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A Framework for Fourth Industrial Revolution Adoption by Small-Scale Rural Farmers in Sub-Saharan Africa: A Systematic Literature Review

By Willard Munyoka, Nkhangweni Lawrence Mashau and Modimowabarwa Kanyane

Abstract

Climate change is witnessed in unpredictable weather conditions that negatively affect human lives, economies, and farming worldwide. This results in severe heat waves and a shift in rainfall patterns. This is a major global threat to agriculture and food security, especially for rural farmers. Small-scale rural-based farmers contribute immensely to local communities' socio-economic well-being and food security. However, most of the small-scale rural farmers are constrained, especially regarding resources. There is a need for the agricultural industry in rural areas to adopt the fourth industrial revolution (4IR) technologies to predict and make well-informed decisions on how to manage existing, often constrained resources efficiently. Government support, in various forms, is equally needed. Furthermore, adopting 4IR by small-scale rural farmers will assist countries in the Sub-Saharan African region in achieving the United Nations Sustainable Development Goal Number 2 on 'Zero Hunger' by achieving food security and promoting smart, sustainable agriculture. However, there is a deficiency in the literature on 4IR adoption frameworks to guide small-scale rural farmers in adopting 4IR tools to manage their resources and promote sustainable agriculture. This study aims to develop a 4IR adoption framework that could guide small-scale rural farmers in adopting 4IR tools for managing their resources and promoting smart agriculture. A systematic literature review approach is employed to identify critical components significant for adopting 4IR in rural farming. Rural farmers may use this framework as a guiding lens when adopting 4IR tools. This study broadens the scope of the scant literature on the best practices for adopting 4IR for smart small-scale rural farming in Sub-Saharan Africa and other developing nations with similar setups. The smart-scale rural farming is mainstreamed within the smart village concept and the greenfield or green economy resilient to harsh climate change conditions.

> The small-scale farmers represent a significant portion of the Sub-Saharan African region's population and play a crucial role in ensuring food security, yet they often face numerous challenges when it comes to the adoption of 4IR technologies *(Kakani et al. 2020; Almadani and Mostafa 2021; Dlamini, Chizema and Van Greunen 2023)*

Introduction

The literature shows that the Fourth Industrial Revolution (4IR) is emerging as a hot potato in the agricultural sector with a focus on smart agriculture meant to address climate change and population growth (Javaid et al. 2022; Joy et al. 2022; Sharma et al. 2022)with a focus on smart and precision agriculture to maximise benefits in the context of growing populations and climate change. Agriculture 4.0 supports the adoption of intelligent systems in all spheres of farming, harvesting, irrigation, and so on. Though there is enough inclusion of Artificial Intelligence and Internet of Things (IoT. Adding to that, 4IR is upon us, ushering in an era of unprecedented technological advancement and innovation that has the potential to transform agriculture industries, economies and societies worldwide (Joy et al. 2022; Slob and Hurst 2022)with a focus on smart and precision agriculture to maximise benefits in the context of growing populations and climate change. Agriculture 4.0 supports the adoption of intelligent systems in all spheres of farming, harvesting, irrigation, and so on. Though there is enough inclusion of Artificial Intelligence and Internet of Things (IoT. The 4IR presents boundless opportunities for growth and development, particularly for small-scale rural farmers in Africa (Dlamini, Chizema and Van Greunen 2023; Ngongoma, Kabeya and Moloi 2023)which is well developed. Despite the increase of commercial agriculture, the agricultural expansion of smallholders is essential for long-term socioeconomic stability and food security. A smart farming culture is described in the fourth industrial revolution (4IR.

