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Article

Digital economy and agricultural development: An analysis on BIMSTEC countries

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Abstract: This research explores the role of digital economy in driving agricultural development in the BIMSTEC region, which includes Thailand, Myanmar, Sri Lanka, Nepal, India, Bangladesh and Bhutan (with Bhutan excluded due to data limitations) with a particular focus on mobile technologies, computing capacity and internet connectivity which were the most readily available data points for BIMSTEC. Using a combination of document analysis, and panel data analysis with the data covering 10 years (2012–2021), the study examines the interplay of key digital technologies with agricultural growth while controlling for factors including water usage, fertilizer consumption, and land temperature and agricultural land area. The analysis incorporates additional variables such as infrastructure development, credit to agriculture, investment in agricultural research, and education level. The findings reveal a strong positive correlation between mobile technology, Internet and computing capacity in BIMSTEC. This study underscores that digital tools are pivotal in enhancing agricultural productivity, yet their impact is significantly combined with investment in infrastructure and education. This study suggests that digital solutions, when strategically integrated with broader socio-economic factors can effectively challenges in developing countries, particularly in rural and underserved regions. This research contributes to the growing body of literature on digital economy in agriculture, highlighting how digital technologies can foster agricultural productivity in developing countries.

Keywords: digital economy; agricultural development; BIMSTEC; mobile technologies; computing capacity; internet capacity; infrastructure; credit; agricultural research; education

1. Introduction

Agricultural development is crucial today to address extreme poverty and meet the needs of projected population of 10 billion by 2050 (World bank, 2023). Agricultural development is the key to address these challenges especially in developing countries where approximately 2.5 billion depend on it (Mottaleb, 2018). Digital technologies in agriculture provide farmers with better over growing crops making the process more predictable and efficient. The 'digital agriculture' is trendy today in developing countries with the early stages of implementation. Adopting digital agriculture in developing economies are important due to the emerging impacts on digitalization. The necessity of digital agriculture is critical due to limited capacity of these countries. Studies on the digital economy and agricultural development are substantial and multidimensional. Digital economy in agriculture is needed to address the issues in climate change and food security. Natural disasters such as droughts, floods, storms, crop pests and diseases are common in developing countries (Sagarik and Chansukree, 2018). Economic, environmental, social as well as climate change are interrelated (Amaro, 2018). Thus, modern technologies are critical for the secure of food production and to produce more food to meet future demand.

BIMSTEC or Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation initiated in 1997 including seven countries as Thailand, Myanmar, India, Sri Lanka, Bangladesh, Bhutan, and Nepal. Agriculture is the largest source of employment in BIMSTEC (IFPRI, 2020). Climate change impact is a serious issue for BISTEC countries due to the geo-location. The Bay of Bengal is often impacted with extreme events such as droughts, floods, and cyclones, and this impacts a significant damage in agricultural productivity (Chaturvedi, 2019). Digital economy is crucial today for the transformation of agriculture into modernization (Shan et al., 2022). Even though many sectors have considered the improvement of efficiency and production using the digital economy, still less attention is paid to the agricultural sector regarding innovation, even though it is a major source of income for the majority in developing countries. In BIMSTEC, South Asian countries are more exposed to climate change issues due to geolocation (Kahtun, 2019). Thus, digital economy in agriculture is more needed for these countries and this study fills those gaps in the research area. In addition to that, research publications related to agriculture in BIMSTEC are very limited (Janodia et al., 2021). Therefore, research in this area encourages innovation for tech-solution agriculture and provides more incentives for other researchers for future research.As the data were analyzed for different years, this study provides data-driven insight for a deep understanding for future investments and the strategies of the countries. Further, understanding the connection between the digital economy in agriculture in BIMSTEC provides a broad understanding for policymakers.

2. Theoretical background

The transition of agriculture emerged throughout the history and modernization theory discussed the development revolution of all societies lead the transformation of traditional agricultural into modern processes (Bradshaw, 1987; Chirot and Hall, 1982). Modernization emerged with several historical developments and the origin of modernization goes back to the time of Max Weber, who mainly discussed the transition of traditional society into a modern one (Mayhew, 1985). Rostow's (1960) "The Stages of Economic Growth" outlined a five-stage model as the traditional society stage, preconditions for takeoff stage, take off, drive to maturity, and the age of high mass consumption, which significantly emphasize industrialization, and the role of technology and investment (Barber, 2001).

The conventional agricultural policy model dominated both developed and developing countries. The nature of investment, management decisions, and institutional design were decided by this model (Song, 1998). Rolling (1996) identified that the model is based on three supportive theoretical perspectives:Cochrane's agricultural treadmill, diffusion of innovations, and the linear model of technology transfer. The agricultural trade mill defines that farmers have been trapped in the process when there are technological advances, which leads to productivity gains and increased supply, reducing prices and new technology achievements. This implies that, if farmers need to remain, they need to implement new technologies. The diffusion of innovation theory which was introduced by Rogers explains how an idea, or a product, spreads among the population or a social system. It conveys the process of new ideas, services, and products which result in value creation and economic growth (Rogers, 1983). Technology transfer comprises different assumptions such as "the best is the most modern, there is a simple frontier of world scientific knowledge, agricultural technology has global transferability irrespective for ecological conditions and, farmers in poor country are traditional and they should undergo in transformation process to become the modern farmers" (Ellis, 1992; Majumder, 2002).

