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An Empirical Exploration of E-Agriculture System Acceptance, Satisfaction, and Usage

Santosh Kumar Rai, National Institute of Technology, Patna, India
Jyoti Prakash Singh, National Institute of Technology, Patna, India*
https://orcid.org/0000-0002-3742-7484
Kumod Kumar, Chandragupt Institute of Management Patna, Bihar, India
Khalid H. M. Alhamzi, Imam Mohammad Ibn Saud Islamic University, Saudi Arabia

ABSTRACT

The Indian economy relies heavily on agriculture, and an e-agriculture portal is a digital tool for sustainable development. It enables government and farmers to exchange information and share resources with anyone. However, many farmers are unaware of it, negatively impacting production and supply chains. The paper uses the Unified Theory of Acceptance and Use of Technology to analyze the intention to use an e-agriculture portal. The study used empirical methods to assess how citizen satisfaction concerns affect the purpose of using e-agriculture portal. Data were collected from 294 rural area farmers and further analyzed using partial least squares structural equation modelling. The study's main findings are that (1) performance expectancy has the most significant impact, while facilitating conditions have the least impact and experience and habit don't significantly impact on e-agriculture portal usage. (2) using e-agriculture portal positively affects citizen satisfaction, citizen engagement, trust in government, and trust in technology.

KEYWORDS

e-Agriculture Portal, e-Government, Structural Equation Modelling, UTAUT

In today's era of information and communications technology (ICT) (Humayun Kabir & Roy, 2015), the influence of the ICT sector has permeated every facet of human life. Agriculture is a substantial component of the Indian economy, contributing 18.3% of the nation's gross domestic product in 2022–23 and employing more than 60% of the labor force in the agriculture sector (Department of Agriculture & Farmers Welfare, 2023). Seventy percent of its rural populations still make their living mostly from agriculture (Food and Agriculture Organization, 2023). Most farmers live in rural areas, and ICT tools may assist them in establishing an information network to empower them for better farming (Rashid et al., 2016).

E-agriculture portals provide a global community dedicated to promoting sustainable agriculture and rural development through the exchange of information, ideas, and resources (Food and Agriculture

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Organization, 2023). Official agriculture websites offer aids such as information on seeds, tools, expert advice, video tutorials, collaboration platforms, and bank loans for rural farmers (Kashem et al., 2010). E-agriculture is recognized as an evolving field with a primary focus on advancing agricultural and rural development through the improvement of information and communication processes (Barnabas, 2013).

An e-agriculture portal is designed for farmers to obtain information about farm activities, such as the optimal choice of cultivation for the land, together with precise dates for sowing, transplanting, cultivating, and harvesting as well as when to water the plants (Ganesh Kumar et al., 2017). Farming yields may be improved with proper seed, pesticide, and water amounts (Pachayappan et al., 2020). Portals can also help farmers receive fair rates for their products through an e-marketplace, which prevents intermediary distributors from deceiving them (Rashid et al., 2016). E-marketplaces may potentially be able to break the lengthy agricultural product distribution chain (Nugroho et al., 2018). The presence of an electronic marketplace within the realm of the e-agriculture portal offers an appealing alternative for the community to fulfil their food requirements (Nugroho et al., 2018).

India's climate change and seasonal monsoon unpredictability pose challenges for farmers, production processes, and the government in achieving annual food-production targets, but advanced technology and e-agriculture portals can enable smooth farm management (Solomon, 2016). ICTs have brought about substantial transformations in the agricultural landscapes of developed nations (Bournaris et al., 2011). Many farm activities have been connected to databases, e-portals, e-communication, and authorized producers to access government and nongovernment projects, e-markets, and credits for boosting and strengthening the agriculture sector (Tsolakis et al., 2019).

Farmers often live far away from government facilities, which poses challenges in their capacity to access essential facilities. Resistance to incorporating electronic agricultural methods serves as an indicator of underlying socioeconomic challenges, lack of progress, and environmental decline (Jain et al., 2009). Many socioeconomic challenges in the field of agriculture relate to income levels, employment opportunities, access to resources, education and awareness, health and well-being, social capital and community development, and gender inequality. Per the National Survey of India report, 77.7% of Indians were literate in 2022 (NFHS-5 and NSO, 2021 and 2022). Farmers face unexpected rainfall, issues in irrigation, finding markets for their crops, credit related issues, proper access to weather forecasts, infertile land, and inadequate infrastructure. Inadequate infrastructure in farming refers to the insufficient development or maintenance of essential physical and organizational structures, such as transportation, storage, processing, market access, ICT, power supply, and irrigation systems (Muzari et al., 2012). Inadequate infrastructure in agriculture encompasses a range of factors that hinder the overall efficiency, productivity, and competitiveness of farming activities. Addressing these infrastructure challenges is crucial for sustainable agricultural development and for improving the livelihoods of farmers. Electronic government services can address and fulfil these needs (Bournaris et al., 2013). The agricultural sector encounters various challenges attributed to soil degradation, climate variations, and rising costs. In addressing these issues, precision agriculture utilizes wireless sensor networks to optimize the acquisition, communication, and processing of data, serving as fundamental technologies to enhance crop yield (Singh et al., 2021).

Numerous governments have already embraced e-government to deliver agricultural services to their farming populations (Bournaris et al., 2013). Technology in agriculture offers potential benefits such as increased income, poverty alleviation, improved nutrition, reduced food costs, and job creation, with farmer education level influencing adoption (Mwangi & Kariuki, 2015). E-agriculture portal adoption is a technological solution that addresses numerous challenges in the agricultural sector. The Asian Tigers' successful agricultural transformation, driven by the adoption of advanced technologies, illustrates the pivotal role of embracing the e-agriculture portal (Eweoya et al., 2021).

According to the Telecom Regulatory Authority of India (2023), there are 1,034.26 million active wireless subscribers in India. Widespread telecommunications access offers a great opportunity for e-agriculture portal implementation. Mobile phones are valuable for the farming population, the

Ministry of Agriculture uses SMS on mobile phones to inform farmers about locations of quality seedlings and fertilizers, promoting prompt planting and increased agricultural output, leading to a positive impact on the country's gross domestic product. To provide crop-insurance services to economically weak farmers, the Ministry of Agriculture and Farmer Welfare has launched a scheme called Pradhan Mantri Fasal Bima Yojana (2023). To create a one-stop shop for meeting all informational needs relating to agriculture, the government of India has launched a portal known as the Farmers' Portal (2023). Pradhan Mantri Krishi Sinchai Yojana (2023) aims to improve irrigation investment, reduce water wastage, and adopt precision technology. Pradhan Mantri Kisan Maan Dhan Yojana (2023) provides a monthly assured pension of INR 3000 after 60 years of age to farmers, with the spouse receiving 50% of the pension if the farmer dies.

