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FACTORS INFLUENCING THE ADOPTION OF DIGITAL TECHNOLOGIES BY SMALL-SCALE PRODUCERS IN INDIA'S AGRICULTURE VALUE CHAINS (AVCS)

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ABSTRACT

Digital technology presents significant opportunities for small-scale farmers in tackling the diverse difficulties encountered within Agriculture Value Chains (AVCs). Nevertheless, small-scale farmers encounter considerable obstacles that impede their adoption of digital technologies. This research investigates the various economic, social, and political factors that impact the adoption and deployment of digital solutions in autonomous vehicle companies (AVCs). This study provides significant insights into the governance implications and institutional barriers related to the investigation of digital technology adoption. In order to obtain empirical data, the study utilised a rigorous approach, acquiring information from a sample of 480 farmers located in the state of Haryana, India. The attainment of this objective was facilitated by the implementation of structured questionnaires and the use of the snowball sampling methodology, thereby guaranteeing the acquisition of a dataset that is representative of the population under study. The results of the regression study highlight the primary influence of economic factors on the adoption of digital agriculture solutions, with social and political aspects closely following suit. This highlights the necessity of a developmental framework that is tailored to the individual situation, in order to facilitate the successful incorporation of digital solutions within the small-scale farming sector. The findings underscore a positive pattern, whereby farmers are increasingly adopting digital tools to improve their agricultural methods. The primary driving force behind this phenomenon is mostly attributed to the appeal of financial advantages and the existence of favourable governmental policies. This study contributes a crucial dimension to our comprehension of the dynamics related to the adoption of digital technology in the agricultural sector. It elucidates the complex interaction among economic, political, and social factors, and presents a potential trajectory for the progress of small-scale farmers in the era of digitalization.

KEYWORDS: Digital Technology, Agriculture Value Chains, Economic Factors, Social and Political

Factors and Small-Scale Farmers.

1. Introduction

The UN approved the 2030 Agenda for Sustainable Development in September 2015, which includes 17 Sustainable Development Goals (SDGs) that address social, economic, and environmental issues (SDSN, 2015). Several targets, notably poverty eradication (SDG 1), zero hunger (SDG 2), and sustainable consumption and production (SDG 12), are heavily impacted by small-scale agriculture. This influence is particularly noticeable in improving sustainable food security, according to the FAO (2015). The Indian Union (AU) endorsed Goal 5 of Agenda 2063 in 2013 to modernise agriculture and boost productivity (AUC & AUDA-NEPAD, 2020). The 2012 Indian National Development Plan (NDP) aims to use underutilised land, expand irrigated agriculture, and boost commercial output to create jobs (NAHF, 2017). This plan improves Agriculture Value Chains (AVCs) to help small-scale farmers move to commercial farming (AUC & AUDA-NEPAD, 2020). According to the International Telecommunication Union (ITU, 2016), commercial AVCs have a significant impact on agricultural development, specifically in the context of poverty reduction. According to Corallo et al. (2018), adherence to both national and international rules is crucial when utilising digital information for marketing purposes in AVCs. The utilisation of mobile phones and internet applications has brought about a significant transformation in communication within the agriculture sector (Boateng et al., 2017). Moreover, the emergence of the "New Digital Economy" presents opportunities for the implementation of digitally-oriented solutions to address diverse difficulties in agricultural growth (Sturgeon, 2017). The advancements in digital technology within the agricultural sector have been substantial (FAO & ITU, 2017). According to Heeks (2018), the integration of digital technology in agricultural development results in heightened food production and improved efficiency in terms of average variable cost (AVC).

However, certain obstacles such as the digital divide, insufficient human and institutional capacity, restricted knowledge sharing, and inefficient information management have the potential to impede advancements (Mago & Mago, 2015). Although there are instances where digital technology has proven beneficial in supporting small-scale agricultural development, its successful implementation has not been consistently reproduced (Deichmann et al., 2016). Foster and Heeks (2015) suggest that new government policies can eliminate structural barriers to inclusive innovation and reduce social exclusion and inequality. To develop small scale agriculture in marginalized or vulnerable communities political will is required (FAO, 2015). ICT and agriculture officials must promote this technology revolution for digital growth. The study defines digital development as society's dependence on digital technology. This link affects digital governance, consumption, and design (Heeks, 2016). The economic, social, and political factors that impact on small-scale farmers' agricultural value chains (AVCs) must be understood to understand digital technology's integration. This comprehensive analysis lays the groundwork for future studies on the digital revolution's impact on small-scale farmers' agricultural value chains, helping scholars and industry professionals design and conduct them.

2. Agricultural Value Chain (AVC)

Agricultural Value Chains (AVCs) encompass the diverse stages that agricultural goods undergo, commencing from production and culminating in consumption, with value being augmented at each juncture (ADBG, 2013). The utilization of digital technology is becoming more widely acknowledged as a catalyst for transforming agricultural productivity, optimizing value chains, guaranteeing food safety, and facilitating entry into commercial marketplaces (FAO & ITU, 2016; Corallo et al., 2018; NAHF, 2017). The utilization of digital tools in the field of agriculture has been found to facilitate the dissemination of knowledge and improve the availability of extension services, hence increasing the accessibility of Agricultural Value Chains (AVCs) to small-scale farmers (Deichmann et al., 2016; FAO, 2015). When utilizing digital technology to enhance marketing in AVCs, compliance with rules is essential (Corallo et al., 2018). The movement of food along the value chain plays a crucial role in connecting human activities with the natural environment (FAO, 2015). The integration of digital technology inside the agricultural value chains (AVCs) of small-scale farmers plays a crucial role in fostering agricultural prosperity in India. This statement underscores the significance of digital technology in augmenting agricultural progress and presents a theoretical framework for analysing the implementation of such technology. The assessment serves as a basis for future research and offers insights to policymakers, scholars, and industry experts regarding the potential advantages and obstacles connected with the digitalization of small-scale agriculture.

2.1. Agricultural Value Chain for small-scale farmers in India

The goal of India's initiatives to support small-scale farming is to remedy historical land ownership disparities that existed throughout the colonial and apartheid eras of government (DAFF, 2016). The agricultural sector in India exhibits a dualistic structure, wherein a clear division exists between two distinct groups of farmers. On one end, there are predominantly white, well-established, and capital-intensive large-scale farmers. On the other end, there are predominantly black, less-developed smallholder and subsistence farmers who possess limited resources (Thamaga-Chitja & Morojele, 2014). Despite the conclusion of the Apartheid era, enduring discrepancies in development persisted. Notably, significant white-owned farms, supermarket chains, and agribusinesses, which received major subsidies, continued to engage in competition with black peasant farmers who were devoid of comparable financial assistance (DAFF, 2016). The significance of information is of utmost importance in tackling the issues encountered by the small-scale agriculture industry in India (SDSN, 2015). The need of sharing agricultural knowledge and skills with small-scale farmers has been underscored by the Department of Agriculture, Forestry, and Fisheries (DAFF, 2016). Nevertheless, a significant number of farmers exhibit a lack of knowledge regarding the complexities associated with the implementation of digital technologies inside agricultural value chains (AVCs), as emphasised by Heeks (2018).