Hayami and Ruttan (1971) found the induced innovation model which agrees technical change as endogenous for the development process rather than the exogenous factor, which independently operates in, and the kind of development process. This model indicates that the technological innovations that occur reduce the changes in relative factor scarcities, which revealed the relative prices of the factors. Mellor (1966) suggested, traditional agriculture moves into the second phase as "technology dynamics agriculture-low capital technology". Once the agriculture moves into this from traditional agriculture, it can provide resources for the growth of the non-farm sector. Different steps were identified in technologically dynamic agriculture as institutional changes, encouragement of research, supply of new and improved physical inputs, development of a communication system and spread of education.

3. Literature review

Previous evidence shows that many scholars argue the favorable factors in digital economy for agricultural development. Broad applications which are used in digital economy is a new driving force for the agricultural high-quality development (Shin and Choi, 2015). According to the Kimenyi and Moyo (2011), adoption in new technologies offer significant opportunities in service sector development such as agriculture, education, health etc. According to Niu (2021), modern information technology further develops the agricultural production, industries, and consumption which is connected by Internet technology. Technology adoption in agriculture increases the agricultural productivity (Bruinsma, 2017). Digital economy plays a significant role in a country with digital applications in agricultural sector (Hopestone, 2013). Digital economy enables farmers to connect different stakeholders, consumers, credit facilitators, research institutions, manufacturers, and policy makers. As the ICT applications enable fast and efficient information among sellers and buyers, it impacts to reduce the communication costs and market operations efficiently. Halewood and Surya (2012) studied that using ICT to access the price information of the commodities have increased the income of farmers and traders by 36% in developing countries. Further, ICT has contributed alternative networks such as community supported agriculture providing innovative system to the agricultural sector (Barbosa et al., 2022; Berti and Mulligan, 2015). In a market where there is monopoly power on the part of traders, consumer welfare can be implemented increasing information access (Aker and Mbiti, 2010). Credit constraints deter farmers for making new investments and borrowing finance for their farming activities (Adjognon et al., 2017). Fountas et al. (2020) argue that the new applications quickly transformed traditional agriculture into a data intensive industry. Fuglie (1996) studied the US agricultural development system and summarized that investment in agricultural research has provided a huge economic benefit. Lio and Liu (2006) found that a higher education level is fundamental for ICT related agricultural productivity. Human capacity development through education is a key element for technological innovation. The study of Hopestone (2013) reveals that social economic elements such as higher education skills are important for agricultural transformation while Mittal et al. (2010) highlighted that education is important for the successful inputs of digital agriculture. In this line, it is essential to seek whether digital economy favorably impact for the agricultural development in developing economies such as BIMSTEC.

Concerning the above supporting reference, the hypothesis were selected as in **Table 1**:

Table 1. Research hypotheses' supporting reference.

Research hypothesis	Statement
H_1	Mobile technologies have a positive impact on agricultural development.
H_2	The computing capacity of the country has a positive impact on agricultural development.
H_3	Internet capacity has a positive impact on agricultural development.
H_4	Infrastructure development has a positive impact on agricultural development.
H_5	Credit to agriculture has a positive impact on agricultural development.
H_6	Investment in agricultural research has a positive impact on agricultural development.
H_7	Education level has a positive impact on agricultural development.

Source: Author's compilations.

Control variables

Different factors are involved in agricultural development and the control variables were selected for the avoidance of inaccurate regression results. Farmers use fertilizers in their agricultural activities. After 1960, due to the high demand for food, fertilizers played a huge role in agricultural productivity (FAO, 2016). Zhang et al. (2023) suggested that science and technology in agriculture helps to reduce the use of fertilizer. Water is a critical input in agricultural production and agriculture is considered as the 'most water-intensive sector' (Ingrao et al., 2023; World bank, 2022). The total agricultural land of each country was selected as a control variable considering the findings that agricultural areas support for the food security and improve agricultural production (Viana et al., 2022). Temperature limits crop productivity and the temperature instability caused for favorable conditions for insect pests (Olesen et al., 2011; Schmidhuber, 2007).

The below framework as in **Figure 1** was identified considering all the facts in literature review.