The small-scale farmers represent a significant portion of the Sub-Saharan African region's population and play a crucial role in ensuring food security, yet they often face numerous challenges when it comes to the adoption of 4IR technologies (Kakani et al. 2020; Almadani and Mostafa 2021; Dlamini, Chizema and Van Greunen 2023) which is well developed. Despite the increase of commercial agriculture, the agricultural expansion of smallholders is essential for long-term socioeconomic stability and food security. A smart farming culture is described in the fourth industrial revolution (4IR. They encounter challenges such as a lack of digital infrastructure, technologies, digital literacy, data analytics, and budget, to name a few (Sharma et al. 2022; Talari et al. 2022). Similarly, African small-scale rural farmers face many challenges, including limited access to resources, climate change and market volatility (Winberg 2020; Dlamini, Chizema and Van Greunen 2023)which is well developed. Despite the increase of commercial agriculture, the agricultural expansion of smallholders is essential for long-term socioeconomic stability and food security. A smart farming culture is described in the fourth industrial revolution (4IR.

The adoption of 4IR technologies, such as precision agriculture, Internet of Things (IoT) sensors, artificial intelligence, and blockchain may address some of the pressing issues in small-scaled farms (Noor et al. 2022; Campuzano et al. 2023; Hassoun et al. 2023)including the dairy industry. Growing literature shows that the adoption of technologies of the fourth industrial revolution (named Industry 4.0. For example, IoT sensors can assist small-scale rural farmers by monitoring soil moisture levels in real-time to enable them to manage and improve water usage while ensuring that the crops achieve the anticipated growth (Campuzano et al. 2023). Similarly, AI-powered predictive analytics may assist rural farmers in predicting weather patterns or pest outbreaks, just to name a few, to enable them to plan for these disastrous events in advance to minimise losses.

These technologies can enhance productivity, increase crop harvests, improve resource management and provide valuable insights into market dynamics that will ultimately improve the livelihoods of rural farming communities (Joy et al. 2022; Noor et al. 2022; Sarkar et al. 2023)with a focus on smart and precision agriculture to maximise benefits in the context of growing populations and climate change. Agriculture 4.0 supports the adoption of intelligent systems in all spheres of farming, harvesting, irrigation, and so on. Though there is enough inclusion of Artificial Intelligence and Internet of Things (IoT. Blockchain technologies could ensure transparent and traceable supply chains, allowing small-scale farmers to gain trust and secure better market prices for their products (Campuzano et al. 2023; Gumbi, Gumbi and Twinomurinzi 2023)including the dairy industry. Growing literature shows that the adoption of technologies of the fourth industrial revolution (named Industry 4.0.

In the literature, there is little research that explores and develops a framework for the fourth industrial revolution adoption by small-scale rural farmers in Sub-Saharan Africa to manage their resources and promote sustainable agriculture (Dlamini, Chizema and Van Greunen 2023; Hassoun et al. 2023; Ngongoma, Kabeya and Moloi 2023) which is well developed. Despite the increase of commercial agriculture, the agricultural expansion of smallholders is essential for long-term socioeconomic stability and food security. A smart farming culture is described in the fourth industrial revolution (4IR. Therefore, this study aims to develop a 4IR adoption framework that could guide small-scale rural farmers to adopt 4IR tools. To achieve this aim, this study employed a systematic literature review (SLR) to critically examine and synthesize the existing literature to develop a framework to assist small-scale farmers in adopting 4IR in Sub-Saharan Africa.

The conceptual framework targets to bridge the gap by offering practical, accessible guidelines that small-scale rural farmers can follow to integrate 4IR technologies into their farming practices. The proposed framework will be specifically developed considering the distinct conditions of rural areas, including their resource limitations. In addition, this framework will offer insights into the critical factors that small-scale rural farmers must address before the implementation of 4IR in the farms. This study will also make a significant contribution to the academic literature by providing a study that will inform future investigations.

The SLR aims to provide a comprehensive overview of the existing body of research on the adoption of 4IR technologies by small-scale rural farmers in Sub-Saharan Africa (Schukat and Heise 2021; Rudrakar and Rughani 2023). It also seeks to identify the key factors that may influence the adoption decisions, assess the impact of 4IR technologies on agricultural practices, and propose a robust framework to facilitate the successful integration of these transformative innovations into the agricultural landscape of the region (Niloofar et al.

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2021; Spanaki, Karafili and Despoudi 2021; Abbate, Centobelli and Cerchione 2023).