The aim of present study to understand farmers' expectations and requirements for satisfaction with e-agriculture portals in India, as traditional government service delivery systems struggle to reach remote communities and raise awareness of government services. The low literacy rate in rural India results in a limited understanding of schemes and information available on these portals and poses a significant challenge to the successful implementation of e-governance projects. The inability of illiterate individuals to access e-governance applications hampers the overall effectiveness of such initiatives. Additionally, the widespread lack of internet technology (IT) literacy among the population further complicates the situation. Many Indians are not only illiterate but also lack awareness and knowledge of IT (Mittal & Kaur, 2013). To know and understand the government schemes related to farm activities, rural residents also go to the local Common Service Centre (CSC) and get information. To address these challenges, our study aims to understand the expectations of farmers regarding e-agriculture portals and expose which requirements need to be met for farmers' satisfaction with e-agriculture portals. Two research questions guided the study's design and methodology:

RQ1. What is the level of adoption of e-agriculture portal among Indian farmers?
RQ2. What factors affect the adoption of e-agriculture portal and how can it be improved?

Methodologically, we employed the e-governance service adoption and satisfaction framework to delineate the research constructs, considering customer satisfaction with e-government services while accounting for the mediating and moderating elements that influence customer contentment in e-government services (El-Gamal et al., 2021). In this study, we have derived various adoption and satisfaction parameters for farmers. To determine the path coefficient and relative importance between the research constructs, the research model we used was the structural equation modeling (SEM) approach with partial least squares (PLS).

Despite extensive searching on Google/Google Scholar, we found few papers that explore the role of e-agriculture portals in improving service delivery in farming activities, focusing mainly on farmers' satisfaction and awareness.

This study measures user satisfaction with an e-agricultural portal, aiming to boost agricultural production and economic growth. It expands the unified theory of acceptance and use of technology (UTAUT) model, incorporating trust in technology (TIT), trust in government (TIG), price value (PV), habit (HT), citizens' engagement (ENG), and citizens' satisfaction (SAT). The Appendix (Table 7, *E-agriculture Schemes and Their Portals*) shows that several schemes and their portals have been launched by the government.

LITERATURE REVIEW AND RESEARCH FRAMEWORK

Literature Review of E-Agriculture and Related Studies

The government has implemented electronic governance to enhance residents' lives and make government services more flexible and transparent, leveraging advancements in ICT and internet

connectivity and raising citizen expectations for more accessible services. This study focuses on e-services, delivering government farm-activity services through an e-agriculture portal and aiming to modernize agricultural practices through technology advancement (Fernando et al., 2016). The e-agriculture portal uses advanced ICT infrastructure to improve agricultural information exchange among farmers, focusing on rural electronics usage, electronic farmers, and agricultural electronics (Zhang & Zhang, 2010). ICT advancements drive automation in business practices, particularly in agriculture. This includes operations such as soil sampling, variable-level fertilization, field and mapping analysis, fertilization, crop scouting, harvesting, data administration, traceability, and system development (Suprem et al., 2013). The implementation of information technology in agriculture contributes to the sector's success and advancement. The utilization of ICT greatly benefits all stages of farm management, including soil preparation, planting, irrigation, pest management, and harvest (Suprem et al., 2013).

ICT applications consist of expert systems, decision-support systems, sensors, data inventories, and geographic information systems (GIS). According to Suprem et al. (2013), ICT could significantly boost agricultural product sales through e-commerce after harvesting, enhancing the widespread adoption of this technology across various locations. They describe techniques for soil sampling and their technological implementation and utilization of a global positioning system (GPS) and GIS for field and yield mapping; explore advancements in robotic-based harvesters; and outline prospective research in this domain. Additionally, the paper by Suprem et al. delves into food-processing and -packaging technologies, including traceability and the current state of radio frequency identification networking research. It also examines the use of sensor networks, data-management systems, and execution systems. Furthermore, the document addresses automation and control standards, such as fieldbus systems.

Blockchain technology is revolutionizing agricultural systems, particularly in supply-chain management and Intenet of Things (IoT) applications. According to Lin et al. (2020), it enhances food safety, security, quality control, waste reduction, operational data analysis, and efficient contract exchanges, supporting small-scale farmers, and reducing economic costs. Mohamad and Gombe (2023) explore the integration of ICT in agricultural value chains, its outreach and limitations, its diffusion, and its societal impact. The article examines blockchain-related concepts within the realm of ICT-based technology. Additionally, they introduce a model ICT e-agriculture system that integrates blockchain infrastructure, designed for implementation at both local and regional levels. According to Lin et al. (2017), ascertain the technical and social requirements specific to employing blockchain technology in ICT e-agriculture systems, an evaluation tool is put forward. The suggested system and tool offer a means to assess and advance e-agriculture systems effectively. To identify the context-specific technical and social prerequisites of blockchain technology in ICT e-agriculture portals, an evaluation tool was also introduced. The proposed system and tool provide a framework for assessing and implementing advancements in e-agriculture portals (Lin et al., 2017).

An e-agriculture portal monitoring system was designed for farmers in Bangladesh, with a primary focus on advancing both the farmers' progress and the overall development of the country (Rashid et al., 2016). IoT smart farming is a multidisciplinary field that includes computing, automation, artificial intelligence, communication technology, and agricultural knowledge (Huo et al., 2024). The Smart Sustainable Agriculture platform, which uses IoT and machine-learning technologies as its base, with the goal of improving the effectiveness of agricultural sustainable growth governance (Haval & Rahman, 2024).

Literature Review of E-Agriculture in an Indian Context

The Indian government's National Informatics Centre has been putting new technology to use to reduce the technological disparity between rural and urban communities. The adoption of e-governance would only improve the efficiency with which services are provided (Inakefe et al., 2023). The Indian government has integrated ICT in agriculture, providing farm-activity services, and knowledge to

rural farmers through an e-agriculture portal. CSCs are operational in 600,000 villages, offering services such as agriculture, finance, banking, education, health care, transport, insurance, and utility payment (National E-governance Plan, 2023). The e-agriculture portal has the potential to significantly contribute to rural development efforts. Specifically, it can facilitate farmers' entry into novel markets and the adoption of advanced technologies, enhance irrigation infrastructure, and enhance agricultural productivity (Organisation for Economic Co-operation and Development, 2001). Moreover, it can assist farmers in acquiring new skills and identifying fresh avenues for employment (Organisation for Economic Co-operation and Development, 2001).

Digital initiatives in Indian agriculture enhance productivity, reduce costs, reduce chemical dependency, and boost farmers' economic prosperity, making technology integration a crucial factor (Indian Brand Equity Foundation, 2023). Digital tools offer a pathway to reduce dependence on traditional methods, such as fertilizers and pesticides (Gamage et al., 2023) and to address food-security concerns. Technological solutions enable smallholder farmers to access new markets and track crops from seed to sale, providing valuable insights into yields and market potential (Nanehkaran, 2013).