Figure 1 depicts the advantages of growing technology inside the digital agricultural value chain (AVC) for different stakeholders, encompassing farmers, consumers, the environment, and new participants. The emergence of more participants in the market offers prospective commercial prospects for small and medium-sized enterprises (SMEs), enables the assimilation of cutting-edge agricultural technologies, and promotes the expansion and progress of entrepreneurial initiatives. Campion (2018) asserts that the utilisation of digital tools holds the capacity to empower small-scale farmers through various means. These include fostering a more comprehensive comprehension of their expenditures, facilitating enhanced decision-making processes, and promoting agricultural knowledge dissemination within agricultural value chains (AVCs). Ultimately, these advancements aim to augment financial accessibility for small-scale farmers. It is imperative to resolve historical disparities and foster the integration of digital technologies in the context of small-scale agriculture in India in order to facilitate the advancement of this industry. The potential for empowering small-scale farmers, enhancing their decision-making abilities, and improving the efficiency of agricultural value chains is enormous through the transmission of information and the integration of digital tools.

<table>
<tr><th>Farmer's Suppliers (Input Supply Industry)</th><th>Farmer's/ Producers</th><th>Processing post-harvest and storage</th><th>Distribution and Retail</th><th>Consumer</th></tr>
<tr><td colspan="3">AI and IOT Data Collection and Analysis</td><td colspan="2">E-Business</td></tr>
<tr><td colspan="3">GNSS Precision Agriculture</td><td colspan="2">Blockchain Technology</td></tr>
<tr><td colspan="3">Smart Farming and smart irrigation</td><td colspan="2"></td></tr>
<tr><td colspan="5">ICT Digitalized Communication (Broadband)</td></tr>
<tr><td colspan="5">Robotics Automation</td></tr>
<tr><td colspan="5">Blockchain Smart Contracts</td></tr>
</table>

Figure 1. Vertical integration of Digital agricultural value chains.

Source: Adapted from Pesce et al. (2019).

Small-scale producers possess the capacity to surmount obstacles to development through the utilisation of digital technologies and connectivity (Graham, 2019). Nevertheless, a significant obstacle encountered by these individuals is frequently their failure to completely comprehend the magnitude and scope of the necessary adjustments (Juma, 2019). The agricultural sector in India is characterised by a significant number of small-scale farmers who face challenges associated with economies of scale. The limited availability of farming land, financial resources, technology, and other necessary inputs poses significant challenges, resulting in adverse effects on agricultural production capacity (Malan, 2018). Malan (2018) claims that the Fourth Industrial Revolution (4IR) could help small-scale farmers in India by introducing new food production, cultivation, promotion, and distribution methods. Small scale farmers capacities and livelihoods can benefit from Digital development. According to studies (Mago & Mago, 2015), Digital developments enhances small scale farmers livelihoods and reduces poverty. Understanding the barriers to small-scale farmers' use of digital technology adoption in agricultural value chains (AVCs) is crucial to the research's goal of understanding the factors that influence their acceptance.

2.2. Challenges faced by farmers to use digital technology

Small-scale producers in rural areas struggle to utilise digital technology due to infrastructure and capacity issues. Insufficient digital technology competency among researchers and restricted power infrastructure for agricultural information distribution to farmers are also major impediments.

Northern Indian states face similar challenges in adopting digital technologies by small-scale farmers. These challenges originate from low education, money, cultural opposition to change, and a lack of localised material in local languages. Nmadu et al. (2013) found that illiteracy, language and poverty prevent Nigerian small-scale farmers from using digital technology to acquire commercial information. Odini (2014) found that small-scale farmers in Kenya lack information due to poor infrastructure, literacy, information services, and technical capabilities. These limits limit accessibility to agricultural value chain players like processors, merchants, and consumers (Munyua, 2007; Musa et al., 2013).

According to empirical research, there is evidence to suggest that farmers' attitudes towards the integration of novel technologies undergo transformation as technological advancements occur throughout time. Research conducted in US in 2007 and 2011 indicated that agriculturalists exhibited a lack of adoption of economically advantageous agricultural technology, mostly attributable to factors such as exorbitant expenses, limited availability of time, and contentment with prevailing methodologies (Paudel et al., 2011). According to research showed in 2020, the primary determinant for adoption was found to be profit, followed by environmental benefits. According to Paudel et al. (2020), farmers with higher levels of education and experience demonstrated a greater propensity to adopt technologies primarily driven by commercial motives. Conversely, younger farmers exhibited a stronger inclination towards considering the environmental benefits associated with technology adoption. These studies elucidate the shifting perspectives of farmers throughout time, which are shaped by various factors including cost considerations and the progressive comprehension of the potential advantages of technology.

The aforementioned studies demonstrate a multitude of hurdles that exert an influence on the adoption of digital technologies in small-scale agriculture, many of which are frequently beyond the purview of the farmers themselves. The independent acquisition of digital technology poses a significant challenge for small-scale farmers, mostly due to their limited incomes. As a result, this imposes restrictions on the utilization of digital technology as a means to augment productivity and ensure economic sustainability. In order to address these issues, it is crucial for governmental bodies and developmental institutions within the agricultural sector to provide substantial help to small-scale farmers in efficiently implementing digital technologies.

Digital development is becoming increasingly important in helping poor people improve their capacities and functionings. Digital development's effects might be examined from economic, livelihood, or competency perspectives (Heeks, 2016). The economic, social and political factors that affect small-scale farmers' operational capacities must be identified to improve their growth using digital technology. This study examines the factors that influence small-scale farmers' adoption of digital technologies to improve their operations. This study will examine the theoretical foundations and conceptual framework that informed the research in the next section.

3. Theoretical framework and conceptual discussions

The fundamental pillars of study comprise ontological perspectives on reality, epistemological considerations regarding the information utilised in the study, and data collection, evaluation, and processing in order to generate novel insights (Tuli, 2005). Here, we discuss the theoretical foundations and conceptual framework used to conduct and analyse this study. Sen (1985) emphasizes the need of prioritizing freedom to choose and achieve specified functionings for vulnerable small-scale farmers. Development in this approach includes economic growth and individual freedom (Kleine, 2010). According to Gigler (2004), distinct dimensions of person skills are linked to a variety of outcome indicators that can be quantified in relation to digital effect. This study examines the multiple factors that affect small-scale farmers' digital technology use in agricultural value chains. The theoretical approach in this study implies that asset interactions affect capacity development. When paired with appropriate structures and procedures, these assets enable specific functioning. These functions include practical methods for achieving livelihood goals. This study investigates the economic, social and political factors that drive small-scale agriculturalists in agricultural value chains (AVCs) to use digital technologies. This study also examines how these factors may affect institutional support. This study seeks to understand how small-scale agriculture adopts digital technology. This research examines governance and institutions to help farmers make better decisions, improve their skills, and achieve more.

