



E-Governance in Agriculture: A Framework on Digital Technology Adaptation by Smallholder Farmers

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ABSTRACT

Digital farming is a modern paradigm for food production that utilizes modern technology to enhance various benefits for farmers through e-agriculture and provide higher crop yields than those achievable with traditional methods. Agriculture has been a dominant industry since the beginning, and its relevance is more crucial than ever. Population growth requires producing quality food, which may be available through new technology-based solutions. Considering food production a social expectation, managing the problems goes beyond the individual interests of farmers; governmental actions are required in the industry. The focus of the study is limited to the digital technology adaptability of smallholder farmers in the agricultural industry in Bangladesh; however, the results are generalizable. It is assumed that adapting digital technologies can be triggered through e-governance among smallholder farmers. By emphasizing the benefits of adopting this technology and illustrating how it can be best utilized, the productivity of agriculture can be improved among them. Understanding the differences compared to large-scale farming, the maturity of farms, and promoting development actions require a comprehensive framework. The study aims to present the justification of the initial framework elements. There are secondary data sources used for finding critical factors. A comprehensive response must incorporate education, government policies, and capacity building.

CCS CONCEPTS

• Information systems applications; • Technologies; • Arts and humanities;

KEYWORDS

Agriculture, Evaluation framework, Technology adoption, Smallholder farmers

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1 INTRODUCTION

The contribution of agriculture is fundamental for the economy in less developed countries; it is significant in accompanying inclusive economic growth and development. Moreover, it is the sole source of livelihood for several families, and these countries are remarkable suppliers of the global food system. At the same time, the potential of small farms lags behind that of large-scale farms. There are several challenges since smallholder farmers have insufficient access to modern technology and financial resources, and the risks of unfavorable weather conditions can be managed less effectively. Modern technologies can deliver several opportunities for smallholder farmers to overcome serious challenges. For example, it can help them improve productivity, access new markets, and reduce costs.

Smallholder agriculture means cultivating land primarily by farmers who own less than five hectares (12 acres) of land [1]. It is an important sector in any country, but especially in developing countries, because it contributes to food security and poverty alleviation. However, many smallholder farmers lack the infrastructure and technical resources to improve yields and adopt modern production practices and marketing strategies. Thus, there is a need for technologies that can help smallholder farmers gain the necessary tools and resources to improve their productivity and resilience to risk. Agronomy information management (AIM) [2] is a technology comprising a suite of computer-enabled tools used to harvest, store, and analyze crop data. AIM can help smallholder farmers in several ways. Among others, it can provide them with supplemental information on crops and management practices, help them optimize their use of inputs, and help them manage their finances better. Some technologies can help smallholder farmers, including but not limited to biotechnology, Reduced Input Intensification, or Community-Based Agricultural Development. Technology-based interventions such as these can play a critical role in adapting smallholder farmers and helping them improve their farming productivity and resilience to risk.

The scope of the study covers Bangladesh, which has been an agrarian country since its beginning. However, the transformation of economic structures and reforms in governance reshaped other sectors as well [3] [4] [5]. The contribution of agriculture in Bangladesh has been prime. Since the liberation, its share has been reduced due to the fast expansion of other sub-sectors and the development of service sectors that contribute significantly to today's economy.

E-governance offers excellent opportunities for developing countries to set themselves on a fast growth trajectory. The benefits and opportunities of such governance are essential for them to cope with the pre-existing crisis and the contemporary challenges that

pressure the government to adapt to it. The significant contribution of digitalization in governance creates ample opportunities for both the government and the governed to connect for further collaboration and cooperation. In addition, government policy has given agriculture ample importance due to the demand for food for the millions of people in the country. To minimize the policy gap between the administration and citizens, the government has adopted several policies, including information and communication technology, to involve people in the governing system. To this end, the agricultural sector of Bangladesh has implemented several policies through e-governance to provide digital services for farmers to improve agricultural productivity and meet food security in the 21st century. There are international efforts to develop the knowledge base. It is important that organizations like the World Bank also promote developing and implementing modern farming technology. They believe it can help smallholder farmers improve their livelihoods and contribute to food security worldwide [6] [7].

The study aims to contribute to a better understanding of the adaptability of smallholder farmers to digital technologies in e-governance in the agricultural sector of Bangladesh. The findings of the study may inform and be helpful for policy-makers, agriculture extension service providers, and related other stakeholders in modernizing strategies to improve the scale of adaptability of smallholder farmers to digital technology to expedite e-governance in the agricultural sector of Bangladesh.