According to statistics available on the Pradhan Mantri Fasal Bima Yojana portal, for the 2023 monsoon season, the number of crop-insurance applications was 48,648,144 for loanee farmers and 25,428,001 for non-loanee farmers (Pradhan Mantri Fasal Bima Yojana, 2023). The Pradhan Mantri Kisan Samman Nidhi Yojana (PM-Kisan) is a crucial scheme in 19 Indian states providing minimum income support of up to Rs 6,000 to small and marginal farmers. According to the statistics available on the PM-Kisan portal, approximately 95,358,300 farmers benefited from this scheme from April to July 2023–24 (Pradhan Mantri Kisan Samman Nidhi Yojana, 2023). Hota and Verma (2022) have identified various challenges from 47 research papers to the adoption of e-agriculture portals in India such as lack of understanding about e-agriculture, poor access to network and internet connectivity, lack of supportive regulations, high capital cost, small land holding, renting and sharing practices, the need for strong data ecosystem, lower digital literacy at the grassroots level, data trust and security, and the complexity of capturing a variety of crops, climate zones, and soil conditions under a digital umbrella.

Addressing these challenges requires a comprehensive approach involving education, infrastructure development, policy interventions, and technology design that caters to the specific needs and conditions of the diverse agricultural landscape in India.

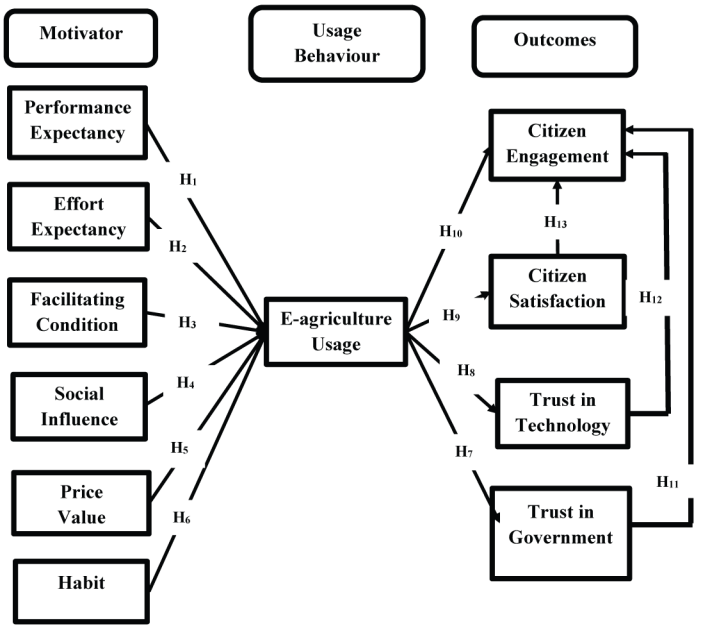
Theoretical Background

Technology adoption is a widely recognized research domain within information systems, focusing on understanding various elements associated with technology features and their context (Dwivedi et al., 2019). UTAUT, a widely accepted theory, explains half of actual technology-usage variations and 70% of intentions, making it a simple and useful explanation for technology usage (Rana et al., 2011, 2012; Venkatesh et al., 2003).

UTAUT is one of the most popular models for analyzing usage, satisfaction, and adoption of e-government and e-agriculture applications (Almaiah & Nasereddin, 2020). Six crucial factors need to be taken into account in this situation: ENG, SAT, PV, HT, TIG, and TIT. These factors were included in the original UTAUT, in which PV and HT are antecedents and ENG, SAT, TIT, and TIG are outcomes of the usage of e-agriculture portals. Incorporating these six components is motivated by several factors. Much of the previous research that builds upon UTAUT (Venkatesh et al., 2003) has focused primarily on evaluating the usage of technology and people's behavioral intentions. The study by Venkatesh et al., (2023) explores the impact of e-agriculture portals on TIT, TIG, ENG, and SAT.

In our research model, there are two groups of factors that influence intention to use. The first group, known as universal predictors, includes factors such as performance expectancy (PE), effort expectancy (EE), facilitating conditions (FC), social influence (SI), PV, and HT. The second group, which is context-specific, consists of TIG, TIT, ENG, and SAT. We also considered one universal predictor for actual usage, which is usage behavior.

Figure 1. Proposed Research Model



RESEARCH MODEL AND DEVELOPMENT OF HYPOTHESES

The e-agriculture portal usage in this research is dependent on the extended UTAUT model. Fig. 1 depicts the research model used in this investigation.

The following subsections will present an overview of the proposed model and an analysis of the model's components or research constructs and will also introduce the hypotheses that have been developed.

Overview of the Proposed Research Model

The proposed research model is based on the extended UTAUT model. The UTAUT model has been widely used for the adoption of e-government applications. It is the most comprehensive theory in the information systems domain for understanding individual technology adoption and use.

In the UTAUT model, four distinct components have a direct impact on both behavioral intention and use behavior. These constructs are PE, EE, FC, and SI. For example, Hooda et al. (2022) discovered that the UTAUT key constructs of PE, EE, SI, and FC have a considerable and favorable influence on users' intentions to use e-government services. However, the UTAUT model has its own limits when it comes to comprehending the adoption of an e-agriculture portal because the model overlooks the portal's unique qualities (Gursoy et al., 2019). Due to the nature of the e-agriculture portal as well as the intended users, it was thus suggested that extra constructs be included as antecedents in the UTAUT core architecture. We incorporated new antecedents such as PV and HT into our research model to the list of antecedents of the use and introduced several moderating effects. When the perceived benefits of utilizing a technology outweigh its monetary cost, resulting in a positive impact on intention (Dodds et al., 1991), we include PV as an antecedent for the behavioral intention to use the e-agriculture portal. HT was proposed and validated by Venkatesh et al. (2012) to address technology adoption from the customer perspective. Consequently, conceptualized HT as a cognitive construct may be directly or indirectly linked to usage of an e-agriculture portal. The empirical research on the impact

of habit on technology use has identified various mechanisms by which habit influences technology use. Kim & Malhotra (2005) discovered a substantial correlation between past technology usage and future technology use, which is relevant to the operationalization of HT as prior use. Moreover, study by Kim and Malhotra (2005) highlighted the implications of studying acceptance, satisfaction, and usage of e-agriculture portals.

Consequently, given that our study tackles e-agriculture portals, four constructs—TIT, TIG, ENG, and SAT—were incorporated in the original UTAUT of Venkatesh et al. (2003) as consequences of the usage of an e-agriculture portal. There are various reasons for incorporating these four constructs. This study further explores the effect of e-agriculture use and the outcomes of such use as measured by TIT, TIG, ENG, and SAT. In the farmer context, increased TIT and TIG improved ENG and SAT. Although the work of Albanna et al. (2022) focused primarily on identifying the antecedents of technology use, it also offered theoretical and empirical support for the validity of expanding the UTAUT to encompass usage outcomes.