In the succeeding sections that follow, the study will explore the concept of 4IR, small-scale rural farms and 4IR adoption. This is done to elucidate the challenges and opportunities faced by small-scale rural farmers and propose a robust framework that integrates technological, socioeconomic, and institutional factors to facilitate a sustainable and inclusive transformation of the agriculture sector in the region. Furthermore, the systematic literature review method will be discussed to outline the process that was followed when conducting this study. Finally, this aspires to contribute to the ongoing discourse surrounding the 4IR to potentially revolutionise small-scale rural farms, reduce rural poverty, and secure food production for future generations in Sub-Saharan Africa.

Methodology

This study employed a systematic literature review (SLR) to identify and review literature to develop a framework for 4IR adoption by small-scale rural farmers in Sub-Saharan Africa. The researchers started by searching for the literature from the IEEE Xplorer, ProQuest, ScienceDirect and Web of Science databases. This study is an interdisciplinary field since it cuts through information systems and agriculture. Therefore, multidisciplinary databases that often used in the studies of this nature were chosen (Campuzano et al. 2023; Gumbi, Gumbi and Twinomurinzi 2023; Mashau, Kroeze and Howard 2021). The literature was searched from these databases using the following keywords to extract relevant articles:

- "Fourth Industrial Revolution" AND "Small-Scale Farming"
- "Fourth Industrial Revolution" AND "Farming"
- "Fourth Industrial Revolution AND "Small-Scale Farm"
- "Fourth Industrial Revolution AND "Farm"
- "4IR" AND "Small-Scale Farming"
- "4IR" AND "Farming"
- "4IR" AND "Farm"
- "4IR" AND "Small-Scale Farm"

The literature was searched examining all the metadata. Each search was restricted to articles that were peer-reviewed and written in English between 01/01/2018 and 08/092023. In total, all the searches retrieved 317 articles from the selected databases (see Table 2). Therefore, duplicated articles were identified, and 103 duplicated files were deleted from the review pool. Furthermore, the remaining articles were screened by examining titles and the abstract to verify their relevance. All the sources whose abstracts were relevant and aligned with this study's focus on the adoption of 4IR technologies in rural farming were added to the review pool. One hundred seventy-two (172) articles were deleted from the review pool during this phase because they were not related to the 4IR topic.

Table 2: SLR search results

Databases	Initial search results	Final reviewed results
IEEE Xplorer	52	7
ScienceDirect	183	13
Web of Science	55	15
ProQuest	27	1
Total	317	36

From all the articles that were saved in the review pool, the full text was read, and 6 more articles were deleted from the review pool because it was realised after this close reading that the content was not relevant to the 4IR topic. In total 36 articles that are pertinent to this study were reviewed to develop a framework for 4IR adoption by small-scale rural farmers in Sub-Saharan Africa. To minimise or avoid personal bias and to ensure that all relevant articles are considered, all the authors conducted the search and screening independently and evaluated the articles for inclusion and exclusion based on the PRISMA model. After that, the authors met and discussed their disagreements, looking at the articles' relevance, rigour and value.

Overview of the Fourth Industrial Revolution

The term fourth industrial revolution was coined in 2016 by Klaus Schwab (Effoduh 2016). This term is also known as Industry 4.0 (Guha, Chakrabarti and Chatterjee 2021; Joy et al. 2022). In the literature, scholars define this term differently (see Table 3):

Apart from the definitions highlighted in Table 1, the fourth industrial revolution in farming is also known as Agricultural 4.0. Therefore agricultural 4.0 is seen as the use of intelligent tools such as the Internet of Things, big data, artificial intelligence,