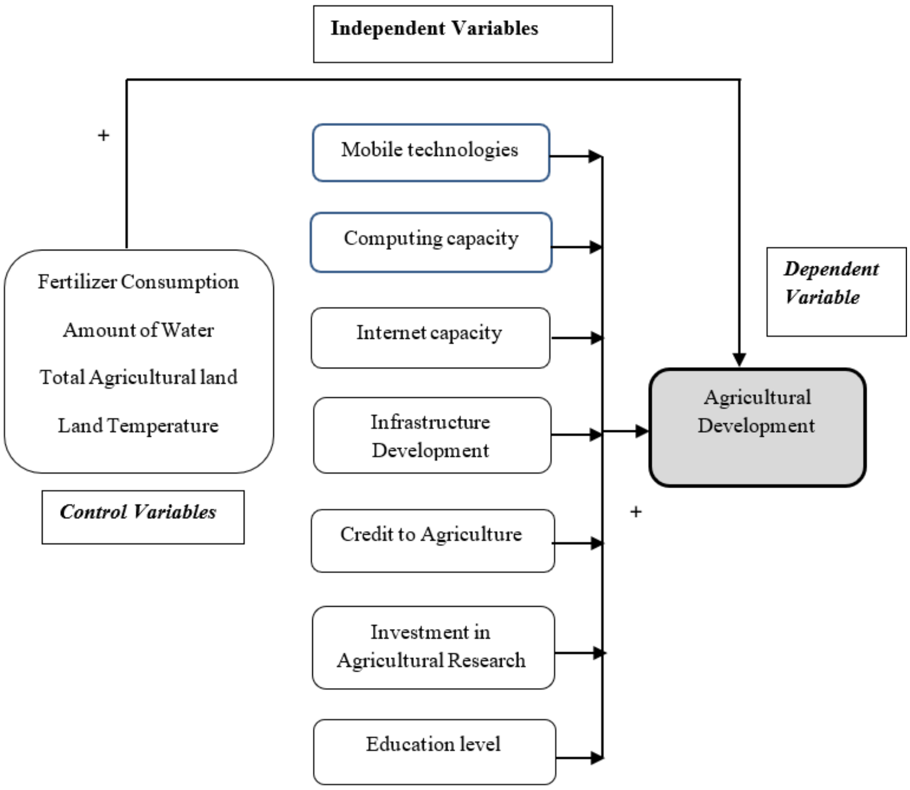

Figure 1. Conceptual framework.

4. Document analysis: State of the digital economy and agricultural development in BIMSTEC

Before moving to the discussion section and the empirical analysis, a qualitative analysis of the digital economy and agricultural development was carried out, providing further evidence and support for this study. The qualitative analysis here provides a broad analysis of the impact of the digital economy on the agricultural development which is supported to hyphothesis. Further, it was provided the digital improvement in agricultural sector in individual BIMSTEC member countries, to strongly support for this study.

Progress of the digital economy and agricultural development

The agricultural system relates to the sustainable development goals related to climate change, hunger, land use, and poverty. Technical innovation is the heart of agricultural productivity, which is related to transformation in agriculture. The digital technology revolution in agriculture is different from others due to the characteristics of digital goods and digital information. By 2050, it is estimated that each farm will produce 4.1 million daily data points (Meola, 2016). According to Gerard Sylvester, FAO investment officer, "understanding the levels and linkages in the rural milleu and how to leverage digital technologies to build human capital for agriculture is pertinent to implementing successful interventions aimed at overcoming agri food challenges and building resilient farming communities" (FAO, 2021). Digital technologies reduce the cost of obtaining information such as product prices, advice, etc. For example, information through SMS is cheaper than visits by the agent (Aker, 2011). Extension services via mobile phones expand geographic reach, frequent contacts with low costs, and increasing access to information by small landholders. Farms do not need to have physical visits for the customers or members in their network and it is easy to save the transport costs and time.

The market size of precision farming is expected to grow from USD 9.7 billion to USD 21.9 billion in 2031 (Precision Farming Market, 2023). The primary diversity of this expansion is cutting-edge technologies, lowering labor expenses, growing IoT devices, monetary saving, and farming methods to address climate change at the global level. The Asia pacific region is expected to grow with opportunities in precision farming with the need for automated systems in the agriculture sector with the growth of the increasing labor costs. The growing population in the region and food demand are fueling the adoption of precision farming.

Digital platforms further lower the economic divides, accessing downstream-upstream markets. Through the digital platforms, remote areas are better covered and as a result small producers now can directly contact input suppliers, customers, and international markets, bypassing the intermediary. Further, cheaper way of access can be obtained for different services such as negotiating, payment services, and undertaking transactions. Further, digital tracing systems extend tracing networks and reduce the hurdles that prevent some farmers from providing price premiums for producers to satisfy the preferences of consumers. As a result, small producers are able to access global value chains, thus improving their visibility to access markets with the support of digital technologies. Digital solutions narrow the inequality between rural and urban areas and digital technologies such as SMS messages, apps, and offline recordings, empower small-scale farmers and provide knowledge and access to data. Digital technologies support farmers in terms of managing soil and water more sustainability, minimizing the usage of inputs. Pesticides, water, and fertilizers can be used whenever needed, reducing the harm to water resources and soil (Berry et al., 2003). For example, accurate input applications reduce fertilizer runoffs, and farmers can apply IoT technology to improve water efficiency while saving 13 to 20% of the water. Further, proper use of fertilizer can improve soil quality (Beanstalk AgTech, 2023).