We therefore think that the UTAUT is a suitable framework for researching the use of e-agriculture services and the effects of such usage on the general public, drawing on the empirical data and the theoretical perspective covered above. It is also important to note the original UTAUT's simplified model, which looks directly at the relationships between constructs (Dwivedi et al., 2020).

Hypotheses Development

As shown in Fig. 1, a total of 13 hypotheses are proposed based on relationships between constructs.

PE

PE is the degree to which a user believes that using a specific technology would increase their ability to execute their job (Venkatesh et al., 2003). Individuals evaluate the utility of a service by considering its expected benefits (Dhagarra et al., 2020). The strong predictive factor in determining farmers' intentions to use e-agriculture portals lies in their perception of the services as beneficial and useful (Bournaris et al., 2011). PE has been demonstrated to be crucial in the realm of electronic-government adoption, particularly within the context of agriculture (Eweoya et al., 2021). If citizens think an application would help them in their daily lives, they are more likely to adopt e-governance (Hanafizadeh et al., 2014). We believe that the utilization of innovative technologies in e-agriculture portals will offer farmers distinct benefits, leading to a notable enhancement in their performance and production. This leads to the following hypothesis:

H_1. PE positively influences the use of e-agriculture portals.

EE

EE is the ease and user-friendliness of a system, and citizens' attitudes toward e-government portals are positively correlated with their intention to continue using them (Yap et al., 2019). Governments have developed e-agriculture portals, such as Farmers' Portal and mKisan Portal, that offer comprehensive information and services for farmers, demonstrating that ease of use and convenience significantly affect citizens' adoption of these services (Web and App Services for Farmers, 2016). As a result, we put forth the following hypothesis:

H_2. EE positively influences the use of e-agriculture portals.

FC

FC connect to the way in which users understand that appropriate organizational assets and infrastructure are available to ease the utilization of an explicit technology (Venkatesh et al., 2003).

FC also encompasses citizens' confidence in the dependability of services within the context of the existing public network infrastructure (Saif Almuraqab & Jasimuddin, 2017). The importance of FC in promoting the adoption of e-government services highlights the need for appropriate ICT infrastructure and low-cost connectivity (Sabani, 2021). E-agriculture portals require innovative technologies, infrastructure, advanced telecommunications, internet access, digital literacy, and technical support. Accessible FC ensure reliable and efficient government resources for farmers. We therefore propose the following hypothesis:

H_3. FC positively influences the use of e-agriculture portals.

SI

SI is the extent to which a user believes that significant others believe they ought to use a technology or system (Venkatesh et al., 2003; Venkatesh et al., 2012). Hence, the adoption of the SI approach has a clear and beneficial influence on users (consumers) in enhancing their behavioural intentions when engaging with e-agriculture portal initiatives. Kulviwat et al. (2007) state that SIs and intent to adopt an invention like e-agriculture tend to be more effective and significant if the innovation is consumed in public. We therefore propose the following hypothesis:

H_4. SI positively influences the use of e-agriculture portals.

PV/Cost

PV or cost can be defined as the trade-off made by consumers, considering the perceived benefits they gain from using a particular system and the financial cost associated with its usage (Bandinelli et al., 2023). The study of Venkatesh et al., (2012) extended the UTAUT model by including PV within the realm of consumer context (Venkatesh et al., 2012). The concept of PV in e-agriculture highlights how consumers' perceived value of a technology significantly influences their intention to adopt and use it (Bandinelli et al., 2023). When the advantages of using a technology are perceived to outweigh the monetary costs, it is inferred that this positive PV has a favorable impact on the intention to use and vice versa. We therefore propose the following hypothesis:

H_5. PV/cost positively influences the use of e-agriculture portals.

HT

HT is known as the degree to which people tend to carry out actions automatically as a result of learning (Limayem et al., 2007). While the concept of HT is often understood in similar ways, it has been defined and understood from two distinct viewpoints. The first perspective sees HT as a result of previous behavior, while the second perspective regards it as the degree to which an individual perceives the behavior as automatic (Venkatesh et al., 2003). HTs play a crucial role in consumers' response to e-agriculture portals, positively influencing their behavioral intentions after being triggered (Tamilmani et al., 2019). We therefore propose the following hypothesis:

H_6. HT positively influences the use of e-agriculture portals.

TIG

TIG is known as the measure of a person's faith in the Government system and the caliber of public services provided (Teo et al., 2008). The quality of a person's previous interactions with the government significantly influences trust and, consequently, plays a crucial role in their willingness to embrace

technology (Ho & Chung, 2020). The role of TIG is applicable only in cases when the government is defined as an actor in the adoption process. The government provides for and encourages e-agriculture portals, so public confidence in the government can be quite important (Van Bavel et al., 2020). Akinbi et al. (2021) found that one of the main factors influencing the desire to utilize an e-agriculture portal is ultimately a lack of trust in the government. Consequently, we propose the following hypothesis:

H_7. TIG positively influences use of e-agriculture portals.

TIT

TIT is the level of confidence that users have in the potential for favorable results when utilizing technological tools and solutions (McKnight et al., 2011). TIT plays a crucial role in determining whether individuals will embrace and use new web-based applications (Lee et al., 2011). Trust is influenced by an individual's past interactions with the government concerning technology, and these interactions are pivotal in determining the level of technology adoption (Ho & Chung, 2020; Lee et al., 2011). To resolve privacy apprehensions regarding e-government services, it is imperative for citizens to have TIG (Venkatesh et al., 2003). An individual's behavior when using new technology is greatly influenced by their level of TIT (Venkatesh et al., 2012). We therefore propose the following hypothesis:

H_8. TIT positively influences the use of e-agriculture portals.

SAT

SAT can be defined as the extent to which users feel that a system fulfils their information needs (Ives et al., 1983). Satisfaction is often described as an emotion tied to a specific experience. It is a psychological state that arises from comparing one's expectations to their actual experiences, which is commonly referred to as confirmation (Bhattacherjee, 2001). Typically, SAT is assessed after using or consuming a technology, system, product, or service. Porumbescu (2016) found that the utilization of social media platforms by citizens within the public sector is strongly associated with higher levels of satisfaction and trust in the government. As a result, we believe that SAT is a suitable aspect to explore in this research, as it represents one of the potential results of using an e-agriculture portal (Porumbescu, 2016). We therefore propose the following hypothesis:

H_9. SAT positively influences the use of e-agriculture portals.

ENG

ENG, also known as involvement, entails the increased chances for individuals to actively contribute to policymaking and give the government access to all of the citizens' understanding and expertise (Algharabat & Rana, 2021). Algharabat & Rana (2021) highlighted the importance of ENG in e-agriculture portals, arguing that their presence encourages participation in policymaking and public/private partnerships, thereby enhancing government satisfaction and public trust. We therefore propose the following hypothesis:

H_{10}. ENG positively influences the use of e-agriculture portals.