4. Research methodology

An important part of any academic project is the Literature Review, which collects and analyzes relevant prior literature in a planned way. The function of a literature review is to establish a robust framework for the progression of knowledge by identifying, selecting, and evaluating relevant scholarly works that have been previously published, as well as identifying gaps in the existing research that require further investigation (Webster & Watson, 2002). Within the framework of this study, which aims to establish a conceptual developmental framework for facilitating the integration of digital technology into Agriculture Value Chains (AVCs) among small-scale agrarians, the main goal is to initiate an analysis and identification of the factors that influence the implementation of digital technology in current AVCs.

This study aims to provide a complete analysis of the adoption of digital technology in agricultural value chains (AVCs) by small-scale agrarians, including all relevant features of the concept. The objective is to acquire comprehension regarding the economic, social and political variables that exert effect on the institutions engaged in the development, utilization, & regulation of digital AVCs. The research encompassed a cohort of 480 agricultural practitioners residing in the state of Haryana. The questionnaire was carefully constructed to consist of two distinct pieces. The first section was dedicated to gathering demographic information, while the second section aimed to explore the several aspects that impact the adoption of digital technology for AVCs. The data gathering process employed a combination of snowball sampling and convenience sampling approaches within a specific sample of six districts from each administrative zones in the state of Haryana. The study's selection criteria were created based on the well specified and organized research topics. In order to conduct data analysis, the researchers utilized factor analysis to extract the significant factors. Subsequently, regression analysis was employed to investigate the degree of influence exerted by each factor on the adoption of digital technology for AVCs. Hence, the following section of this paper will explicate the analysis undertaken in this study, classifying, and elucidating the outcomes.

4.1. Analysis of the factors affecting AVCs

The demographic data presented provides a complete analysis of the farmers in Haryana, India, showcasing a wide range of features and circumstances within this pivotal agricultural industry. The age distribution of farmers in Haryana exhibits a notable characteristic, including a wide spectrum. Approximately 42.3% of the population surveyed may be categorized within the age range of 30 to 50 years, suggesting a notable level of engagement from individuals in the middle age bracket in the agricultural sector. Simultaneously, it is noteworthy that a considerable proportion of farmers, amounting to 24.8%, fall within the age bracket of 50 years and above. This observation implies the persistent dedication of older cohorts to the field of agriculture. The presence of age variety in Haryana's farming sector serves to underscore the intergenerational dynamics that characterize agricultural practices in the region. This amalgamation of seasoned expertise and youthful vigor plays a pivotal role in ensuring the long-term viability of agricultural livelihoods.

The research underlines a large gender disparity within the farming sector. The data reveals that a significant majority of farmers, specifically 84.8%, are male, whereas a comparatively smaller proportion of 15.2% are female. The existing gender imbalance highlights the ongoing lack of female presence in the agricultural sector, a matter that requires focused efforts and assistance to promote gender equality and enable women farmers to assume a more prominent position in the field of agriculture. The level of educational achievement among farmers in the state of Haryana exhibits variation, with approximately 36.5% having attained senior secondary education. However, a considerable percentage of individuals, amounting to 25.0%, lack the ability to read and write, whereas 25.6% have received education up to the matriculation level. The presence of varying education levels among the farming community underscores the necessity for educational efforts and skill development programmes that are customized to address the unique requirements of these persons. Such initiatives would enable the adoption of enhanced agricultural practices and enhance their access to information.

The predominant demographic among farmers in Haryana consists of individuals belonging to joint families, comprising approximately 76.0% of the overall population. This observation highlights the widespread existence of traditional joint family systems in the region, wherein agricultural decision-making and resource allocation are commonly undertaken collectively. In contrast, it is observed that 24.0% of farmers belong to nuclear families, indicating a trend towards smaller family units. This shift has possible ramifications for decision-making autonomy and the distribution of resources.

Approximately 50.0% of farmers are located in rural areas, indicating the significant influence of agriculture on the livelihoods of rural communities. Moreover, it is worth noting that almost 30% of the population resides in metropolitan regions, indicating a notable expansion in the range of revenue streams and means of subsistence among certain agricultural workers. Furthermore, a substantial proportion of 20.4% of individuals are located in semi-urban regions, indicating a complex amalgamation of urban and rural factors that shape their way of life and economic endeavors. The agricultural community exhibits variation in housing conditions, with 61.0% residing in "Pakka" houses, which are permanent, well-built structures. Nevertheless, a notable proportion of 6.5% of individuals continue to reside in "Kaccha" dwellings, characterized by their inferior structural integrity and frequent need for enhancements. The remaining 32.5% of farmers are found to be residing in "Mansion" dwellings, indicating a notable level of diversity in housing standards within this group.

The variability in landholding size serves as a reflection of the heterogeneous nature of land ownership within the farming community. A considerable proportion is classified as "Marginal" (31.7%), indicating the presence of minor landholdings measuring less than 1 hectare. Simultaneously, it is noteworthy to mention that there are other important types of landholders, namely the "Semi-Medium" landholders comprising 33.1% and the "Small" landholders comprising 22.1%. The observed variation in landholding size serves to highlight the existing imbalances and difficulties associated with land access and agricultural output. Farming constitutes the predominant source of revenue for the majority of farmers, with 62.1% of their total income. Nevertheless, a significant proportion of farmers in the region, specifically 37.9%, depend on several sources of income. This finding underscores the need of diversification and economic stability for agricultural practitioners in the area. This observation underscores the complex and diverse nature of income creation among farmers, frequently encompassing off-farm endeavors and alternative means of sustenance.

In summary, the composition of farmers in Haryana encompasses a multifaceted array of characteristics including age, gender, educational background, familial structure, place of residence, housing conditions, land ownership, and sources of income. Comprehending these attributes is crucial in formulating policies and interventions aimed at addressing the varied requirements and obstacles encountered by this essential group. Additionally, it is imperative for fostering sustainable, inclusive, and gender-equitable agricultural practices within the region.

Table 4.1 Profiling of dimensions of digital adoption of AVCs

Sr No	Factors Name	No of items	Factor loading	Eigen values	Cronbach Alpha
1	Economic Factor	6	0.865 to 0.715	5.149	0.877
2	Social Factor	5	0.888 to 0.709	4.265	0.897
3	Political Factors	3	0.759 to 0.700	3.214	0.820
4	Digital Adoption	6	0.912 to 0.841	2.151	0.921
5	Agriculture Value Chains (AVCs)	5	0.899 to 0.768	1.235	0.908
6	Institutional Framework	4	0.799 to 0.729	1.112	0.844

Source: Author’s calculations SPSS 21.0 Version

Table 4.1 provides a complete overview of the dimensions associated with the digital adoption of Agriculture Value Chains (AVCs). This study examines the economic aspects that impact the adoption of digital technologies in autonomous vehicles (AVCs), encompassing a total of six topics. The high factor loading values suggest a robust association between these factors and the dimension. The eigenvalue of 5.149, which exhibits considerable magnitude, indicates that the economic element plays a large role in the comprehensive comprehension of digital adoption. The dimension's high Cronbach Alpha coefficient of 0.877 indicates its dependability, highlighting its efficacy in assessing the economic facets of digital adoption in AVCs.