Moreover, infrastructure development is a critical component for the advancement of agriculture (Ren et al., 2023). In agriculture, infrastructure development is related to the enhancement of physical and organizational structure, which is needed for agricultural development. This study mainly focuses on technology infrastructure as it relates to digital tools to enable precision farming. Mobile technology, fixed broadband, and computer cable infrastructure are significant in terms of modernizing agriculture. High speed Internet access, which is supported by fixed broadband infrastructure, is crucial in digital agriculture. Weather forecasts, reliable information, and market prices can be accessed with reliable Internet access. Agricultural extension services can be supported from fixed broadband support for pest control, soil health, and crop management. These services can be provided effectively for broader audiences for timely guidance by leveraging broadband. Further, digital payment systems, financial management, and smoother transactions can be supported through fixed broadband.

Large amounts of data can be collected and analyzed with high Internet speed, which leads to better soil conditions, crop health, and weather patterns identification. Computer cable infrastructure supports communication and data transfer and facilitates the connection of different IoT devices such as drones and sensors, which are used for managing irrigation systems, crop conditions, and tracking livestock. Effective data transfer using robust cabling improves the effectiveness of these technologies. Complex agricultural data can be analyzed through high-speed data transfer, providing collaboration in research efforts in various regions. Reliable computer cable infrastructure can be benefitted from farm management software systems, which are used for the management of finances, inventory, and labor (Shekhar et al., 2017).

Efficient data processing is significant for the effective use of systems, which leads to efficient operations and decision-making (Makini et al., 2020). A range of functionalities are being offered by mobile technologies such as pest identification, crop tracking, and financial management. Access to applications makes for an easy approach for the farmers to manage their activities and to obtain information. Further, mobile networks enable connectivity in remote areas where fixed broadband infrastructure is limited and ensures that farmers can access communication services, digital tools, and communication services. With real time data sharing and communication, issues can be instantly reported and can be accessed by farmers such as equipment malfunctions, pest outbreaks, and prompt advice. Further, mobile technology serves are more accessible for mobile banking and financial services. This financial inclusion enables farmers to invest in purchase inputs, and in their operations and to expand their businesses.

All countries in BIMSTEC are currently focusing more on digital economy in agricultural development. Thailand as a prominent agricultural producer has been involved in “digital” technological transformation. The program the “Young Smart Farmer” has been implemented to provide knowledge of farming technology, IoT innovation, and farming technology and entrepreneurship (UN-ASEAN Business Council, 2023). It is expected to create smart farmers with creativity and innovation so that they can become leaders in their community and expand smart enterprises and networks. It is expected to create more opportunities for farmers with digital services and platforms and to achieve more quantity and quality in agricultural productivity. Further, Myanmar’s agricultural sector is now undergoing a transformational shift from a traditional structure due to the adoption of digital agricultural practices. The country is focusing on modernized agricultural practices with the increasing pressures of food security, population growth, and climate change. The vision of Myanmar is to become a “climate-resilient, food, and nutrition, secure country, with a globally competitive agriculture sector attaining high productivity through climate-smart good agricultural practices resulting in a higher standard of living especially in the rural areas” (Ministry of Agriculture, 2015).

India, with its diverse climate conditions and huge agricultural landscape, has undergone a transformative shift in farming practices with smart farming technique adoption. Smart farming with advanced technologies such as AI, IoT, data analytics, and drones have led to a revolution in the agriculture of the country, improving sustainability, productivity, and the livelihoods of the farmers. Smart farming consists of a broad range of applications and technologies, and smart farming initiatives in India extent a broad spectrum of innovative technologies and practices that are required for different needs and settings of its agricultural landscape. Smart farming has revolutionizing the farming practices, from the fertile grasslands of Punjab to the rain-fed fields in Odisha. As of 2019, there were more than 450 agri-based tech driven startups in India (PGurus, 2022).

Sri Lanka embarked on it process towards smart farming in 2016, introducing its e-agriculture strategy, marking a significant milestone as the first initiative in the Asia pacific. Digital farming practices established in Sri Lanka to address the challenges of rural livelihoods, food security, and climate change. Smart farming initiatives in the country encompass a diverse range of innovative technologies and practices, tailored to the unique farming practices and unique agro-ecological zones prevalent across the country (Ministry of Irrigation and Ministry of Agriculture, 2021). Climate-smart agriculture in the country comprises agricultural practices, and policies and technologies, which aim to improve sustainability over climate change, resilience, and productivity. The agriculture system is vulnerable to climate change impacts such as rising temperature, erratic rainfall patterns, and floods. Climate-smart agriculture strategies focus on implementing agricultural practices for these changes, including soil conservation, drought resistant crop varieties, and water saving irrigation techniques (Kadupitiya et al., 2023).