TIT and ENG

Public agencies are enhancing the accessibility and usability of government data by utilizing technological advancements such as social media, digital-device applications, artificial intelligence

(AI) and machine learning–based applications, and IoT-powered applications (Ismagilova et al., 2019). Citizens' growing TIT is driving innovation. This trust allows companies to pursue invention without worrying about public confidence. As citizens integrate with technology, they have faith in a safe, secure, reliable digital environment, driving further innovations. We therefore propose the following hypothesis:

H_{11}. TIT positively influences ENG.

TIG and ENG

Citizens' TIT is influenced by their prior interactions and relationships with the government (Akinbi et al., 2021). However, previous research has not empirically examined how TIG affects privacy concerns associated with e-agriculture portals. Our study explores the contextual significance in the context of the adoption of TIG applications. We therefore propose the following hypothesis:

H_{12}. TIG positively influences ENG.

SAT and ENG

Previous research has indicated that SAT plays a crucial role in significantly increasing ENG (Shihab et al., 2021). Effective ENG in government is based on positive public interaction with digital services. Citizens' positive experiences using e-government technologies foster involvement and prevent isolation from the governance system. This engagement enhances citizens' overall involvement and connection with the government. SAT with digital government services can potentially boost ENG and decrease the likelihood of future disengagement. In light of the above information, we propose the following hypothesis:

H_{13}. SAT positively influences ENG.

METHODOLOGY

Sample and Procedures

To examine the connection between the theories offered in the research model depicted in Fig. 1, manual questionnaires were created to gather information from people living in rural areas. Particularly, this data has been collected from rural residents who have benefited from the national-level agriculture-based schemes like PM-Fasal Bima Yojana, PM-Kisan Yojana, and many more. The 10 constructs in the theoretical model were measured in this study using a variety of multivariate analysis approaches involving 26 items. The following guidelines exist: 10 responses are provided for every item, and a minimum sample size of 260 has been employed (Hair et al., 2010). This manual-based questionnaire was distributed to mukhiyas (village leaders), Panchayat Samiti (block council) members, ward members, and residents of multiple villages to collect data from rural residents. Consequently, 323 questionnaires were gathered in total. After the questionnaires were verified and screened, it was discovered that 29 of them had missing information, making them incomplete. These surveys were disregarded and did not feature in the data analysis. As a result, 294 questionnaires were appropriate and legitimate for the analysis of the data.

Instrument Development

The questionnaire consisted of two sections: collecting demographic data (see Table 1) and gathering opinions on technology and service features relevant to e-agriculture portals. A comprehensive literature study was conducted to develop questions for evaluating each research construct, using

Table 1. Demographic Information of Respondents

Gender	Male	179	61%
	Female	115	39%
Age	18–27	38	13%
	28–37	189	64%
	38–47	41	14%
	48–57	17	6%
	>58	9	3%
Education	Below matriculation	49	17%
	Matriculation	197	67%
	Higher secondary school	39	13%
	Graduate	9	3%
Income status	Below poverty line	243	83%
	Lower middle class	33	11%
	Upper middle class	18	6%
Usage level of e-agriculture portals	Sometimes use	186	63%
	Frequently use	73	25%
	Always use	35	12%
Experience with e-agriculture portals	<1	179	61%
	1–3	83	28%
	>3	32	11%

Note. *N*=294.

accepted research as a guide (see the Appendix, Table 8, *Measurement Scale*). Farmers' experiences on e-agriculture portals were measured using a five-point Likert scale: strongly aware, aware, no point of view, unaware, and strongly unaware. Table 2 illustrates the distribution of responses regarding the level of awareness concerning e-agriculture portals.

The analysis of Table 2 reveals that 83 respondents (28.23%) expressed a strong awareness of the benefits associated with e-agriculture portals for farmers. Additionally, 96 respondents (32.65%) indicated being aware of the advantages provided by e-agriculture portals. A notable portion of the respondents, 39 (13.27%), did not hold a specific viewpoint on e-agriculture portals, while 41 (13.95%) admitted being unaware about these services. Furthermore, 35 respondents (11.9%) expressed a strong unawareness regarding e-agriculture portals. In summary, the majority of respondents exhibited awareness of e-agriculture portals,.

DATA AND RESULTS ANALYSIS

Analytical methods encompassed the utilization of both IBM SPSS (Statistical Package for Social Science) and SEM employing PLS. Two stages of methodology were used in this research. We tested the discriminant and convergent validity of the constructs in the initial phase, which involved testing a measurement model. In the second phase, the investigators looked at the structural model, testing the hypotheses (path analysis) that were put forth for the study model.

Table 2. Awareness Level

Particulars	Number of Respondents	Percentage
Strongly aware	83	28.23
Aware	96	32.65
No point of view	39	13.27
Unaware	41	13.95
Strongly unaware	35	11.90

Measurement Model

The measurement instrument's reliability and validity were assessed using content, reliability, and convergent validity criteria. Content validity was ensured through previous literature validation and the subject-matter expert's assessment of the initial survey draft. The study used Cronbach's alpha test (Cronbach, 1949) to ensure scale reliability, with all constructs having adequate internal consistency. A Cronbach's α value of ≥0.70 for each research model construct is generally regarded as acceptable for scale reliability (Hair et al., 2019). Every construct in the suggested model, as shown in Table 3, has acceptable internal consistency, with Cronbach's α values ranging from 0.703 (TIG) to 0.783 (HT).

The convergent validity was evaluated using average variance extracted (AVE) and composite reliability (CR) (Hair et al., 2019). It is advised that CR and AVE values for each construct be greater than 0.70 and 0.50, respectively, in order to demonstrate convergent validity. All of the constructs in the suggested model had CR and AVE values in our investigation that were higher than these suggested cutoffs (see Table 3). Furthermore, all item measurements' standardized factor loadings on their corresponding theoretical constructs were discovered to be above 0.710, indicating significance (Hair et al., 2019), with the exception of SAT3, SI1, EE3, and PE1. Factor loading was measured for the final model assessment after the items for PE1, EE3, SI1, SI2, and SAT3 were deleted due to their weakest loading. Therefore, this study satisfactorily demonstrated the measurement instrument's content validity, reliability, and convergent validity.

Using the Fornell-Larcker test, discriminant validity was evaluated in the study. A test achieves discriminant validity when the correlation between any construct and every other construct in the model is lower than the square root of the AVE for that specific construct(Fornell & Larcker, 1981). The data presented in Table 4 indicates that all inter-construct correlations are below the square root of the AVE for their respective constructs, providing confirmation of the discriminant validity of the measurement instrument.

