availability of monitoring tools is a major concern. The major concern that has ever been raised was the access of data using the manual system. The worry is that farmers need support from the department. • Yes, the department has a plan to assist farmers in the adoption of IoT technologies, supported by the policies that are in place. • Another concern, farmers are resistant to change.	Department's influence change management	5,14,18–25
• Agriculture is the foundation for every household as it is the key source of bringing food and it is playing a vital part in the development of the economy of the country. By using IoT technologies means transformation from manual driven tools to automation. With IoT, links the devices and collection of information, the object of connecting physical objects via the Internet. • Some policies and regulations support IoT, the security so the sensitivity of the data becomes important. The is security methods to avoid physical attackers and gate crasher from the IoT devices. I believe that hence we are dealing with the sensitive data as it guarantees us that not everyone will be able to access our data that is stored on the cloud. The security issues not only require technical issues but also the appropriate enforcement of policies and guidelines.	Advantages with IoT devices	160–164,200–220

IoT, internet of things.

driven in order to avoid missing any potentially essential information, and to aid in the creation of codes for specific data extracts. Given the methods that make up phase two, data extracts were coded many times. Table 2 shows examples of the aforementioned, where column two contains numerous codes.

Column 1 of Table 2 refers to the data extract, whereas column 2 shows the codes generated from the data.

Some of the codes could also be linked to multiple information extracts. Table 2 shows an example of this form of coding, with three data extracts connected with a single code in the first row (in column two). During phase two, the researcher was careful not to interpret the extracts, but instead built a coding context based on what was said.

Phase three

From the coded data extracts, the researcher discovered candidate themes and any connected sub-themes. Table 3 shows an example of a candidate theme and its sub-themes. This has facilitated further research by identifying not just individuals but also the source of the codes. When employing this type of data, the candidate themes had to be refined, and their corresponding data extracts had to be compiled during phase four. At this point, the goal was not to eliminate any concepts, but to develop as many candidate themes as possible.

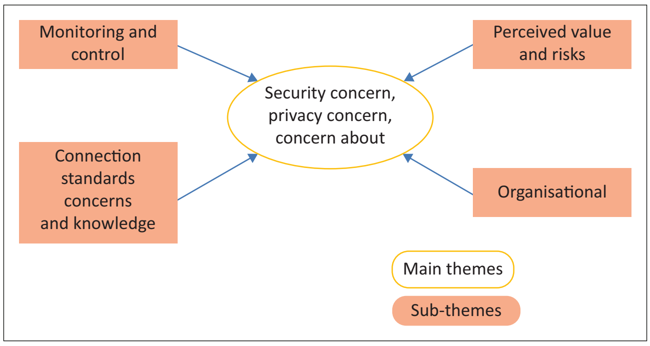


FIGURE 3: Final thematic map.

Phase four

This phase consists of a two-step procedure in which the candidate themes from phase three were polished. All of the extracts connected to the codes must be interpreted to see if they support the theme, if there are any contradictions, and if the themes overlap. The validity of discovered themes was checked by taking meanings as they were depicted by the participants across the entire data set. Some themes were renamed, merged with other prospective themes, and others were deleted as a result of this process. Table 4 shows an extract from one theme, as well as the data extracts gathered under it.

Phase five

After going through the whole interview data corpus, the researcher used the result of step four (refined themes) to create the final thematic map (see Figure 3). These themes were organised to avoid overlap, as suggested by Braun and Clarke (2006). As the primary result of phase five, the researcher was able to develop the final thematic map to analyse the data extracts connected with these topics.

Phase six

According to the researcher's view, the following events occurred when phase six of the analysis process ended, resulting in the formation of a narrative:

- the data extract that corresponds to the identified themes
- the setting in which these data extracts were placed
- operational and monitoring tools for farmers.

Thematic interpretation

Several linked notions emerged through the research of the shown subjects. The researcher decided to construct a new conceptual framework based on this. The new conceptual framework led the interpretation process by using the combinations of new emerged themes and priory themes.

Discussion

The discussion of the results is divided into two parts. Firstly, we discuss the emerged themes, and secondly, priori themes.

TABLE 4: Extract from a candidate theme.

Candidate theme Sub-themes Code	Sub-themes	Code
Knowledge of IoT monitoring tools	• IoT impact • Communication technology • Cost of IoT • Privacy • Policy	• Knowledge on the impact of adopting IoT. • First understanding the IoT system is the ability to make devices communicate remotely and sending of information to the cloud. • Knowledge of the cost impact of adopting IoT. • Knowledge of policy and privacy is the demanding method.

IoT, internet of things.

TABLE 5: Refined theme together with some collated data extracts.