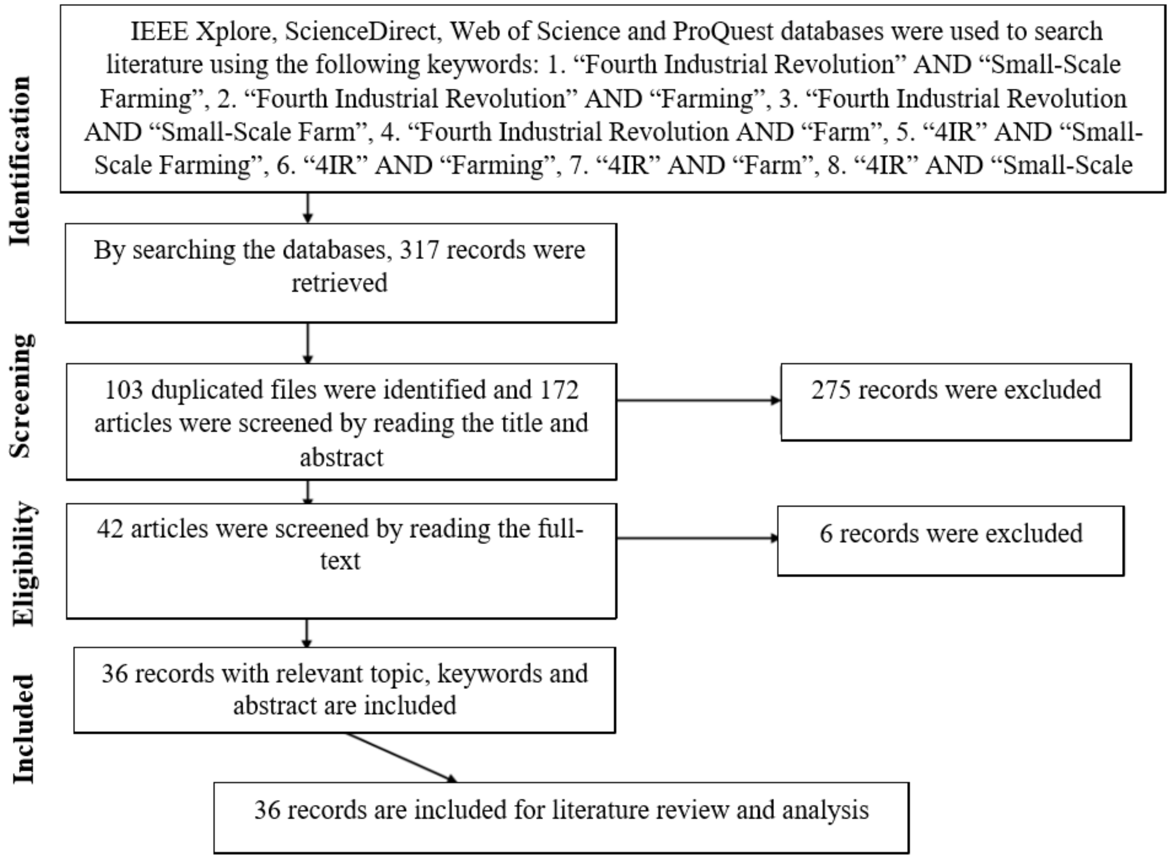

Figure 1: Systematic Literature Review identification diagram

Table 3: Fourth Industrial Revolution definitions

Authors	Definitions
Slob and Hurst (2022)	The 4IR is defined as a combination of innovations in AI, robotics, the IoT, genetic engineering, quantum computing, and other technologies.
Dlamini et al. (2023)	The 4IR is defined as an idea that combines AI and big data to monitor, identify insect pests, detect soil moisture, decide when to harvest, and reduce labour-intensive human monitoring in the farming industry.
Spanaki et al. (2021)	The 4IR is defined as a design of computer-generated products and three-dimensional (3D) printing, which produce solid objects by stacking successive layers of materials.
Abbasi, Martinez, and Ahmad (2022)	The Fourth Industrial Revolution is about more than just technology-driven change that offers the opportunity to help everyone, including leaders, policymakers and people from all income groups and nations, to harness converging technologies to create an inclusive, human-centred future.

and so on in all areas of farming to manage resources effectively and catapult production (Joy et al. 2022; Talari et al. 2022; Polymeni et al. 2023). This study will adopt this version as a definition for this research.