Structural Model

The relationships between the study model's constructs were examined in the structural model. PLS and a bootstrapping technique using 5,000 resamples were both used to accomplish this. The PLS-SEM analysis results, which are displayed in Fig. 2 and Table 5, show how to estimate the structural model and evaluate the study's hypotheses.

According to the findings, most determinant constructs (PE, EE, FC, SI, PV, and HT) have significant and direct influence on e-agriculture usage (EAU). It was noted, nevertheless, that there is no statistically significant correlation between HT and EAU. PE has the highest effect ($\beta = 0.238$, $p \leq 0.001$) among all the significant EAU antecedents, while FC has the lowest effect ($\beta = 0.103$, $p \leq 0.01$). Furthermore, the results indicate that EAU has a direct and significant impact on every outcome variable, suggesting that it is a primary predictor for all of them. SAT is the area where EAU has the largest effect, with a beta coefficient of 0.643 ($p \leq 0.001$). In contrast, its influence on TIT is relatively weaker, with a beta coefficient of 0.277 ($p \leq 0.001$). According to the results of the study

Table 3. Construct Reliability and Convergent Validity

Construct	Item	Factor Loading	α	CR	AVE
PE	PE1	Deleted	0.710	0.777	0.636
	PE2	0.821			
	PE3	0.773			
FC	FC1	0.899	0.755	0.854	0.746
	FC2	0.827			
EE	EE1	0.827	0.722	0.827	0.706
	EE2	0.853			
	EE3	Deleted			
TIG	TIG1	0.883	0.703	0.845	0.732
	TIG2	0.827			
TIT	TIT1	0.868	0.739	0.868	0.767
	TIT2	0.884			
SI	SI1	Deleted	0.743	0.756	0.504
	SI2	Deleted			
	SI3	0.71			
PV	PV1	0.846	0.716	0.836	0.718
	PV2	0.849			
HT	HT1	0.833	0.783	0.831	0.711
	HT2	0.853			
SAT	SAT1	0.841	0.729	0.817	0.691
	SAT2	0.821			
	SAT3	Deleted			
ENG	ENG1	0.831	0.763	0.881	0.711
	ENG2	0.852			
	ENG3	0.846			

on ENG, the most important factor is SAT ($\beta = 0.417$, $p \leq 0.001$), followed by TIG ($\beta = 0.379$, $p \leq 0.001$) and TIT ($\beta = 0.271$, $p \leq 0.001$).

As seen in Table 6 and Fig. 2, the first target of this study construct, EAU, has a high R^2 value of 63.8%. Except for HT, the determinant variables (PE, EE, FC, SI, and PV) collectively contribute to explaining 63.8% of the variance in EAU. Furthermore, EAU is responsible for 41.6% of SAT, 33.2% of TIG, and 23.1% of TIT. Together, EAU, SAT, TIT, and TIG contribute to 51.2% of ENG. The predictive relevance measure Q^2 is well above 0, demonstrating the structural model's adequate predictive relevance.

DISCUSSION

The study expanded the UTAUT model by incorporating factors such as PV, HT, TIT, TIG, SAT, and ENG. The model explained 63.8% of e-agriculture portal usage variance, proving its effectiveness in

Table 4. Discriminant Validity

	PE	EE	FC	TIG	TIT	SI	PV	HT	SAT	ENG
PE	**0.800**									
EE	0.432	**0.840**								
FC	0.513	0.658	**0.860**							
TIG	0.315	0.712	0.589	**0.860**						
TIT	0.619	0.582	0.658	0.552	**0.880**					
SI	0.581	0.429	0.752	0.651	0.756	**0.810**				
PV	0.658	0.332	0.459	0.698	0.745	0.621	**0.850**			
HT	0.456	0.651	0.374	0.485	0.652	0.589	0.512	**0.840**		
SAT	0.358	0.358	0.685	0.653	0.545	0.425	0.587	0.655	**0.830**	
ENG	0.356	0.275	0.562	0.458	0.427	0.653	0.653	0.582	0.562	**0.840**

Note. The diagonal elements in bold represent the square roots of the AVE values for the constructs. The nondiagonal elements indicate the latent variable correlations.

Figure 2. Results of Structural Model

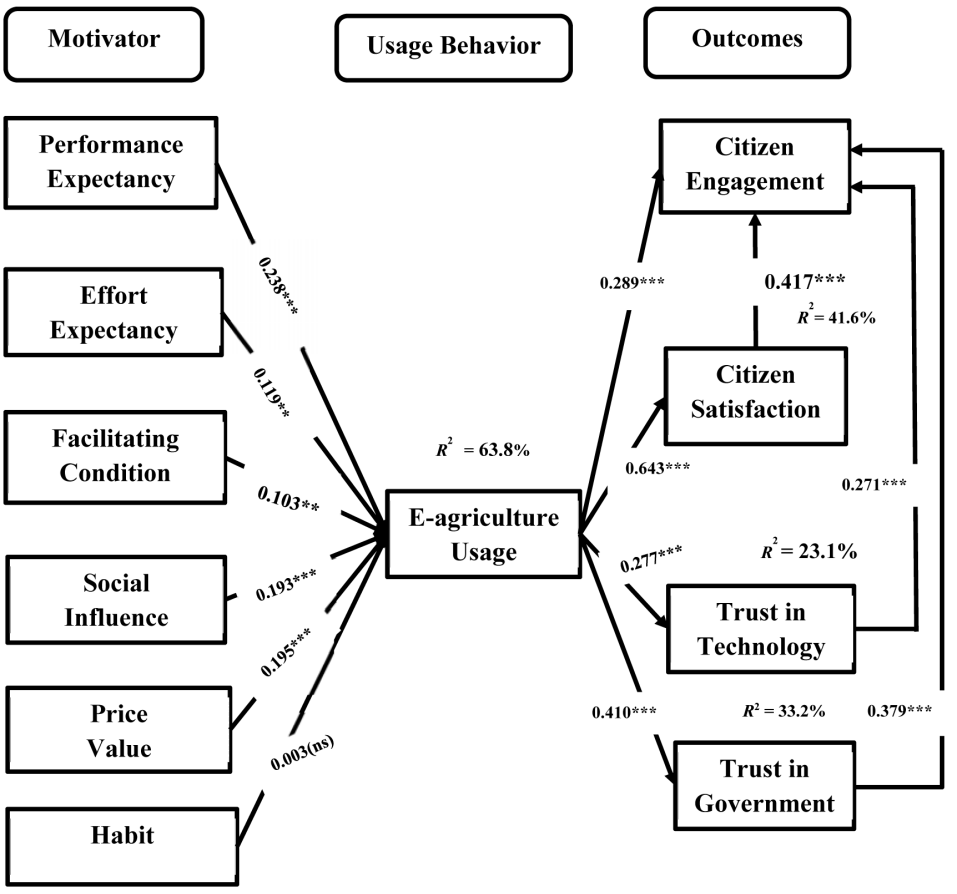


Table 5. An Overview of Hypotheses Testing

Hypothesis	Path	β	*T* Statistics	*p*-value
H_1	PE → EAU	0.238	4.105***	0.000
H_2	EE → EAU	0.119	2.612**	0.005
H_3	FC → EAU	0.103	2.491**	0.009
H_4	SI → EAU	0.193	3.123***	0.001
H_5	PV → EAU	0.195	3.191***	0.001
H_6	HT → EAU	0.003	0.091(ns)	0.501
H_7	EAU → TIG	0.410	5.159***	0.001
H_8	EAU → TIT	0.277	3.895***	0.001
H_9	EAU → SAT	0.643	8.983***	0.000
H_{10}	EAU → ENG	0.289	4.420***	0.001
H_{11}	SAT → ENG	0.417	5.108***	0.000
H_{12}	TIG → ENG	0.379	4.97***	0.000
H_{13}	TIT → ENG	0.271	3.59***	0.000