2 RESEARCH OBJECTIVES

E-governance in agriculture denotes the utilization of modern information and communication technology to advance agriculture services that allow farmers to access related information. Smallholder farmers typically face numerous challenges in Bangladesh's agricultural sector related to markets, credit information, and extension services. In this context, technologies, i.e., mobile phones, ICT, and internet service, can support to minimize the gap and deliver the necessary support to access relevant information to improve agriculture production and the livelihoods of farmers.

The main objective of the study is to scrutinize the adaptability of smallholder farmers to digital technologies in e-governance in agriculture. A research question can be formulated regarding what factors may be acknowledged in a comprehensive framework to characterize the acceptance of digital farming technologies. The specific objectives of this study are as follows:

- To support the identification of the degree of digital technology adoption by smallholder farmers in agriculture.
- To explore the triggering factors that encourage smallholder farmers to adopt digital technologies for e-governance in agriculture.
- To speculate on the impact of e-governance and digital technology adoption on smallholder farmers' productivity and income.
- To assess the efficacy of e-governance in agriculture adaption for improving access to related information for smallholder farmers.

3 RESEARCH METHODOLOGY

Building a detailed model goes beyond the limits of this study. Linking technology development opportunities, e-governance, and farmer-level acceptance requires managing a complex system. Adapting digital technology to agriculture production requires specific conditions that all stakeholders must fulfill. The scope is to draw up a framework model that allows empirical research in the future. The analysis uses secondary data sources for this purpose. Secondary sources comprise academic journals, reports, books, conference proceedings, and other relevant sources of information.

According to the research objectives about technology adoption, the diffusion and technology acceptance models, supplemented with behavioral change models, may be applicable to the agriculture industry. Triggering factors are assumed to be derived from these models. Measuring the efficacy of e-governance must be based on national and local statistical analysis. The framework model must provide the option to define indicators for performance evaluation.

4 THEORETICAL AND CONCEPTUAL FRAMEWORK FOR THE TECHNOLOGY ADAPTATION OF SMALLHOLDER FARMERS

Building confidence in using digital technologies in line with the social norms of a community requires a thorough and systematic approach to research and strategy formulation. The theoretical framework of this study was based on several complementary models:

- Diffusion of Innovation Theory (DoI),
- Technology Acceptance Model (TAM),
- Resource-Based Theory,
- Behavioral Change Theory.

The diffusion of innovation theory denotes that adaptation is a process influenced by several factors in individuals or groups over time in any social system [8]. It describes the spread of innovations in social systems by recognizing the relative advantages of technology use, the harmony of prevailing practices, complications, and observability. Smallholder farmers' adaptation to new technologies depends on the extent to which they align with their current practices. The theory is applicable to describe the tendencies in technology use over time. Besides, targeted models must be considered the theoretical base for several projects and agricultural diffusion innovations [9].

Understanding the unique intentions to use technology requires other models. The technology acceptance model [9] is extensively used to understand the acceptance and adaption of technology. It includes factors such as the ease of using the technology and its observed efficacy that influence the adaptation of technology. In the case of smallholder farmers, the adaptation can show explosive growth if they perceive that it could bring several benefits, such as high yield, market access and information, and cost efficiency for overall production [10].

Of course, the intention to use technology is necessary but insufficient to succeed. The resource-based theory suggests that the availability and accessibility of resources influence the adaptability of digital technology [11]. The investigation also must consider the changes in the approach to technology regardless of its source,