Farmers in Nepal face numerous challenges in developing their agricultural productivity due to the diverse climatic conditions and rugged terrain there. However, the introduction of digital farming has conducted in the country, considering profitability, efficiency, and sustainability. Nepal with its diverse climatic conditions has relied on farming as the primary source of livelihood for it is people. The agricultural sector has faced different challenges, including rugged terrain, erratic weather patterns, and modern technologies. However, the emergence of innovation in agriculture and smart farming has offered a sense of hope for the country to enhance its productivity and to revolutionize its agricultural practices. Now the country is more focused on developing modern technologies in its agricultural practices (Shrestha and Khanal, 2020). Bangladesh, with a significant agrarian economy, is experiencing an intense transformation in its agricultural practices and in adopting smart farming techniques. Digital farming consists of huge potential to revolutionize agriculture in Bangladesh. The agricultural sector in the country is characterized by natural disasters, small landholder farming, vulnerability to climate change, and high population density. In this line, adopting digital farming practices is imperative for the country to enhance its resilience, productivity, and sustainability. Smart farming covers a diverse array of applications and technologies aimed at improving different aspects of agricultural production, and smart farming techniques in Bangladesh have been adopted across regions, different crops, and farming systems (A2i, 2023).

5. Analysis and discussion

This research study is based on the quantitative and qualitative approaches as mentioned above. Using both methods, the research could leverage the strength of the comprehensive analysis of the research objectives. The quantitative analysis was based on numerical data while the document analysis provides rich validation for the quantitative findings. The qualitative approach generates analysis of the document research. Thus, the evidence from the document analysis and the results from the quantitative analysis provide insight into the impact of the digital economy on agricultural development.

Collecting data in any research indicates a strong methodology that proves a deep analysis. Secondary data were used from different sources to analyze the research objectives. The annual data were collected from the seven countries for the period of 2012 to 2021 for a period of 10 years, as indicated earlier, and collected data in excel file an analyzed in SPSS program. The data were analyzed using the panel regression method using fixed effects. Statistical tools such as mean, frequency, and standard deviation were applied to discuss the basic information.

The panel data regression and document analysis were done to obtain a strong support in identification of the results. Strong numerical data from world Bank, FAO and Agricultural Science and Technology Indicators (ASTI) provided reliable results which is strongly supported by document analysis. Same as conceptual framework above, the assumption was that both independent and control variables supported for the agricultural development. The measurement of the data is as follows:

The dependent variable or the agricultural development was measured by Agricultural value added. Value added is "the net output of a sector after adding up all outputs and subtracting intermediate inputs" (World bank, 2022). In this study, the agricultural value added was considered as it would be best to determind the total production of crops and livestock in each country in BIMSTEC with the available data. Mobile technologies were measured through mobile cellular subscriptions (per 100 people). Computing capacity is measured through the household with a computer, and this defines the % of the household with a computer in rural areas. Internet capacity was measured through the Internet users of each country. Infrastructure development was measured by Fixed broadband subscriptions for 100 people. Credit to Agriculture also measured here which covers the amount of loans which is provided by private/commercial banking sector to the producers in agricultural sector. National agricultural research expenditure included all expenses, program costs, capital investments and higher education expenses. Private entities were excluded. To measure the variable 'education' primary completion rate was used in each country.

A multicollinearity test was carried out to check whether the independent variables were highly correlated. Panel data multiple regression analysis was used with fixed effects. However, India had to be excluded due to the huge gap in the statistics and as a result were not reliable. Further, four independent variables—agricultural research, fertilizer consumption, water level, and agricultural land area—had to be excluded in the coefficient section due to multicollinearity and inconsistent coefficients, as it impacts the other variables.

Overall, the study of the descriptive statistics in the **Table 2** can be summarized. A substantial gap is shown in agriculture development, mobile technology usage in rural areas, credit in agriculture, and fertilizer usage, while moderate gaps in rural areas are shown in Internet capacity, expenditure in agricultural research, and agriculture land, showing smaller gaps in rural computing capacity, rural infrastructure development, education level, water, and land temperature. In the total observation, the maximum in agriculture development is represented by India while the lowest is by Sri Lanka. Rural mobile technology is at a maximum in India and the minimum is Myanmar. Computing capacity in rural area is maximum in Thailand while minimum is in Myanmar. Rural Internet capacity is high in Sri Lanka and the minimum is represented by Myanmar. Sri Lanka is also at a maximum in rural infrastructure development while the minimum is Myanmar. In credit to agriculture, India is the highest while the minimum is from Myanmar. Agricultural research is high in Myanmar while the lowest is Nepal. Bangladesh is high in agricultural research while the lowest is shown in Nepal. Further, education level is at a minimum in Nepal while the maximum is in Bangladesh.

Table 2. Results of the descriptive statistics.