The social dimension has five distinct components that explore the various social factors that influence the process of digital adoption. The high factor loading values suggest a strong and reliable association between these items and the social component. The significance of the eigenvalue 4.265 underscores the considerable influence of social variables in comprehending the broader aspects of digital adoption in AVCs. The dimension exhibits a high level of reliability, as indicated by a Cronbach Alpha coefficient of 0.897. This suggests that it can be considered a reliable measure for assessing the impact of social effects on digital adoption.

Political variables are those dynamics factors inside the political system which can impact the functioning and outcomes of a society. The political dimension of digital adoption pertains to the examination of political factors that influence the process. This dimension specifically emphasizes the impact of political forces on the adoption of digital technologies. The factor loading values exhibit a notable magnitude, indicating a robust association between these elements and the dimension. The presence of an eigenvalue of 3.214 suggests that political issues play a substantial role in comprehending the phenomenon of digital adoption. The dimension's reliability, as indicated by a Cronbach Alpha of 0.820, underscores its value as a robust indicator of the political aspects of digital adoption.

Digital Adoption encompasses six distinct elements that are specifically associated with the assimilation and utilisation of digital technologies within AVCs. The high factor loading values underscore the robust association between these items and the dimension of digital adoption. Despite its relatively lower value of 2.151, the eigenvalue remains a crucial contributor to the comprehension of digital adoption. The dimension exhibits a remarkably high Cronbach Alpha coefficient of 0.921, indicating its outstanding reliability as a measure of digital adoption within AVCs. This finding establishes the dimension as a dependable and valid tool for assessing digital adoption. Agriculture value chains (AVCs) dimension examines the distinct attributes of agriculture value chains, which consist of five components. The substantial factor loading levels emphasize the robust correlation between these items and the AVC dimension. Despite being somewhat smaller than other dimensions, the eigenvalue remains a significant factor in comprehending the broader context of digital adoption. The dimension in question demonstrates a high level of reliability in measuring aspects associated with AVCs and their impact on digital adoption, as evidenced by a coefficient of Cronbach Alpha *i.e.* 0.908.

The assessment of the institutional framework involves evaluating the contextual influences which affect the use of digital technologies in AVCs. The observed high factor loading values suggest a strong association between these items and the dimension of institutional framework. The eigenvalue, despite being the smallest among the dimensions, has a substantial role in enhancing the comprehension of digital adoption. The dependability of this dimension, which measures the institutional environment of digital adoption inside AVCs, is shown by a Cronbach Alpha coefficient of 0.844, indicating its usefulness. The aforementioned table demonstrates that digital adoption within Agriculture Value Chains is primarily influenced by economic and societal considerations, as well as the process of digital adoption itself. The aforementioned characteristics exhibit a high degree of reliability and serve as key factors in comprehending the intricacies of digital adoption. Although the political, AVC, and institutional dimensions all make notable contributions, their eigenvalues are slightly lower, suggesting a relatively smaller proportion of explained variance. However, the combination of these dimensions offers a holistic viewpoint on the extent of digital adoption in AVCs.

Table 4.2 Regression model for examining the impact on the adoption of digital technology for AVCs

Model		**Unstandardized Coefficients**	**Sig.**	**Collinearity Statistics**	
		Beta			
1	(Constant)	4.316	.000		
	Economic Factor	.504	.000	0.731	1.321
	Social Factor	.218	.009	0.607	1.352
	Political Factors	.166	.014	0.626	1.930
	Digital Adoption	.337	.004	0.948	1.230
	Institutional Framework	.112	.030	0.968	1.138
Model Summary					
Model	**R**	**R Square**	**Adjusted R Square**	**Sig. F change**	**Durbin Watson**
1	.525	.276	.270	.000	1.891

Source: Author's calculations SPSS 21.0 Version

Table 4.2 displays a regression model that investigates the influence on the adoption of digital technologies within Agriculture Value Chains (AVCs). The word labelled as "Constant" (4.316) in the model signifies the intercept, denoting the value of the dependent variable (specifically, the adoption of digital technology for AVCs) when all independent variables are assigned a value of zero. It is significant with a p-value of .000, demonstrating that there is a baseline level of digital technology adoption even without the influence of other factors. The coefficient associated with the Economic Factor is 0.504, and it is accompanied by a p-value of .000, which suggests a strong and statistically significant correlation between economic considerations and the use of digital technology in AVCs. This implies that enhancement or alteration of economic conditions exerts a significant beneficial influence on the implementation of digital technologies. The Social Factor exhibits a coefficient of 0.218, accompanied by a p-value of .009, so signifying a statistically significant association between social variables and the adoption of digital technology for AVCs. Enhancements in social aspects have a favourable influence on the adoption of digital technology in AVCs. The coefficient associated with Political Factors is 0.166, and it has a p-value of .014, indicating a statistically significant association between political elements and the implementation of digital technology. The use of digital technology in AVCs is influenced by political considerations, which can lead to either changes or improvements. These political elements have a favourable impact on the adoption of digital technology. The coefficient associated with Digital Adoption is 0.337, and it is accompanied by a p-value of .004, indicating a strong and statistically significant correlation between the deployment of digital technology and level of digital implementation in AVCs. This implies that the growth in digital adoption inside AVCs has a favourable influence on the general adoption of digital technology. Coefficient associated with the Institutional Framework variable is 0.112, and it is accompanied by a p-value of .030. These findings indicate a statistically significant association between the institutional framework and the adoption of digital technologies. The deployment of digital technology in AVCs experiences a beneficial influence as the institutional framework undergoes evolution or becomes more supportive. The collinearity statistics indicate that all components have a tolerance over 0.6, and the value of the variance inflation factor (VIF) is below 3. These findings show the absence of significant multicollinearity.

The R-squared value of 0.276 suggests that the parameters considered in the analysis collectively account for 27.6% of the variability observed in the adoption of digital technology in AVCs. This finding indicates a modest level of explanatory capability. The adjusted R-squared value of 0.270 takes into deliberation the various forecasters included in model, providing the more accurate measure of the model's goodness of fit. Additionally, the F-test, with a p-value of .000, provides strong evidence of the overall significance of the model. The Durbin-Watson statistic, with a value of 1.891, is employed to assess the presence of autocorrelation. In this particular instance, the statistic suggests the lack of first-order autocorrelation.

In brief, the regression model demonstrates the noteworthy influence of economic, social, political, digital adoption, and institutional aspects on the adoption of digital technology within Agriculture Value Chains. Taken together, these factors provide a comprehensive explanation for a significant proportion of the variability observed in the adoption of digital technology. The statistical significance of the p-values and the presence of collinearity statistics indicate the robustness and accuracy of the correlations established in the model. Consequently, this model serves as a great instrument for comprehending the various aspects that impact the adoption of digital technology in AVCs.

5. Data analysis evidence and supporting facts

The previous section described an Agricultural Value Chain (AVC) as a logical process that turns resources and raw materials into marketable items. From field production to consumption, several players and actions move agricultural products. It is critical to acquire a thorough grasp of the features of agricultural products, the various agrarian and customer categories, and the possible working capabilities of a digital service in order to assess the integration of digital technology in Agricultural Value Chains (AVCs). The service's pricing structure, together with continuous income streams, affects a digital enterprise's long-term stability and growth (Joiner & Okeleke, 2019). Bukht and Heeks (2018) define the digital economy as economic production based on digital technologies, including digital goods and services (Boateng et al., 2017). Digital economy generates value by using electronic information to enhance, substitute, or supplement economic activities. This phenomenon has become increasingly important in economic value generation (Constantinides et al., 2018).