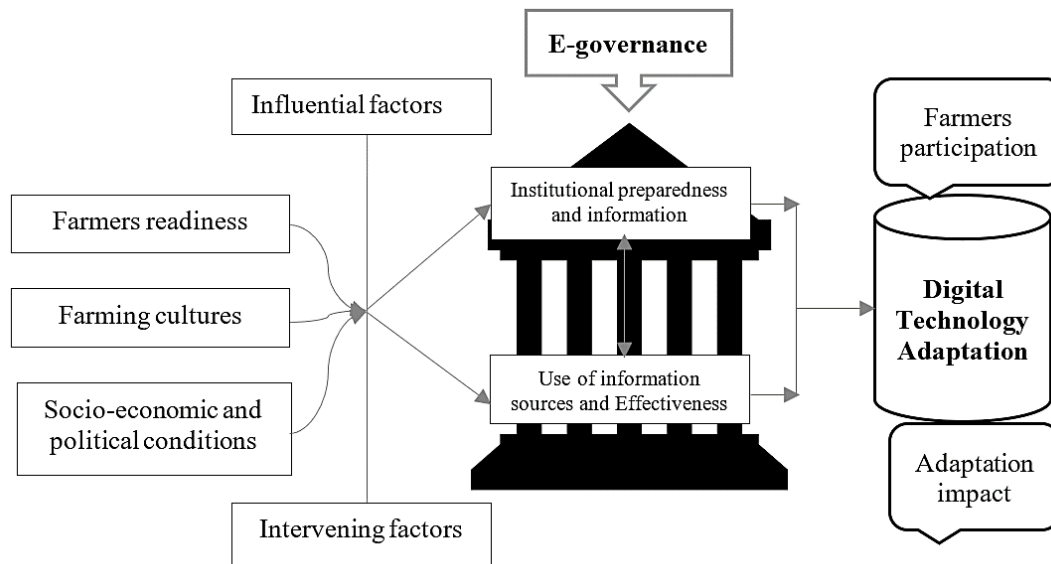


Figure 1: Conceptual framework (own elaboration)

individual opinions, or environmental pressure. The behavioral change theory advocates new behavioral practices, i.e., motivation, self-efficacy, and social norms are induced to adopt a new practice [12].

The conceptual framework for the adaptation of new e-governance-related technologies among farmers includes understanding the actual situation of farmers and the related aspects which play a significant role in determining the effectiveness of an intervention in the agricultural sector of Bangladesh.

Based on the literature review regarding the technology adaptation of smallholder farmers, a conceptual framework was established to examine the possibility of technology adaptation by smallholder farmers (Figure 1). The framework model was designed to explain the relationship between the e-governance system of Bangladesh and the farmers’ readiness to adopt technology in agricultural activities to strengthen the overall agricultural governance through e-governance in general and to increase productivity to reduce the transaction cost between the government and farmers for improved productivity. The conceptual framework for technology adaptation of smallholders typically considers the multiple factors that influence the farmers’ willingness to use digital technology in the farming culture. Adapting such technology is an isolated process and takes place individually under the influence of various factors. The studies on farmers’ willingness to adopt modern technology by individual researchers and agriculture-related organizations specify that farmers’ adaptability to modern technology occurred under the guidance of different institutional, interventional factors linked with each other and functioning in an intertwined mode.

5 FINDINGS

5.1 Farmers’ preparedness for technology adaptation

The results of investigations about technology adaptation by smallholder farmers are complex case studies since the solutions rely on multiple aspects of the technology and the governing system according to the innovative services offered to the farmers, especially the replicability of the outcomes.

In recent times, it has become decisive for the success of the intervention of modern technology in agricultural activities and has transformed the manner of farming from planting, harvesting, pest management, and irrigation to marketing. Although adopting the technologies that can boost production, it requires the willingness and adaptation capabilities of the farmers. The studies on technology adaptation denote that farmers typically consider adaptation as a distinct state with dualistic response variables or without them, while the suitability of the adaptation approach depends on the particular context [13]. Literature also highlights that the decision of smallholder farmers are always related to their education, awareness, socioeconomic status, and other institutional aspects to equip them to choose the available technology [14]. In addition, training, workshops, and extension services can educate smallholder farmers about the potential benefits of the technologies they are adapting.

Nonetheless, access to resources (including land, capital, and inputs) is significant to developing the viability of the farmers getting the prospective benefits from their investment. As a result, government policies can also expedite the overall adaptation process through subsidies and tax incentives. Sociocultural factors are also responsible for new technology adaptation, as if it can threaten conventional farming.