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Agri deve.	60	4,175,717	448,214,033	78,809,051.62	134,820,249.48
Mobile tech	60	2,495,844	776,693,074	152,758,473.45	247,090,524.23
Computing	60	0.81	32.90	7.72	8.56
Internet	60	0.71	41.31	18.90	10.66
Infras dev	60	0.04	8.90	2.57	2.34
Credit agri	60	54.00	186,387.99	25,214.28	53,970.05
Agri research	27	17.70	2385.36	645.58	763.86
Edu level	42	73.80	120.00	89.76	10.15
Fertlizer	60	13	384	152.74	91.89
Water	54	87.36	98.14	90.44	3.66
Agri land	60	19.20	77.30	45.29	18.24
Land Temper	60	0.19	1.86	0.97	0.39

Table 3. Correlations matrix.

Correlations												
	Agri Dev	**Mobile Tech**	**Computing**	**Internet**	**Infras.**	**Credit Agri**	**Research**	**Edu**	**Fertlizer**	**Water**	**Agri land**	**Land Tem.**
Agri Dev	1											
Mobile Tech	0.611	1										
Computing	0.582	0.206	1									
Internet	0.732	0.248	0.925	1								
Infrastructure	0.535	0.443	0.922	0.821	1							
Credit Agri	0.506	0.525	0.760	0.629	0.896	1						
Research	0.237	−0.242	−0.390	−0.153	−0.553	−0.405	1					
Edu level	0.312	−0.060	0.876	0.768	0.800	0.754	−0.308	1				
Fertlizer	0.097	0.757	0.202	0.040	0.498	0.614	−0.677	0.093	1			
Water	−0.248	−0.307	−0.031	0.014	−0.179	−0.554	−0.290	−0.207	−0.322	1		
Agri land	0.134	0.790	0.202	0.039	0.519	0.636	−0.666	0.090	0.984	−0.332	1	
Land Temper	0.507	0.070	0.373	0.440	0.349	0.401	0.357	0.378	−0.215	−0.417	−0.141	1

If concern each independent variable with dependent variable as in **Table 3**, mobile technology (0.611) and Internet capacity (0.732) shows high strong positive impact with agricultural development which indicates that agricultural development is strongly related to mobile technology and Internet capacity. The changes tied closely with other variable and shows relative reliable relationship to make the predictions. Computing capacity also shows a moderate strong positive relationship (0.582) with agricultural development implying positive impact with dependent variable. The correlation of infrastructure development (0.535) and credit to agriculture (0.506) also positive towards agricultural development. On the other hand, there is moderate positive impact between agricultural development and land temperature (0.507) education level (0.312) and agricultural research expenditure as 0.237. However, the correlation is very low in agricultural land (0.134) and as 0.097 in fertilizer usage. Moreover, a weak negative correlation (−0.248) shows between agricultural development and water availability.

Table 4. Results of panel data regression analysis.

Panel data Regression Analysis			
Agricultural development			
	Std. Error	**Coefficient**	***P* value**
Mobile tech	0.044	0.668*	<0.001
Computing capacity	130,035.802	0.387*	<0.001
Internet capacity	102,590.934	0.646*	<0.001
Infrastructure	986,468.107	−0.439*	0.044
Credit agri	2641.464	0.067	0.725
Edu level	132,374.64	−0.157	0.202
Land Temper	2,818,392.72	0.175*	0.047
R-sq 0.805			

(*) means significance, whereas value < 0.05.

The results of the regression analysis in **Table 4** indicates that *R*-squared value of 0.805 indicating that the model explains 80.5% of variation in agricultural development. This highlighted that independent variables in this model are highly effective explaining the variation in agricultural development with a strong fit model to data. The coefficient of mobile technology 0.668, indicates that it significantly associated with agricultural development implying ‘an increase of one unit in mobile technology is associated with a 0.668 increase in agricultural development. Similarly, computing capacity also positive and relatively significant coefficient (0.387) with agricultural development suggesting that improvement in the computing capacity is associated with the development in agriculture. This implies that better access in computing resources improve the agricultural practices and efficiency. The *p*-value of Internet capacity is 0.000 which suggests that one unit of increase of Internet capacity is linked with 0.646 unit increase in agricultural development. This suggests the critical role of internet access improving agricultural productivity. The land temperature shows a positive relationship (0.175) with agricultural development and relatively low. The results reveals that the infrastructure development has negative coefficient with agricultural development. The coefficient is −0.439. However, the *P*-value of credit to agriculture is greater than 0.05 which indicates that it does not have a statistically significant impact on agricultural development. The same applies to education level as the *p*-value is 0.202 which is greater than the 0.05 threshold. Thus, both credit to agriculture and education level do not show any statistically significant impact on development of agriculture.