Note. *$p \leq 0.05$, **$p \leq 0.01$, ***$p \leq 0.001$, (ns) nonsignificant.

Table 6. Assessing Predictive Relevance

Construct	R^2	Q^2
SAT	0.416	0.321
ENG	0.512	0.431
TIG	0.332	0.201
TIT	0.231	0.129
EAU	0.638	0.513

explaining citizen adoption. However, the HT impact was not statistically significant. The extended model maintains UTAUT's predictive validity.

The study suggests that PE positively influences e-agriculture portal usage, as the public's usage increases when they understand the advantages of these services, aligning with previous studies on e-government and ICT adoption (Baishya & Samalia, 2020). The study also emphasizes the significant role of PE in predicting the adoption of various technologies.

As hypothesized in the present study, EE was found to have a positive effect on the use of e-agriculture portals. This implies that e-agriculture portals that are easy to use, simple to comprehend, adaptable, and user-friendly have higher usage rates (Baishya & Samalia, 2020; Sharma et al., 2020).

According to the study, FC have a big impact on how often citizens use e-agriculture portals. This hypothesis is supported by prior research in ICT adoption and e-government studies (Saif Almuraqab et al., 2021), which find that more resources, information, and support improve users' decision-making.

Consistent with earlier research showing SI's importance in e-government and ICT adoption, the study concluded that SI is the third strongest antecedent of EAU (Queiroz & Fosso Wamba, 2019). Indian citizens rely on colleagues' opinions for e-agriculture portals, with SI positively influencing blockchain adoption, despite differing outcomes in developed nations.

Our findings also show that PV is the mental trade-off that consumers make between the perceived benefits of using a system and the fiscal costs associated with its usage (Bandinelli et al., 2023). It is particularly important in e-agriculture portals, as it influences consumers' behavioral intention to adopt a particular technology. If the advantages balance the associated costs, the PV positively impacts the intention to use the technology. Conversely, if the costs balance the benefits, the PV negatively influences the intention to use the technology (Bandinelli et al., 2023).

The study suggests no empirical evidence linking HT to e-agriculture portal usage, contradicting previous literature on ICT and e-government adoption, and suggests that tailored services may not increase usage rates among farmers (Liu & Tao, 2022).

The present study, through both theoretical and empirical analysis, has indicated the substantial positive impact of utilizing e-agriculture approaches on ENG, SAT, TIT, and TIG. Notably, the research findings highlight that SAT serves as a crucial predictor of ENG. Additionally, the study discovered that TIT and TIG positively affect ENG. As a result, this research offers empirical evidence supporting the direct relationship between ENG, SAT, EAU, TIT, and TIG. Collectively, these four factors contribute to explaining 51.2% of the variance in ENG.

IMPLICATIONS

Implications for Theory

The theoretical implications of the current study are twofold. First, the e-agriculture portal is a recent topic discussed in the literature. The present research extends the notion of e-agriculture to include the utilization of emerging technologies. Despite advancements in e-government, crucial questions regarding its impact on transforming state–citizen relationships remain unanswered, particularly in terms of the adoption, diffusion, and utilization of these innovative technologies (Saif Almuraqab et al., 2021; Liu & Kim, 2018). Given the limited research on e-agriculture portal adoption, the present study bridges this gap in the literature.

Second, the present study provides a review of relevant literature in the area of e-agriculture systems, contributing to the existing literature in this area (Alryalat et al., 2017; Dwivedi et al., 2017; Hughes et al., 2022). This research uses an extended UTAUT model to investigate e-agriculture portal adoption, focusing on SAT, TIT, TIG, and ENG. It broadens the theoretical framework of UTAUT by encompassing outcomes associated with e-agriculture portal use. The empirical assessment demonstrates the model's validity and effectiveness, offering valuable theoretical groundwork for understanding e-agriculture portal usage and ICT adoption. This research examines the diverse impacts stemming from the utilization of an e-agriculture portal, namely TIT, TIG, SAT, and ENG. In essence, a significant contribution of this study lies in broadening and advancing the theoretical framework of the UTAUT model. This expansion involves the incorporation of pertinent factors that precede and follow the adoption of an e-agriculture portal. The empirical assessment demonstrates the soundness and effectiveness of the expanded model, incorporating novel relationships within the context of e-agriculture portals. The authors assert that this research establishes crucial theoretical underpinnings, particularly concerning the implications of utilizing e-agriculture initiatives. They contend that this contribution enhances the field of ICT adoption by expanding upon the UTAUT and advancing the comprehension of e-agriculture portal utilization, especially in developing nations.

Implications for Practice

In order to increase the acceptance of e-agriculture portals, this research has highlighted useful implications and recommendations for important stakeholders, including governmental organizations, legislators, technology companies, and application developers.

The study emphasizes the importance of SI in promoting e-agriculture portal acceptance. It suggests that government organizations should engage early adopters through various communication

channels, including print, television, radio, and social media, to foster positive word-of-mouth and retain users.

Furthermore, the positive and notable influence of FC on the utilization of e-agriculture portals underscores the necessity for public agencies to consistently enhance their organizational and technological capabilities. This enhancement is crucial in ensuring citizens can seamlessly utilize these services.

Governments must play a crucial role in educating the public about public services, stressing the virtues and advantages of e-agriculture portals. Public organizations that provide various avenues for obtaining information and services from the government should recognize the critical role that e-agriculture portals play in simplifying duties. Thus, continual enhancement of features and functionalities should be given top priority in the design and development of an e-agriculture portal. Additionally, government systems should consider user opinions and recommendations for improved efficiency. Strategies include seminars, training sessions, and advertising campaigns to encourage e-agriculture adoption and to adapt to changing demands. The research suggests that government organizations should focus on creating user-friendly e-agriculture portals that require minimal effort from delivery teams. This can be achieved through online training, search functions, and usability improvements based on user input.