The potential for enhanced connectivity between small-scale farmers and opportunities and benefits through the rising adoption of digital technology in Agricultural Value Chains (AVCs) can facilitate the scaling up of transformative efforts by governments. A crucial inquiry in comprehending the beneficiaries of this shift pertains to the aspects of control, ownership, and access concerning these novel forms of economic production (Graham, 2019). Hence, it is imperative for platform governance to build suitable frameworks and incentives that effectively strike a balance between openness and control among many stakeholders.

Although digital technology functions as a facilitator, it can present short-term advantages while potentially impeding the timely settlement of fundamental issues (Deichmann & Mishra, 2019). Gaining a comprehensive grasp of the motivations and repercussions among the various individuals engaged is of utmost importance (Constantinides et al., 2018). The comprehension of the growing complexity in digital development requires the adoption of a multidisciplinary approach, due to the involvement of several stakeholder groups with varying worldviews. It is imperative to prioritize the reinforcement of the commercial landscape, the augmentation of skills acquisition, and the establishment of mechanisms to ensure governmental responsibility (Jokonya, 2016). Digital technologies could alter agriculture. Deichmann et al. (2016) noted that numerous promising good results have not been widely implemented. Thus, understanding participants' multidisciplinary nature and creating institutions and governance norms to ensure that digital technology improves the socioeconomic position of disadvantaged people is crucial. This emphasizes the need of understanding the factors that influence small-scale agriculturalists' digital technology adoption in agricultural value chains (AVCs).

5.1. Adoption of digital technology in AVCs

Small-scale manufacturers can benefit from digital technology interventions in cost, productivity, and profit. These interventions may reduce Agriculture Value Chain (AVC) transaction costs by improving market connection (El Bilali & Allahyari, 2018). The inefficiencies and gaps cover information exchange and analytics, market access, financial access, and monitoring and traceability. To manage risks and ensure food safety, digital technology and food traceability systems are essential (FAO, 2013). Deichmann et al. (2016) tracked food through the supply chain to find its source. Export tracing regulations can also be made easier with AI and blockchain (OECD, 2019). In agricultural value chains (AVCs), digital payments are a key step in digital intervention (GSMA, 2018). Financial services, transaction efficiency, and market expansion are the main goals of these interventions. Small farmers often have trouble getting capital and using financial services. Deichmann et al. (2016) state that digital technology helps financial service providers combat financial exclusion by offering fast and secure payment solutions for purchases, agricultural subsidies, inputs and remittances. This improves payment options, credit facilities, and collateral management, according to Joiner and Okeleke (2019). Small-scale farmers can tailor financial services to their needs and abilities with digital innovation (Joiner & Okeleke, 2019). Deichmann et al. (2016) say digital technology helps farmers make input, weather, and investment decisions. These technological advances optimize small-scale farming and boost agricultural productivity (Joiner & Okeleke, 2019).

Smallholder farmers in India encounter substantial obstacles stemming from demographic pressures and the ramifications of climate change, rendering the sustenance of their livelihoods arduous. Conversely, the process of urbanization and the subsequent economic expansion are generating novel prospects within the markets for both processed and fresh foods in the region. In order to effectively tackle the obstacles associated with rural poverty and vulnerability, it is imperative to facilitate the transition of small-scale farms from subsistence-based endeavors to financially viable, commercially-oriented enterprises, while concurrently enhancing their linkages to expanding food markets (Begashaw et al., 2019). According to the OECD (2019), the implementation of digitalization in the context of Agricultural Value Chains (AVCs) can contribute to the advancement of transparency, effective transmission of information, and the automation of various procedures and documentation. In addition, the use of digital technology interventions has been shown to result in favorable environmental consequences through the facilitation of enhanced resource efficiency, the mitigation of environmental footprints, the reduction of greenhouse gas emanations, and the minimization of losses of food (El Bilali & Allahyari, 2018).

Digital technology benefits society across sectors, supporting the United Nation's Sustainability Development Goals (SDGs) (Joiner & Okeleke, 2019). It improves food supply chain transparency, stakeholder information access, food safety, and networking for small-scale agriculturalists (El Bilali & Allahyari, 2018). Digital technology can enhance the rural households' food security, asset value, income and livelihoods, improving resource management and creating opportunities, according to Deichmann et al. (2016). Joiner and Okeleke (2019) note that this technology can increase production, reduce resource waste, and enable rural digital and financial inclusion. Small-scale agriculturalists struggle to adopt digital technology due to infrastructure, training, and cost. Women and youth must have equal access to agricultural productivity information, financial opportunities, and markets to achieve sustainable digital agricultural value chain (AVC) models for small-scale farmers (Bayer, 2018). Small-scale agriculture and rural development require inclusivity.

5.2. Institutional implications

Information sharing is an essential procedure that helps different people or institutions acquire and share knowledge and skills. Information analytics is the process of analyzing data to produce results for partners, external clients, or internal reporting needs (FAO, 2013). According to Constantinides et al. (2018), digital platforms are collections of digital assets that include content and services that facilitate value creation through interactions among external producers, third-party entities and consumers. These platforms have developed to the point that they may now include expertise from different industries without being limited by regional institutional setups (Quinones et al., 2017).

The efficacy of digital technology interpositions is reliant on extensive official support that facilitates the advancement of human capital development, political empowerment, and wealth inequality issues (El Bilali and Allahyari, 2018). Organizations such as Digital Innovation Hubs (DIHs), as described in the 2017 EIP-AGRI report, work to improve market accessibility by creating connections between different competence centers and supporting investors, small-scale farmers, IT vendors, and digital technology experts. Competence centers, advisors/innovation brokers, start-ups, entrepreneurs, small and medium-sized businesses (SMEs), public and private investors, local and national government agencies, and the farming community are essential elements of a perfect framework (EIP-AGRI, 2017).

Implementing a thorough and integrated plan that successfully addresses all relevant issues at the same time is essential to fostering an inclusive and growth-oriented agricultural transformation. Plans from other industries should be in line with those from agriculture to form a coherent whole. Appropriate infrastructure integration can promote economic development, lessen rural poverty, and make it easier for various sectors to interact (Begashaw et al., 2019). The subsequent segment underscores the significance of farmer-centered engagement and cooperation in tackling institutional and governance obstacles linked to the application of digital technology in agricultural value chains (AVCs) that encompass small-scale agrarians. The comprehensive growth of agriculture industry depends on this cooperative approach.

5.3. **Collaboration and participation**

In order to develop effective digital solutions for the Agricultural Value Chain (AVC), it is imperative to have a comprehensive understanding of the requirements and principles held by farmers. According to Wisdom et al. (2018), it is imperative to guarantee that the items align with their specific requirements in order to achieve successful adoption and commercial viability. According to Awuor et al. (2016), there are two strategic approaches that can be employed to address the information needs of farmers: community engagement and collaborative approaches. Farmers play an active role in the development and application of digital technology solutions through the community involvement approach. Previous research conducted by Habiyaremye et al. (2019) has provided evidence supporting the notion that government help and increased participation from local community members positively impact the probability of success for creative enterprises.