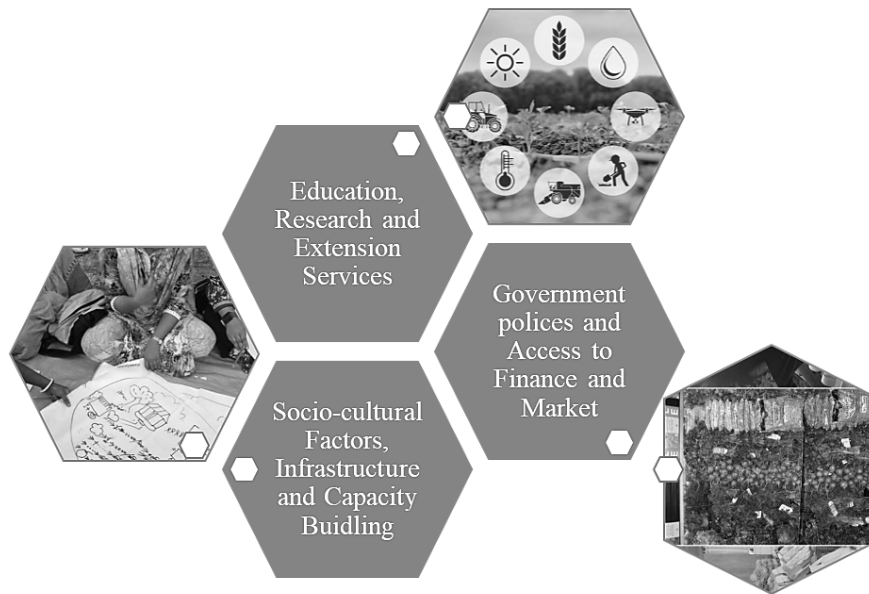


Figure 2: Factors responsible for technology adaptation (based on [16] [17] [18])

5.2 Critical factors for technology adaptation by smallholder farmers

The success of technology adaptation among smallholder farmers depends on several factors. The improvement of appropriate technologies tailored to the particular needs of the farmers is critical; this demands research and development efforts that concentrate on developing new technologies that are affordable, accessible, and easy to use.

Besides, education and improving awareness according to the benefits of modern technology among farmers can ensure and promote the effective use of such technologies for their potential benefits and future sustainability of agricultural production. This is necessary as smallholder farmers in less developed countries traditionally practice conventional farming and hesitate to adopt new technology. Studies found that inadequate knowledge on e-agriculture along with limited number of digital service centers and facilities, lower internet bandwidth, and lack of awareness of the benefits of e-agriculture are responsible for adaptation of e-agriculture in Bangladesh [15]. As gender, age, and social status may significantly influence adaptation, education and awareness building must put pressure on farmers to adopt new technologies in their farming practices. As a result, the overall process demands governmental intervention to promote and organize such programs to build capacity through the extension services that can be expedited by e-governance in the agricultural sector. It also informs and aware the farmers of the available infrastructure that facilitates the adaption process and directs the way for financial resources to manage the technology, which is also crucial from a developing country's perspective. These factors combinedly help the farmers decide whether a technology should be adopted (Figure 2).

5.3 E-governance: institutional preparedness and information sources

E-governance is a challenging process to implement, while effective strategies are crucial to implementing and achieving success, especially in the context of developing countries [19]. Agriculture has passed critical times in developing countries due to their pre-existing and ancient agricultural practices.

E-governance is an evolving process by nature, and a conventional strategic framework is inappropriate to address the altering context of e-governance [20]. The intervention of e-governance in agriculture can accelerate the overall activities of this sector and reenergize the stakeholders, including farmers, service providers, the government, and consumers. It has become unavoidable today to leave farmers behind when we are approaching sustainable development [21]. Information and communication technology are used for improved and smart service delivery to establish a closer connection with the government. In highly developed countries, it has created more service-oriented and transparent improvements in the quality of life. However, a 'digital divide' also exists in developing countries, leading to backlogs in getting benefits from modern information and communication technologies. Studies found that the success of e-governance in agriculture mostly depends on continuous funding, physical infrastructure, development of human resources, and compatibility of the prescribed programs that suit reality. It is also proven by the research on ICT intervention in agriculture that digital tools can enable farmers to develop their managing capacity to decide when and how to do farming with what technology. It can also provide some negative entropy to the e-government system to correct and develop more effective services