Small-scale rural farms

Small-scale farms, often referred to as smallholder farms, are characterized by their relatively small size and limited land and resource holdings (Almadani and Mostafa 2021; Dlamini, Chizema and Van Greunen 2023). These farms are a fundamental component of global agriculture, contributing significantly to food production, rural livelihoods and local economies (Belaud et al. 2019). Small-scale farms play a crucial role in food production, livelihoods, and local economies. Similarly, small farms are vital contributors to food security, especially in developing countries (Guha et al. 2021). They often prioritise diverse crops,

> literature shows that farms need to analyse data to effectively manage resources such as water, fertiliser, and tractors, just to name a few *(Mabiletsa et al. 2020; Jiménez, Cárdenas and Jiménez 2022).*

contribute to local markets and provide direct employment opportunities to the local citizens (Harfouche et al. 2019; Almadani and Mostafa 2021). Small-scale farming also helps preserve traditional agricultural practices and biodiversity (Liu et al. 2021; Campuzano et al. 2023).

Small-scale farms are essential for rural livelihoods, providing income, employment, and Subsistence for millions of people. Fostering the growth of small-scale farms can contribute to poverty reduction and rural development (Abbate, Centobelli and Cerchione 2023). Small-scale farmers often face challenges such as limited access to land, credit, and modern technology (Joy et al. 2022; Noor et al. 2022). Additional challenges include climate change, market fluctuations and land tenure issues. Addressing these challenges requires targeted policies, concerted effort from all stakeholders and information technology interventions (Joy et al. 2022; Dlamini, Chizema and Van Greunen 2023). Access to appropriate technologies, including mobile apps for market information, improved seeds, and sustainable farming practices, can significantly address challenges encountered by farmers and enhance the productivity and resilience of small farms (Almadani and Mostafa 2021; Abbate, Centobelli and Cerchione 2023; Ngongoma, Kabeya and Moloi 2023).

Furthermore, gender dynamics play a significant role in small-scale farming, with women often contributing remarkably to agricultural activities in rural-based farming (Aznar-Sánchez et al. 2019; Gagliardi, Cosma and Marasco 2022). Empowering women in agriculture with the right knowledge and technical skills is essential for improving farm productivity and rural livelihoods (Büyüközkan, Göçer and Uztürk 2021; Choi and Shin 2023). Kanyane (2021) writes that the smart rural village model would offer the opportunity to ensure that requisite skills and jobs are created and retained for instance, through funded commodity production in agriculture – crop and livestock, energy, water, health, food security, transportation and technology spaces. This is because people with skills tend to move to places with higher wages or work opportunities.

Adoption of the fourth industrial revolution by small-scale rural farmers

In the past, three major technological breakthroughs have ushered in industrial revolutions by enabling mass production, accelerating growth and shifting employment from agriculture to manufacturing and later to services (Staneva and Elliot 2023). The adoption of fourth industrial revolution technologies by small-scale rural farmers has the potential to transform agriculture, manage farm resources, improve livelihoods, and enhance food security globally (Campuzano et al. 2023). These require addressing challenges related to access to innovation, affordability, capacity building, and customization of solutions (Schirpke et al. 2019). Furthermore, this will require collaborative efforts involving government departments, state-owned entities and the private sector to assist small-scale farmers in successfully adopting 4IR in rural areas (Schukat and Heise 2021; Dlamini, Chizema and Van Greunen 2023; Hassoun et al. 2023).

However, the literature postulates that small-scale rural farmers should consider the following to adopt 4IR successfully, namely digital infrastructure, connectivity, data analytics, mobile applications, budget, capacity, training and policies (Schirpke et al. 2019). Different scholars also suggest that access to digital infrastructure, including reliable internet connectivity should be a prerequisite when adopting 4IR in small-scale rural farm set-ups. Similarly, other scholars have indicated that mobile devices are a significant element in the adoption of 4IR by small-scall farmers to manage and monitor their resources (Campuzano et al. 2023; Hassoun et al. 2023). On the contrary, literature shows that limited access to digital infrastructure and internet connectivity can hinder the successful adoption of 4IR by small-scale farmers (Ranjan et al. 2022; Dlamini, Chizema and Van Greunen 2023).