LIMITATIONS AND FUTURE WORK

Our study observed only the main variables that were identified in the UTAUT model, as well as PV and HT as antecedents of e-agriculture portal usage. Future research should explore additional factors in IT adoption and e-government literature, such as risk, privacy, self-efficacy, culture, social-media awareness, and personal innovativeness, to gain a more comprehensive understanding of these dynamics influencing IT adoption and e-government initiatives (Kizgin et al., 2020). IT adoption and e-government in India have some limitations that need to be addressed. The study was conducted in a manner that limited its validity and generalizability. It was also a cross-sectional study (Alalwan et al., 2020; Goel et al., 2022), measuring e-agriculture portal usage in terms of frequency. In order to identify changes in consumption behavior over time, future studies should consider utilizing a longitudinal research methodology (Rana and Dwivedi, 2016). The study did not identify a direct effect of HT on e-agriculture portal usage, suggesting that future research should investigate whether HT indirectly influences usage through performance and effort expectations. Future research should also assess the influence of moderating variables in the proposed model (Chatterjee et al., 2022). The study used a relatively small sample to validate the proposed model. Future research could use a larger sample (Chatterjee et al., 2024; Rana et al., 2019).

CONCLUSION

In recent years, the concept of the e-agriculture portal has gained increasing attention from both governments and farmers, marking it as the upcoming revolution in the agriculture domain. Governments worldwide are actively implementing e-agriculture portal initiatives, leading to advantages such as enhanced SAT and increased ENG, TIT, and TIG. The widespread adoption of e-agriculture portals underscores their critical role. This study focuses on understanding not only the factors influencing the use of e-agriculture portals, but also exploring their outcomes. The study employs the UTAUT model, investigating four key factors (PE, EE, SI, and FC) and newly introduced constructs (TIT, TIG, PV, HT, SAT, and ENG) as important determinants of e-agriculture portal usage. Additionally, the research delves into the consequences of utilizing e-agriculture portals, specifically examining their impact on TIT, TIG, SAT, and ENG. The results of the study highlight that the identified factors within the UTAUT model, along with the convenience factor, play a crucial role in influencing the adoption of e-agriculture portals. Furthermore, the research establishes a positive

relationship between the use of e-agriculture portals and users' beliefs regarding TIT, TIG, SAT, and ENG. Furthermore, the findings from this study suggest that SAT, the use of e-agriculture portals, TIG, and TIT contribute to predicting ENG.

CONFLICTS OF INTEREST

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

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CORRESPONDING AUTHOR

Correspondence should be addressed to Dr. Jyoti Prakash Singh; jps@nitp.ac.in

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APPENDIX

Table 7. E-Agriculture Schemes and Their Portal

Name of Scheme/ Portal	Purpose	Web Portal
Interest Subsidy for Short Term Credit to Farmers Scheme	• According to this scheme, farmers receive short-term credit at 7% with an upper limit of Rs 3.00 lakh on the principal amount.	https://www.nabard.org/content1.aspx?id=602&catid=23&mid=530
Pradhan Mantri Fasal Bima Yojana	• The Crop Insurance portal digitizes notifications of areas, crops, and schemes, providing easy access to information for stakeholders, enabling remote and economically weak farmers to benefit from crop-insurance services.	https://pmfby.gov.in/aboutUs
Farmers' Portal	• A platform for farmers to sign up and register themselves. • Farmers' Portal is an effort to develop a one-stop shop for satisfying all informational needs connected to agriculture.	https://farmer.gov.in/
Pradhan Mantri Kisan Samman Nidhi Yojana	• A Central Sector scheme with 100% funding from the government of India. • Under the scheme, an income support of INR 6000 per year in three equal installments will be provided to all land-holding farmer families.	https://pmkisan.gov.in/
Pradhan Mantri Krishi Sinchai Yojana	• Aims to improve irrigation investments, expand cultivable areas, reduce water wastage, adopt precision irrigation technologies, recharge aquifers, and introduce sustainable practices.	https://pmksy.gov.in/
Pradhan Mantri Annadata Aay Sanrakshan Abhiyan	• Aims to offer a comprehensive, accurate, and reliable one-stop source of information about India, linking to other government portals for the most updated information, providing a single-window access.	https://www.india.gov.in/about-portal

Table 8. Measurement Scale

Construct	Item	Survey Questions	Source
PE	PE1	I find e-agriculture portals useful for getting government services and information related to farm activities.	Venkatesh et al., 2003
	PE2	My access to government services and information about farm activities is improved when I use e-agriculture portals.	
	PE3	I can obtain government services and information about farm-related matters more easily when I use e-agriculture portals.	
FC	FC1	I possess the required resources to access and utilize e-agriculture portals.	Venkatesh et al., 2003
	FC2	I possess the requisite knowledge to utilize e-agriculture portals.	
	FC3	I can seek assistance from others when facing issues with utilizing e-agriculture portals.	
EE	EE1	Learning how to use e-agriculture portals is easy for me.	Venkatesh et al., 2003
	EE2	My interaction with e-agriculture portals is clear and understandable.	
	EE3	I find e-agriculture portals easy to use.	
TIG	TIG1	I believe that the government acts in the best interests of its citizens.	Ho & Chung, 2020
	TIG2	I am comfortable engaging with the government because it typically carries out its responsibilities effectively.	
TIT	TIT1	My usual strategy is to have faith in emerging technologies unless they demonstrate that they're not worthy of trust.	McKnight et al., 2011
	TIT2	I typically have confidence in technology unless it provides me with a cause to lose trust in it.	
SI	SI1	People who are important to me think I should use e-agriculture portals.	Venkatesh et al., 2003
	SI2	The individuals shaping my choices believe that I should make use of e-agriculture portals.	
PV	PV1	The cost associated with finding and establishing contact with underprivileged rural residents to work on our challenges is high.	Bandinelli et al., 2023
	PV2	Attracting a sufficient number of underprivileged rural residents for our challenges represents a significant cost.	
HT	HT1	I'm interested in utilizing e-crop care government services to fulfil my government-related farm-activity needs.	Limayem et al., 2007
	HT2	I regularly utilize e-agriculture portals.	
SAT	SAT1	I am satisfied with the value provided by e-agriculture portals in terms of the information they offer.	Verdegem & Verleye, 2009
	SAT2	I am satisfied with the expenses associated with obtaining entry to e-agriculture portals.	
	SAT3	I am satisfied with the transaction security provided by e-agriculture portals.	
ENG	ENG1	E-agriculture portals offer information and communication technology tools that facilitate efficient participation in the decision-making process between the government and the people.	Falco & Kleinhans, 2018
	ENG2	E-agriculture portals offer citizens tools to participate in evaluating the government's performance.	
EAU	EAU1	I'm interested in leveraging e-agriculture portals to fulfil my governmental request.	Venkatesh et al., 2003
	EAU2	I often utilize e-agriculture portals.	