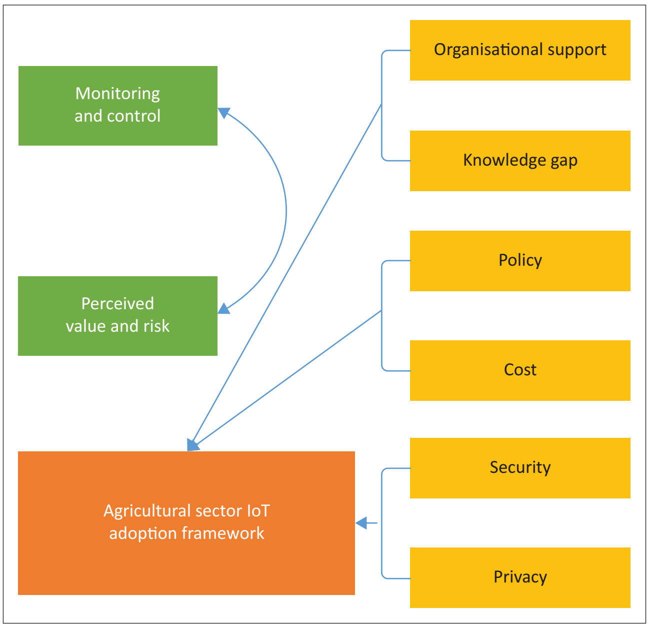
Refined theme	Data extracts
Monitoring and control are essential	• 'There are monitoring system concerns from the farmers as are still using manual driven agricultural systems which results in low productivity'. [P1] • 'Risks associated with change' • 'There is a slow turnaround time with a manual monitoring system that involves human interaction that has an influence in producing fewer data about the environment of the farm and increases labour cost'. [P3] • 'Accessing data through a manual monitoring system is not easy, therefore we need the agriculture department to assist in finding modern tools and technologies to increase effectiveness'. [P6]

Emerged theme 1: Monitoring and control

To understand the readiness of IoT adoption in the agricultural sector, specifically Limpopo province, the first question asked was: 'Do you have any monitoring system in place? Do you think the monitoring/current system has accelerated the turnaround time?' The participants provided numerous opinions founded on their sympathy towards IoT and its possible advantages and potential results. Participants were enquired about the following question for the duration of the interview: 'Do you feel accessing data through your monitoring system is easy? Does technology make farms work harder or easier? If so, in what ways?'

Participant 1 responded, 'We do not have any monitoring system in place, we are using a manually driven system which needs human intervention'. It was further alluded by Participant 5 that the 'Monitoring system is a little bit slow or takes longer, need more labour and time-consuming'. The adoption of IoT in the agricultural sector will enable farmers to accomplish tasks more quickly.

Monitoring and control emerged during the interviews and influenced the adoption of IoT within the agricultural sector in Limpopo. Internet of things-enabled devices that use sensors to monitor product condition, the external environment, and product use in great detail. Findings of this study indicate that because of technological improvements, Internet access is expected to be available anywhere and at any time. Devices may be easily connected, and associated information can be accessed globally thanks to the development of low-cost smart sensor nodes. Table 5 shows some data extracts from the monitoring and control are essential refined theme.



IoT, internet of things.

FIGURE 4: Proposed agricultural sector internet of things adoption framework.

Emerged theme 2: Perceived value and risk

Although the results of this article shows that adoption of IoT in Limpopo agricultural can improve the sector, the sector still fights to locate precisely where IoT will be best positioned for to add value for the sector. Therefore, it is not astounding that farmers have a difficult time accepting how IoT conveys actual importance to their living. Participant 2 states that:

> 'The dispute for IoT adoption is not technological unevenly, it is more around discovering the value of IoT is the sector. I do trust that IoT systems is the way to go for farming but only if farmers have capitals that improve the understanding and improvement.' (Participant 2)

While strongly believing in the potential of IoT, Limpopo agricultural sector struggles to pinpoint exactly where the value of IoT lies for them. Therefore, it is not surprising that farmers also have a hard time understanding how IoT brings real value to their lives. Nearly every participant showed that roughly speaking the challenge for IoT adoption is not technical, anything can be achieved technically, but it is more about finding the value.

The findings from this study show that farmers will differentiate themselves and enhance their competitive advantage based on how well they leverage operant resources, such as predictions of crop output and weather conditions.

Priori theme 1: Organisational support

According to Masseno (2019) IoT adoption in organisations is impacted by a lack of senior management knowledge, commitment, and support, inadequate employee technological skills, and inadequate awareness of security and data privacy concerns. According to the participants, the most important factor is that organisational support is essential for the buy-in of adopting new solutions and making it a success. The study revealed that putting the organisational and institutional infrastructures in place to address the above is difficult because of the required social change, and potential resistance to changes in day-to-day work practices. The impression the researcher captured here was that the participants were aware of how important the role of organisation support is in adopting new technologies as the drivers of decision making.