The findings of this study indicate the significant role of mobile technologies in advancing agriculture development in BIMSTEC. Mobile technology has become a critical tool in digital agriculture providing a wide range of activities from farm management to market access. In BIMSTEC, mobile phones serve as a significant link between farmers and extension services, providing them access for agricultural information, market prices, and weather forecasts. Mobile technologies have been instrumental in reducing operational costs, allowing farmers to increase the productivity while improving access to markets. The results also reveal the positive impact of computing capacity on agricultural development. this study supports the view that an increase in computing capacity contributes significantly to enhance agricultural productivity which support for optimizing farming practices. In addition, findings reveal that internet capacity in rural areas play a major role in facilitating agricultural development. Access to high-speed internet can increase farmer's ability to achieve real-time information and participation in digital marketplaces. Study further suggests that internet capacity alone may not be enough to drive agricultural growth and other factors such as government policies, infrastructure development and market conditions impact for digital economy in agriculture. The ability to leverage internet connectivity in agricultural settings is shaped by regional disparities in infrastructure and digital literacy. The geographically challenging areas such as Nepal, internet access may be hindered with geographical barriers. In that context, offline solutions with digital applications are essential, as farmers face unaffordable costs. This shows the importance of developing cost-effective digital tools which can work in low-bandwidth environments ensuring all farmers can involve in digital economy of agriculture.

The study identifies that infrastructure development has a negative impact on agricultural development. The actual relationship between agricultural outcomes and agricultural productivity may be more complex. The nature of investment in infrastructure and its impact on agriculture can be different across communities and regions. Geographical conditions and governance structures can shape the effectiveness in supporting agricultural development. It can be assumed that in rural areas, farmers are more focused on mobile networks than fixed broadband subscriptions due to their convenient access. Results indicate a negative impact on credit to agriculture. This implies that credit to agriculture does not have a significant impact on the agricultural development directly and it mainly supports indirectly the other factors in terms of improvement. Even though many studies found that education plays a significant role in digital agriculture, this study does not show any significant impact between education and agricultural development. Although, education considers as a critical aspect for agricultural development, the actual relationship between education and agricultural outcome may be different due to technological capacity and the convenience of using different applications. It is possible that other factors such as institutional support, capacity of technology, and accessibility can have greater influence on digital agriculture than education alone. **Table 5** below shows the summary of the hypothesis.

Table 5. Summary of the hypothesis.

Hypothesis	***P*-value**	**Conclusion**
H_1: Mobile technologies have a positive impact on agricultural development.	<0.001	Supported
H_2: The computing capacity of the country has a positive impact on agricultural development.	<0.001	Supported
H_3: Internet capacity has a positive impact on agricultural development.	<0.001	Supported
H_4: Infrastructure development has a positive impact on agricultural development.	0.044	Not supported (Negative)
H_5: Credit to agriculture has a positive impact on agricultural development.	0.725	Not supported
H_7: Education level has a positive impact on agricultural development.	0.202	Not supported

In conclusion, this research identified that the integration of computing capacity, mobile technologies and internet access is important for the digital economy in agriculture in BIMSTEC. The digital economy not only increase the productivity and efficiency in agriculture but also improve inclusive growth providing digital tools and knowledge for farmers that they need to succeed in a rapidly developing agricultural landscape. However, to be fully effective in these technologies, policy makers should address underlying barriers such as internet accessibility, infrastructure limitations and digital literacy to ensure that digital transformation benefits for all in agricultural sector.

6. Conclusion

This research provides novel insights into the role of digital economy in advancing agricultural development in BIMSTEC. The study uniquely connects the fields of digital transformation and agriculture in BIMSTEC which has received a limited attention in existing literature by focusing mobile technologies, computing capacity and internet connectivity. With panel data analysis over 10 years (2012–2021) and a comprehensive set of socio-economic variables, this research reveals the critical interplay between digital tools and agricultural growth, highlighting how the impact is amplified significantly when paired with investment in infrastructure and education. The study highlights the importance of a holistic approach, where digital solutions are not just standalone interventions, but part of a broader strategy to address the challenges in developing countries especially in rural and underserved regions. The study contributes to the growing body of literature on digital economy in agriculture, providing a significant perspective on how strategically integrated digital technologies can drive agricultural productivity and economic growth in developing regions.

6.1. Recommendations and managerial implications

Policymakers in BIMSTEC can benefit from adopting evidence based, technology driven solutions to address both immediate and long term needs in the agricultural sector. For managers, this study highlights the importance of investing in digital literacy programs and adopting IoT solutions to improve productivity and sustainability in agriculture.Subsidies can be provided by governments for telecommunications infrastructure initiatives and development to promote private partnerships for investment in rural connectivity. Mobile, Internet, and computer technology investments further should provide digital literacy and training so that the farmers can utilize digital platforms and tools effectively. Financial institutions and governments should focus on facilitating agricultural credits to develop innovative financial mechanisms, which are needed for small landholder farmers. Policies can be implemented to obtain these credits for modern agricultural inputs, farm management software, digital applications, precision agricultural technologies, and data analytics tools. Managers can consider implementing financial initiatives such as agricultural credit schemes, microfinance programs, and support for rural banking infrastructure to expand the farmers' access to credit for the usage of digital technology. A holistic policy framework can be adopted by policymakers that addresses different dimensions of agricultural development, such as financial inclusion, technology adoption, infrastructure development, and extension services. Public-private partnerships can mobilize resources and innovation to address the different challenges that the agricultural sector has faced.