The collaborative approach acknowledges the limitations of relying just on a single source to adequately address the diverse information requirements of farmers. This statement emphasizes the need of ensuring that all providers of information share a common aim of promptly delivering the necessary information beside their respective jurisdictions (Awuor et al., 2016). In order to cultivate trust and enhance customer loyalty, it is imperative for AVCs to align their decision-making about the adoption of digital technologies with the prevailing market dynamics in the respective regions (Joiner & Okeleke, 2019).

Awuor et al. (2016) suggest stakeholders collaborate more to address their interests and help each other. Digital AVC business models must be tailored to local market characteristics to maximise business potential and ensure long-term success (Joiner & Okeleke, 2019). Many agricultural stakeholders must collaborate to generate and adapt material in native tongues to provide timely and equitable access to agricultural information for agrarians with limited resources. Sharing and spreading knowledge is the goal of this collaboration (FAO et al., 2018). Jackson and Weinberg (2016) suggest that small, transient digital liquidity may not benefit. Therefore, digital AVCs (Alternative Virtual Currencies) must reach critical mass to have an impact. Agriculture stakeholders must support affordable, and sustainable digital technology services (FAO et al., 2018). This article examines digital development and its effects on Indian small-scale agriculture. It examines how digital technology could help this sector grow. Despite the challenges of digital technology interventions on social change, their importance in development cannot be overstated.

6. Concluding remarks

Digital technologies in agricultural value chains worry small farmers. Few academic studies have compared these issues and their causes. To address a knowledge gap, this study examines how social, political and economic elements affect small-scale farmers' digital technology implementation in agricultural value chains (AVCs). We emphasize policy governance and institutional implications. The study shows that the state's role in governance and institutions is more complicated than thought. Since digital technology is complex, small-scale farmers usually adopt it after becoming confident in its capabilities. This study supports previous findings that small-scale farmers should collaborate and participate in digital technology policy frameworks in agricultural value chains. Digital harm reduction requires stakeholder collaboration on digital policies. This approach promotes sustainability and digital inclusion, per Heeks (2018) and the UN (2019). This study emphasizes the need to tailor digital solutions for small-scale agriculturalists to their local preferences and needs. To overcome these challenges and minimize negative effects, one must understand each nation's unique limitations and develop customized strategies. Thus, localized developmental implementation frameworks are needed to integrate digital solutions into autonomous vehicle ecosystems. The framework should include global, regional, and national AVCs. Digital technology in agriculture is limited in its ability to solve farmers' many problems. Despite some positive results, digital technology adoption and implementation have often failed to meet expectations. This study illuminates the causes of these issues, suggesting future research. A all-inclusive developmental outline which can be empirically validated among a representative sample of Indian adults requires more research. This study promotes a comprehensive theoretical framework on small-scale agriculturalists' digital technology use in agricultural value chains. This resource may help digital development researchers focus and direct their work. A number of research gaps are suggested to achieve this goal. The previous initiatives encompass the identification of optimal methodologies, establishment of market standards and requirements, promotion of public-private collaborations, analysis of the roles of youth and women, enhancement of training, capability and refinement of digital technology policies within agricultural value chains of small-scale agriculturalists.

References

- Action Aid International. (2011). *What women farmers need*. Action Aid International, Johannesburg, South Africa. ADBG. (2013). *Agricultural value chain financing (AVCF) and development for enhanced export competitiveness*. African Development Bank Group (ADBG).
- Alkire, S. (2005). *Capability and functionings: Definition and justification* (HDCA introductory briefing note). Human Development and Capability Association (HDCA).
- Andersson, A., Grönlund, Å., & Wicander, G. (2012). Development as freedom – How the capability approach can be used in ICT4D research and practice (editorial). *Information Technology for Development Journal*, *Volume 18*(1), 1–4. https:// doi.org/10.1080/02681102.2011.632076
- AUC & AUDA-NEPAD. (2020, February). *First continental report on the implementation of agenda 2063*. African Union Commission (AUC) and the African Union Development Agency-NEPAD (AUDA-NEPAD). ISBN number: 978-1- 928527-22-0.
- Awuor, F., Raburu, G., Onditi, A., & Rambim, D. (2016). Building e-agriculture framework in Kenya. *Journal of Agricultural Informatics*, *7*(1), 75–93. https://doi.org/10.17700/jai.2016.7.1.244.
- Bayer, J. (2018). *Harnessing the chances of digitalisation for rural development: Lessons-learnt in German-funded rural development projects*. Deutsche Gesellschaft fürInternationale Zusammenarbeit (GIZ) GmbH Registered Offices Bonn and Eschborn Sectoral Project Rural Development. https://www.giz.de/fachexpertise/html/3189.html, https://www.snrd-africa.net/
- Begashaw, B., Verburg, G., Yamauchi, F., Fattibene, B., & Yasuo, F. (2019). *Cooperation with Africa – Linking smallholder production with value-added food markets*. Africa 2030, SDG Center for Africa.
- Boateng, R., Budu, J., Mbrokoh, A. S., Ansong, E., Boateng, S. L., & Anderson, A. B. (2017). *Digital enterprises in Africa: A synthesis of current evidence* (DIODE network paper no. 2). Centre for Development Informatics, University of Manchester.
- Bukht, R., & Heeks, R. (2018). *Digital economy policy in developing countries* (DIODE network paper no. 6). Centre for Development Informatics, University of Manchester.
- Campion, A. (2018, June 15). *Cracking the nut: Promoting agricultural technology adoption and resilience*. Connexus, Antigua, Guatemala.
- Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Introduction—Platforms and infrastructures in the digital age. *Information Systems Research*, *29*(2), 381–400. https://doi.org/10.1287/isre.2018.0794
- Cooper, H. (2010). *Research synthesis and meta-analysis: A step-by-step approach* (5th ed.). Sage.
- Corallo, A., Latino, M. E., & Menegoli, M. (2018). From industry 4.0 to agriculture 4.0: A framework to manage product data in agri-food supply chain for voluntary traceability. *World Academy of Science, Engineering and Digital Technology International Journal of Nutrition and Food Engineering*, *12*(5), 126–130. https://scholar.waset.org/1307- 6892/10008961
- DAFF. (2016, May 30). *Transforming the agricultural sector towards an inclusive rural economy "food*

for all and 1 million jobs, by 2030", a concept document for Operation Phakisa Agriculture, Land Reform and Rural Development. Department of Agriculture, Forestry and Fisheries (DAFF).