On the other hand, the literature shows that farms need to analyse data to effectively manage resources such as water, fertiliser, and tractors, just to name a few (Mabiletsa et al. 2020; Jiménez, Cárdenas and Jiménez 2022). For example, this includes collecting and analysing moisture data from a farm may lead to data-driven decision-making to water crops when it is necessary (Noor et al. 2022; Campuzano et al. 2023). Data analytics in this case may help farmers conserve water and other scarce resources (Jiménez, Cárdenas and Jiménez 2022). In addition, small-scale farms may benefit from data analytics by gaining more insights into crop management, pest control, market trends, transport logistics, etc. (Elijah et al. 2021; Debauche et al. 2022).

The literature also suggests that the use of mobile applications may provide small-scale farmers with access to valuable information on weather forecasts, market prices and agronomic advice (Almadani and Mostafa 2021). Furthermore, mobile applications will enable farmers to have control of their farming activities from wherever they are (Liu et al. 2021; Choi and Shin 2023). In addition, farmers my use mobile applications to instruct digital devices to perform their duties like IoT-enabled crop watering (Sharma et al. 2022). However, the use of 4IR technologies requires training to capacitate small-scale farmers because it is crucial for them to understand how to use these tools effectively (Spanaki et al. 2022).

The literature suggests that for small-scale farmers to effectively adopt 4IR, they need to set aside a budget that will help in improving digital infrastructure and acquiring various technologies (Spanaki et al. 2022; Hassoun et al. 2023). Furthermore, capacity building also requires enough budget to send farmers for training and attending workshops. Enough budget may help farmers address barriers that may impede the successful adoption and implementation of 4IR for smart agriculture (Spanaki, Karafili and Despoudi 2021; Gagliardi, Cosma and Marasco 2022; Campuzano et al. 2023).

Results and Discussions

The critical components significant to adopting 4IR by small-scaled rural farms in Sub-Saharan Africa as evidenced in the reviewed articles are discussed next. The reviewed literature underscored the pivotal role played by having sufficient financial budgets in the adoption of 4IR by small-scale rural farmers. Fifteen qualitative, fourteen qualitative analysed articles posit that budget constraints are a prevalent phenomenon across most small-scale farmers in the Sub-Saharan African region (Sharma et al. 2022; Spanaki et al. 2022; Hassoun et al. 2023). Furthermore, sufficient budgets enable small-scale rural-based farmers to engage in meaningful hands-on training, acquire the 4IR tools and efficiently use them for various farming activities. Thus, constrained financial budget is flagged as an area that needs special attention to findings of previous studies on 4IR adoption by small-scale farmers in developing nations (Jellason et al. 2021; Smidt and Jokonya 2022; Gumbi et al. 2023). This finding implies that to effectively adopt 4IR technologies, small-scale rural farmers in developing nations require financial support from the government and other key stakeholders like non-governmental organizations.

Fourth industrial revolution technologies such as the Internet of Things, big and predictive data analytics, artificial intelligence, precision agriculture, sensors collecting data and monitoring fundamental crop health, weather, and soil quality tools come at an exorbitant cost, often beyond the reach of most small-scale rural farmers. The findings of this study establish that the majority of small-scale rural farmers are severely budget-constrained and this poses a huge barrier to effectively adopting and embracing cutting-edge 4IR for agriculture tools (Ranjan et al. 2022; Dlamini, Chizema and Van Greunen 2023). Moreover, the 4IR for agriculture tools requires fast and efficient internet connectivity to effectively work. Yet, the cost of internet connectivity and access in the context of most developing nations in the Sub-Saharan Africa region is very exorbitant; thus, further exacerbating and constraining the widespread adoption of such innovative technologies. This finding concurs with the findings of previous scholars on 4IR for agriculture who attested that the lack of digital infrastructure poses a severe challenge to the effective adoption of 4IR tools across small to medium-scale agriculture producers (Sutherland 2020; Hassoun et al. 2023; Spanaki et al. 2022). This finding is a wake-up call to all key stakeholders in the government, policymakers and funding organizations working so hard to ensure food security and sustainability to establish mechanisms to assist small-scale rural farmers to embrace 4IR for agriculture hustle-free. This may call for government interventions through subsidizing the cost of these 4IR tools and internet connectivity to cushion and enable small-scale farmers in their adoption efforts.