Priori theme 2: Cost

According to Asplund and Nadjm-Tehrani (2016), the ability to monitor equipment from a distance is seen as the main advantage, since this saves time and money compared to personnel physically travelling to the site. All participants showed that they find it to be beneficial, cost-effective, and useful as a technology of their choice within the farming organisation.

The study found that farmers believe that IoT systems are the way to go. It will eliminate the human interaction that will affect producing more data about the environment of the farm, reduce labour cost, reasonably make use of resources, reduce the production costs, and would improve the environmental background.

Priori theme 3: A knowledge gap

All participants indicated that they are not familiar with any IoT technologies used in farming. As a result, major new technology education and training for farmers are required. In addition, educating farmers about new technology is a critical step in technology introduction.

Priori theme 4: Security

Since agriculture IoT data might be sent across untrusted public networks, security solutions must support delegated authentication. Internet of Things-specific security vulnerabilities can have far-reaching consequences, allowing cyber thieves to seize control of physical objects close to people. An effective access control mechanism can be designed to facilitate privacy preservation in green IoT-based agriculture.

Priori theme 5: Privacy

There are privacy-preserving protocols that use message authentication codes (MAC) to protect data integrity and authentication for IoT applications. The MAC solution is applied to the original IoT data, allowing the sender to verify that the data have not been altered during transmission.

In the study by Sharma, Chen and Sheth (2018), the ubiquity of IoT devices gives rise to significant privacy concerns, including, for example, the challenge of uncontrolled data generation and diffusion, inadequate authentication, preservation of anonymity, and risks about sensitive data.

The findings of the study are that when data is outsourced to the Cloud, privacy issues are heightened as a result of data transit, storage, and processing outside legislative boundaries, as well as a perceived lack of control over data access by third parties.

Priori theme 6: Policy

The policy lays out the evaluation criteria to use when choosing a third-party provider, the contract requirements, and the procedures to undertake to verify compliance with standards, guidelines, and architectures. Participants also stressed that having rules in place that promote the adoption of new technologies makes it easier to begin planning and coordinating the resources needed.

The study revealed that an organisation that wants to create a successful IoT adoption policy must have a clear goal in mind. Most significantly, the examined agriculture sector should keep in mind that, with the right regulations in place, they may achieve a highly advanced and efficient working environment. As a result, the policy should be addressed when the time comes to implement IoT.

Limitations of the study

This research focussed solely on the non-technological barriers to IoT adoption. As a result, the conclusions of this research are limited to the Limpopo agriculture sector, farming industries, excluding technology components such as software and hardware.

These restrictions, however, were not considered to have an impact on the study’s integrity or findings. The researchers anticipate that the study’s findings and recommendations might be applied to other farm sectors in similar situations.

Conclusions

This article reports on established factors that may influence the adoption and use of IoT within the agricultural sector in Limpopo province. The non-pragmatic data gathered from the literature, together with the pragmatic findings, revealed that a variety of factors influence the acceptance and application of IoT in agriculture, as outlined below:

- Monitoring and control influences the adoption and use of IoT within the agricultural sector in Limpopo province.
- Perceived value and risk influence the adoption and use of IoT within the agricultural sector in Limpopo province.
- Organisational support has a positive impact on the adoption and use of IoT within the agricultural sector in Limpopo province.
- Knowledge gap has a positive impact on the adoption and use of IoT within the agricultural sector in Limpopo province.
- Security has a positive impact on the adoption and use of IoT within the agricultural sector in Limpopo province.

- Cost influences the adoption and use of IoT within the agricultural sector in Limpopo province.
- Policy influences the adoption and use of IoT within the agricultural sector in Limpopo province.
- Privacy also influences the adoption and use of IoT within the agricultural sector in Limpopo province.

Regardless of the benefits of the IoT, it is recommended that decision-makers in the Limpopo province's agriculture industry evaluate the variables of UTAUT.

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Competing interests

The authors have declared that no competing interest exists.

Authors' contributions

M.N.M. conceptualised and collected data as part of her Master of Computing at the Tshwane University of Technology, while S.N.M. and M.S. supervised the study and assisted in its conceptualisation.

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Data availability

The data used in this study are available and can be shared when required or necessary upon reasonable request from the corresponding author M.N.M.

Disclaimer

The views and opinions expressed in this article are those of the authors and do not necessarily reflect the official policy or position of any affiliated agency of the authors.

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