- Deichmann, U., Goyal, A., & Mishra, D. (2016). *Will digital technologies transform agriculture in developing countries?* (Policy research working paper series 7669). World Bank.
- Deichmann, U., & Mishra, D. (2019). Marginal benefits at the global margins: The unfulfilled potential of digital technol- ogies. In M. Graham (Ed.), *Digital economies at global margins* (pp. 21–24). International Development Research Centre, London, MIT Press.
- EIP-AGRI. (2017, October). *Seminar: Digital innovation hubs for agriculture* (Final report European Innovation (EIP-AGRI) Partnership – Agricultural Productivity and Sustainability). European Commission.
- El Bilali, H., & Allahyari, S. (2018). Transition towards sustainability in agriculture and food systems: Role of information and communication technologies. *Information Processing in Agriculture*, *5*(4), 456–464. https://doi.org/10.1016/j.inpa. 2018.06.006
- FAO. (2013). *Information communication digital technology (ICT) solutions for inclusive agricultural value chains*. Food and Agriculture Organization (FAO). http://www.fao.org/docrep/017/aq078e/aq078e.pdf
- FAO. (2015). *Achieving zero hunger: The critical role of investments in social protection and agriculture*. Food and Agriculture Organization (FAO), International Fund for Agricultural Development. http://www.fao.org/3/a-i4777e.pdf
- FAO & AUC. (2018). *Sustainable agricultural mechanization: A framework for Africa*. Food and Agriculture Organization (FAO) & African Union Commission (AUC). 127 pp.
- FAO, IFPRI & OECD. (2018). *Information and communication digital technology (ICT) in agriculture*. A report to the G20 agricultural deputies prepared by Food and Agriculture Organization of the United Nations (FAO) with inputs from International Food Policy Research Institute (IFPRI) and Organization of Economic Cooperation and Development (OECD).
- FAO and ITU. (2016). *E-agriculture strategy guide. Piloted in Asia-Pacific countries*. Published by the Food and Agriculture Organization (FAO) of the United Nations and the International Telecommunications Union (ITU), Bangkok.
- FAO & ITU. (2017). *Paving the way to a national e-agriculture strategy*. Technical Centre for Agricultural and Rural Cooperation ACP-EU Online Discussion on the e-Agriculture Platform.
- Foster, C., & Heeks, R. (2015). *Policies to support inclusive innovation* (DIODE network paper). Centre for Development Informatics, University of Manchester. https://doi.org/10.1016/0736-5853(84)90003-0
- Gaiha, R., & Mathur, S. (2018). *Agricultural research, digital technology and nutrition in Sub-Saharan Africa* (GDI working paper 2018-029). University of Manchester.
- Gigler, B. (2004, September 5–7). *Including the excluded: Can ICTs empower poor communities?* Paper presented at 4th International Conference on the Capability Approach, Pavia, Italy.
- Gillespie, J., Kim, S. A., & Paudel, K. (2007). Why don't producers adopt best management practices? An analysis of the beef cattle industry. *Agricultural Economics*, *36*(1), 89–102. https://doi.org/10.1111/j.1574-0862.2007.00179.x
- Graham, M. (2019). Changing connectivity and digital economies at global margins. In M. Graham (Ed.), *Digital econom- ies at global margins* (pp. 1–18). International Development Research Centre, London,

MIT Press.

- GSMA. (2018). *Opportunities in agricultural value chain digitisation: Learnings from Uganda*. Groupe Spéciale Mobile Association (GSMA). https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/01/Opportunities- in-agricultural-value-chain-digitisation-Learnings-from-Uganda.pdf
- Habiyaremye, A., Kruss, G., & Booyens, I. (2019). Innovation for inclusive rural transformation: The role of the state. *Innovation and Development*, *10*(2), 155–168. https://doi.org/10.1080/2157930X.2019.1596368.
- Heeks, R. (2016). *Examining "digital development": The shape of things to come?* (GDI development informatics working papers, no. 64) (pp. 1–84).
- Heeks, R. (2018). *Development implications of digital economies* (DIODE network paper). Centre for Development Informatics, University of Manchester.
- Horner, R., & Alford, M. (2019). *The roles of the state in global value chains: An update and agenda* (GDI working paper 2019-036). University of Manchester.
- ITU. (2016). *ITU-T focus group digital* financial services. *Impact of agricultural value chains on digital liquidity*. International Telecommunications Union (ITU).
- Jackson, T. H., & Weinberg, A. (2016). *Impact of agricultural value chains on digital liquidity – Focus group technical report*. https://creativecommons.org/licenses/by-nc-sa/4.0/
- Joiner, J., & Okeleke, K. (2019). *E-commerce in agriculture: New business models for smallholders' inclusion into the formal economy*. GSMA Head Office.
- Jokonya, O. (2016). Towards a critical systems thinking approach during IT adoption in organisations. *Procedia Computer Science*, *100*, 856–864. ISSN 1877-0509. https://doi.org/10.1016/j.procs.2016.09.235
- Juma, C. (2019). Digital services and industrial inclusion: Growing Africa's technological complexity. In M. Graham (Ed.), *Digital economies at global margins* (pp. 33–37). International Development Research Centre, London, MIT Press. Kanoktanaporn, S., Diao, X., Matsushita, S., Aoyogi, Y., Briones, M. R., Jiang, J. A., Takeshima, H., Saeed, M., Hossain, S. T.,
- Watanabe, K., & Parth, S. (2019). *APO agricultural transformation framework*. Asian Productivity Organization (APO). Kleine, D. (2010). ICT4What? Using the choice framework to operationalize the capability approach to development. *Journal of International Development*, *22*(5), 674–692. https://doi.org/10.1002/jid.1719 Krone, M., & Dannenberg, P. (2018). Analysing the effects of information and communication technologies (ICTs) on the
- integration of East African farmers in a value chain context. *Zeitschrift für Wirtschaftsgeographie*, *62*(1), 65–81. https:// doi.org/10.1515/zfw-2017-0029
- Lee, H. L., Mendelson, H., & Rammohan, S. (2017, August). *Technology in agribusiness-opportunities to drive value* (White paper). Stanford Value Chain Innovation Initiative, Stanford Graduate School of Business, United States.
- Loukos, P., & Javed, A. (2018). *Opportunities in agricultural value chain digitisation: Learnings from Ghana*. GSM Association. https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2018/01/
- Mago, S., & Mago, S. (2015). Information and communications technologies (ICTs) and livelihoods enhancement

in agro- rural communities in Zimbabwe: Connections using the capabilities approach. *Journal of Communication*, *6*(1), 93–103. https://doi.org/10.1080/0976691X.2015.11884851