6.2. Theoretical contributions

Different contributions can be identified in this study concerning the literature review and theoretical background. First, the study can be considered as a novel contribution to the existing knowledge of the digital economy on agricultural development using quantitative analysis selecting BIMSTEC as study area. Second, the Transfer of Technology theory suggests that merely developing technology is not sufficient in an economy and other relevant beneficiaries should be transmitted for proper support. Integrating the technology process into rural agricultural development is multifaceted and intricate. Third, the countries in BIMSTEC are still in the transformation period, moving into technologically dynamic agriculture from traditional agriculture. Digital agriculture provides a paradigm shift for these countries to shift from traditional methods to modern technologies such as data analytics, sensors, and satellite imagery. Precision agriculture, automation and robotics, data driven decision-making and smart irrigation systems are now focused on by countries as they are moving towards digital agriculture. Thus, the future environment should be capable of moving from low capital technology into high capital technology (Mellor's theory). Fourth, this study has discussed both positive (mobile technology, Internet capacity, computing capacity) and negative influences (infrastructure level, credit to agriculture, and education level) by systematically analyzing the impacts of different factors. Thus, the study creates a practical model of mobile technology, Internet capacity, and computing capacity to enhance agricultural development in the digital economy.

Fifth, the study specifies empirical evidence for policy implications and intervention strategies that can promote agricultural development. Expanding digital infrastructure can be supported for mobile network coverage in underserved areas, investing in high-speed Internet, ensuring reliable access for farmers to technological tools.

6.3. Policy implications

According to the results of this study, it recommends that government should prioritize investments for mobile technology infrastructure, expanding network coverage in rural areas, and it can expand 5G technology, providing satellite-based services. In this line, farmers should be able to access more modern applications related to agriculture, accessing valuable information, weather forecasts, and agricultural best practices, empowering them to take accurate decisions enhancing their productivity. Subsidies can be provided for telecommunications infrastructure initiatives and development to promote private partnerships for investment in rural connectivity. It is also suggested that computer training sessions be provided for farmers, in addition to education, especially related to mobile applications covering the agricultural supply chain, such as how to sell their products and markets. Financial institutions and governments should focus on facilitating agricultural credits to develop innovative financial mechanisms, which are needed for small landholder farmers. Policies can be implemented to obtain these credits for modern agricultural inputs, farm management software, digital applications, precision agricultural technologies, and data analytics tools. Governments can consider implementing financial initiatives such as agricultural credit schemes, microfinance programs, and support for rural banking infrastructure to expand the farmers' access to credit for the usage of digital technology. One such innovative mechanism could be introducing a digital currency platform among accredited service providers only for farmer communities, such as providing special rates to buy or sell raw materials, or computers, or other items that cover the agricultural supply chain. Policymakers can prioritize the development of infrastructure in rural areas to address the challenges related to Internet access and extension services. This involves investments in mobile networks, market access, and the reduction of post-harvest losses. Mobile access can introduce new technologies such as 5G or other satellite services such as "Star Link." Farmer organizations which can be set up at the village level or district level can introduce such new technologies as individual farmers may not be able to afford the costs. Effective agricultural development policies can be implemented with the collaboration of the government, the private sector, and civil society. Public-private partnerships can mobilize resources and innovation to address the different challenges that the agricultural sector has faced. These digital systems can be connected to mobile applications that would help farmers understand the resource they use, and finally they would learn how to use resources efficiently.

6.4. Future research

Future research can explore alternative methodologies, such as theoretical frameworks, to understand the complex relationship with the role of credit to agriculture and infrastructure investments and education level in agricultural development in order to identify strategies for its potential benefits. Support from the literature review and previous evidence is still debatable for this and further research should be needed to explore the relationship among them. In addition to that, BIMSTEC countries are facing different threats such as political instability, carbon emissions, and disinformation for farmers which impact the success of this the digital economy in the agricultural process. The political instability of these countries leads to frequent changes in civil unrest, changes in government, and inconsistent policy frameworks. These conditions can lead to discontinuity in agricultural projects in digital infrastructure, making it difficult to implement long-term digital strategies. Political instability impacts investors and complicates maintaining a stable regulatory environment, which is essential for maintaining digital industries and digital rights. Increased carbon emissions leads to natural disasters and extreme weather events, which impact digital infrastructure and data centers. Further, rising pollution levels can impact public health, which reduces the productivity and capacity of the workforce. This can lead to higher operational costs which require investments in sustainable technologies and practices. Thus, countries need to consider how to strengthen political stability, promote sustainable practices, and adopt green technologies.

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