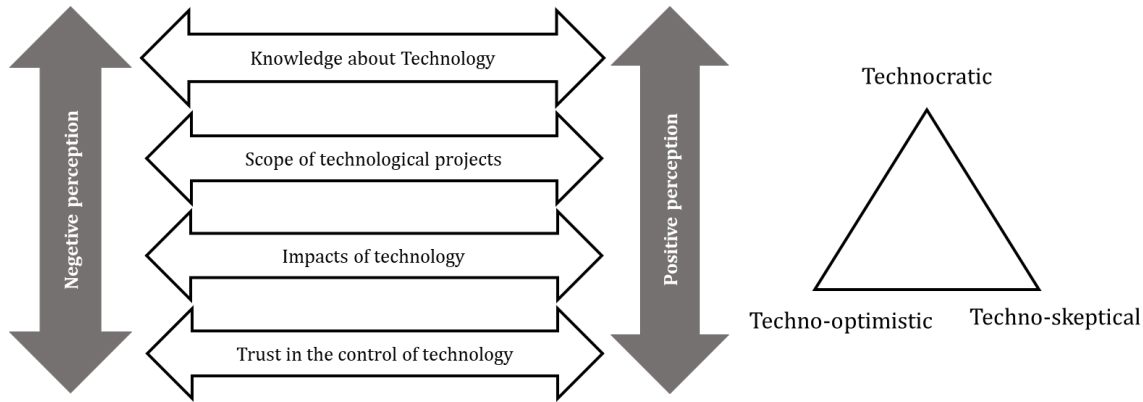


Figure 3: A framework for understanding adaptation technology perception (based on [25])

[22]. Studies found that the management of continuity and the alteration of the forces are more effective for better implementation of e-governance in developing country perspectives.

5.4 Farmers’ perceptions of technology adaptation

Beyond the knowledge about adaptation, farmers’ perceptions of the new technology must be shaped. Humans usually adapt by learning, interpreting their sensory impressions to provide meaning to society, and behaving accordingly.

The effect of climate change nowadays has an impact on the perceptions of smallholder farmers, primarily connected with the sociocultural and institutional settings and observed correlation between climate factors and effects on farming practices [23]. Besides, there are limited studies on perceptions of technology adaptations which is why it becomes more complicated as it is contingent on societal factors like other technical ones [24]. To address and minimize the gap, an interdisciplinary fusion of established beliefs and values about technology that are feasible to cope with changing situations. The shared dimensions of perceptions (Figure 3) on technology adaptation are usually knowledge, scope, and impact of such technology and belief in control of that technology. These factors are essential to developing and configuring the social readiness to adopt the technology, which is likely to be observed negatively or positively. However, scholars suggested bridging the gap between opposing epistemological cultures that support various panaches of knowledge production about the perception of technology adaptation.

It is also observed that technology that serves the interest of the elite class and control by them can get a negative response from others that serve mass interest and control by collective groups or society [26] [27].

6 CONCLUSIONS

Digital technologies for the agriculture industry are available, and their positive impact on productivity and administration is unambiguous. The bottleneck of enjoying the benefits nationally or globally is the extension of the system to smallholders. A national extension is a serious issue in less developed countries like Bangladesh.

Forcing E-governance in agriculture can solve several issues for smallholder farmers timely and cost-effectively. It will support the farmers to increase their financial status and agricultural production to ensure future food security and economic sustainability.

Beyond the financial background and access to logistics systems and equipment, a great challenge is the acceptance of the new solutions by the stakeholders through building trust in them. To achieve this, an appropriate policy formulation and implementation with the public-private partnership and participation of a broad range of farmers are needed to ensure applicability. Studies also found that implementing projects that provide e-agriculture services through e-governance in the agricultural sector influences the empowerment process of farmers that directly contributes to promoting the technology adaptation process in the agricultural sector. Scholars suggested formulating policies and programs that empower the farmers and increase their awareness to adopt new technology by developing their skills and knowledge about those modern artifacts that smooth their farming activities. Digital divides are a strong barrier to smallholder farmers that left them behind from modern technology and lingering in the technology adaptation of e-governance solutions in developing countries.

It can be concluded that the adaptation of e-agriculture in Bangladesh can bring significant improvements in the agriculture sector. Nevertheless, farmers have gained access to vital agricultural information, market data, and expert advice through integrating information and communication technologies. That has led to enhanced productivity, reduced post-harvest losses, and improved resource management. The proposed framework can yield benefits in e-agriculture to foster entrepreneurship, innovation, and market relations, and it can also have benefits to farmers by strengthening their resilience. Challenges, like limited connectivity and digital literacy, must be addressed to ensure equitable access. Besides, continued investment and a supportive environment are crucial for the sustained success of e-agriculture in Bangladesh.

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