- Malan, N. (2018). *The new agriculture and developing emerging farmers: Harnessing the fourth industrial revolution*. https://www.dailymaverick.co.za/article/2018-12-09-the-new-agriculture-and-developing-emerging-farmers-harnessing- the-fourth-industrial-revolution/
- Maru, A., Berne, D., De Beer, J., Pesce, V., Kalyesubula, S., Fourie, N., Addison, C., Collett, A., & Chaves, J. (2018). *Digital and data-driven agriculture: Harnessing the power of data for smallholders*. Global Forum on Agricultural Research and Innovation (GFAR), with Global Open Data for Agriculture and Nutrition (GODAN) Initiative and the Technical Centre for Agricultural and Rural Cooperation (CTA).
- Mattern, M., & Ramirez, R. (2017). *Digitizing value chain finance for smallholder farmers* (Focus note 106). CGAP.
- Matto, G. (2018). Agriculture information access and the use of ICTs among smallholder farmers: A case of Bembeke EPA in Dedza District, Malawi. *Research Report Series*, *2*(1), 59–72.
- Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). Preferred reporting items for systematic reviews and meta-ana- lyses: The PRISMA statement. *PLoS Medicine*, *6*(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097
- Munyua, H. (2007). *ICTs and small-scale agriculture in Africa. A scoping study*. IDRC. http://www.idrc.ca/uploads/user-S/ 12212542261Final_Report_HMunya.pdf
- Musa, N. S., Githekho J. M., & El-siddig, K. (2013). The adoption and use of ICT by small-scale farmers in Gezira State, Sudan. *International Journal of Trade, Economics and Finance*, *4*(2).
- NAHF. (2017). *An overview of Operation Phakisa*. National Animal Health Forum (NAHF). http://nahf.co.za/an-overview- of-operation-phakisa-2017-04-07/
- Nmadu, J., Aiyelitsoya, N., A, F., & Sallawu, H. (2013). Use of ICT in securing marketing information among small scale farmers in Niger State, Nigeria. *International Journal of Trade, Economics and Finance*, *4*(2), 66–72. https://doi.org/ 10.7763/IJTEF.2013.V4.262
- Odini, S. (2014). Access to and use of agricultural information by small scale women farmers in support of efforts to attain food security in Vihiga County, Kenya. *Journal of Emerging Trends in Economics and Management Sciences*, *5* (2), 80–86. https://hdl.handle.net/10520/EJC152937
- OECD. (2019). *Digital opportunities for trade in agriculture and food sectors*. Joint Working Party on Agriculture and Trade, Organisation for Economic Co-operation and Development (OECD) TAD/TC/CA/WP (2018)4/FINAL.
- Ospina, A. V., & Heeks, R. (2016). *Measuring and intervening on resilience: The RABIT approach*. Centre for Development Informatics, University of Manchester.
- Ospina, A. V., Heeks, R., Camacho, K., Calvo, M., Zuniga, V., Barrios, P., & Rojas, I. (2016). *Benchmarking urban community resilience*. Centre for Development Informatics, University of Manchester.
- Paudel, K. P., Mishra, A. K., Pandit, M., Larkin, S., Rejesus, R., & Velandia, M. (2020). Modeling multiple reasons for adopting precision technologies: Evidence from U.S. cotton producers. *Computers and Electronics in Agriculture*, *175*, 105625. https://doi.org/10.1016/j.compag.2020.105625
- Paudel, K. P., Pandit, M., Mishra, A. K., & Segarra, E. (2011). *Why don't farmers adopt precision farming*

technologies in cotton production? (No. 321-2016-10736).

- Pesce, M., Kirova, M., Soma, K., Bogaardt, M. J., Poppe, K., Thurston, C., Monfort Belles, C., Wolfert, S., Beers, G., & Urdu, D. (2019). *Research for AGRI committee – Impacts of the digital economy on the food-chain and the CAP*. European Parliament, Policy Department for Structural and Cohesion Policies.
- Quinones, G., Heeks, R., & Nicholson, B. (2017). *The broad issues surrounding digital data, information, knowledge, information systems, and information and communication technologies in the process of socio-economic development* (Development Informatics paper 67). University of Manchester. http://www.gdi.manchester.ac.uk/research/ publications/working-papers/di/
- Robeyns, I. (2005). Sen's capability approach to welfare economics. In W. Kuklys (Ed.), *Amartya* (pp. 9–30). Berlin: Springer. *Sen's capability approach theoretical insights and empirical applications* (pp. 9–30). Berlin: Springer..
- Rose, D. C., & Chilvers, J. (2018). Agriculture 4.0: Broadening responsible innovation in an era of smart farming. *Frontiers in Sustainable Food Systems*, *2*(87), 1–7. https://doi.org/10.3389/fsufs.2018.00087.
- Samii, R. (2008, August 24–27). *Role of ICTs as enablers for agriculture and small-scale farmers*. International Fund for Agricultural Development (IFAD). Joint Conference of IAALD, AFITA and WCCA World Congress.
- SDSN. (2015). *Indicators and a monitoring framework for the sustainable development goals: Launching a data revolution for the SDGs*. A report for the Leadership Council of the Sustainable Development Solutions Network (SDSN). Revised working draft (version 7). http://unsdsn.org/wp-content/uploads/2015/03/150320-SDSN-Indicator-Report.pdf
- Sealey, D. (2018). *Digital value chain: It's time for smallholder farmers to enter value chains*. http://storm81.com/strategy/ digital-value-chain
- Sen, A. (1985). Well-being, agency and freedom: The Dewey lectures 1984. *The Jornal of Philosophy*, *82*(4), 169–221. Sen, A. (1999). *Development as freedom*. Oxford University Press.
- Stewart, F., & Deneulin, S. (2002). Amarta Sen's contribution to development thinking. *Studies in Comparative International Development*, *37*(61), 61–70.
- Stugeon, T. (2017). *The 'New' digital economy and development* (UNCTAD technical notes on ICT for development No. 8).
- Thamaga-Chitja, J. M., & Morojele, P. (2014). The context of smallholder farming in South Africa: Towards a livelihood asset building framework. *Journal of Human Ecology*, *45*(2), 147–155. https://doi.org/10.1080/09709274.2014.11906688
- Tuli, F. (2005). The basis of distinction between qualitative and quantitative research in social science: Reflection on ontological, epistemological and methodological perspectives. *Journal of Education & Science*, *6*(1), 97–108. https://doi.org/10.4314/ejesc.v6i1.65364
- UN. (2019). *Project breakthrough*. PA Knowledge. United Nations (UN) Global Compact. https://www.paconsulting.com/ insights/2018/sustainability/united-nations-global-compact/
- Ungerer, M., Bowmaker-Falconer, A., Oosthuizen, C., Phehane, V., & Strever, A. (2018). *The future of the Western Cape agricultural sector in the context of the fourth industrial revolution* (Synthesis report). Western Cape Department of Agriculture (WCDoA), together with the University of Stellenbosch Business School (USB).

- Vroegindewey, R., & Hodbod, J. (2018). Resilience of agricultural value chains in developing country contexts: A frame- work and assessment approach. *Sustainability*, *10*(4), 916. https://doi.org/10.3390/su10040916
- Webster, J., & Watson, R. T. (2002). Analysing the past to prepare for the future: Writing a literature review. *MIS Quarterly*, *26*(2), 13–23. http://www.jstor.org/stable/4132319
- Wisdom, A., Baatjies, N., Biallas, M. O., Caire, D., Heitmann, S., Kasujja, A., Dueck-Mbeba, R., Mudiri, J., Naouar, R., Ndaw, C.,Oulai, R., Ramji, M., Savonitto, B., & Wensley, M. (2018). *Digital financial services for agriculture*. International Finance Corporation, World Bank Group.
- Zheng, Y. (2007). *Exploring the value of the capability approach for e-development*. Proceedings of the 9th International Conference on Social Implications of Computers in Developing Countries, San Pablo, 28-30 May 2007.