The reviewed literature further demonstrated that access to 4IR innovative tools is the first and foremost stage in the adoption process. The second phase of possessing the right soft skills to effectively use such technologies for smart farming remains a major obstacle for most small-scale farmers across the Sub-Saharan Africa region. Although most small-scale rural farmers can use smartphones daily for general purposes, the use of 4IR tools like IoT, smart agriculture apps and predictive analytics require some astute configurations, monitoring and manipulations which often pose serious challenges to most rural-based farmers who are not technology savvy. Besides, the literature demonstrated that acquiring such knowledge comes at a huge cost, often beyond the reach of most rural-based small-scale farmers (Schirpke et al. 2019; Campuzano et al. 2023; Gagliardi et al. 2022; Spanaki et al. 2021). Therefore, the United Nations Food and Agriculture Organization (FAO) through its various umbrella regional bodies, in collaboration with NGOs and government entities should intensify its efforts to capacitate and upskill small-scale rural farmers with the relevant 4IR for agriculture skills to catapult smart agriculture and ensure sustainable societies and food security.

A Proposed Framework

A proposed framework for the fourth industrial revolution adoption by small-scale rural farmers in Sub-Saharan Africa – which is an artefact of this study was developed using findings from the systematic review. The critical components

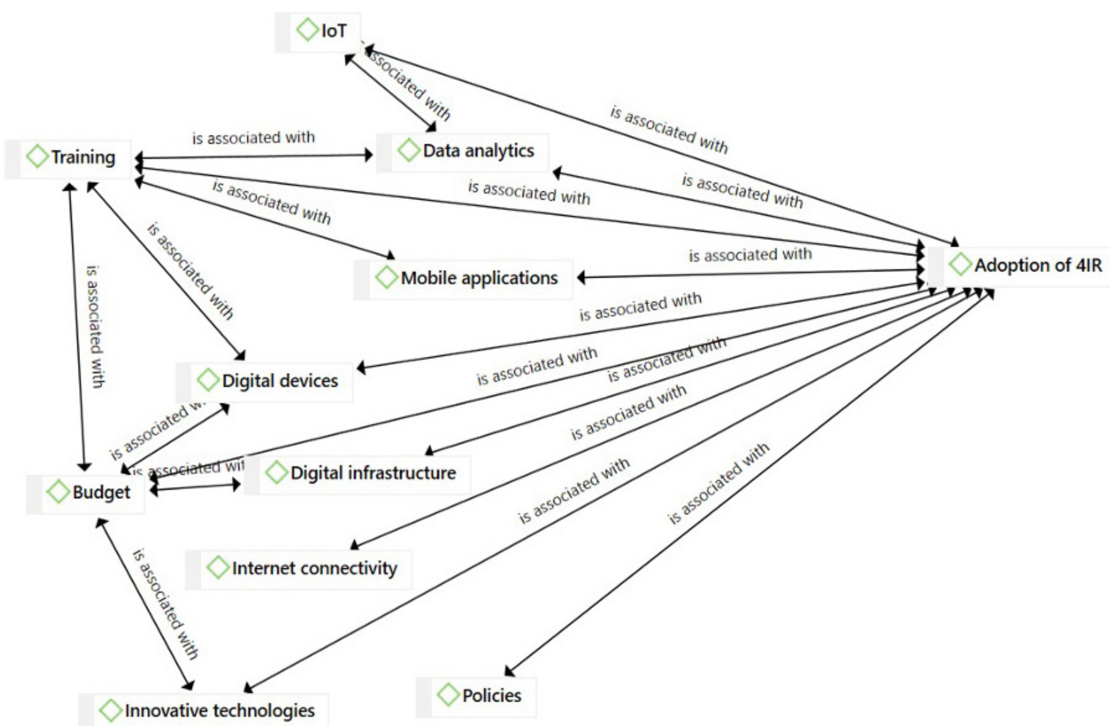

Figure 2: Proposed conceptual framework.

identified to be significant to the adoption of 4IR by small-scale rural farms were integrated to develop a model depicted below (see Figure 2).

The proposed framework (see Figure 2) shows that digital infrastructure, digital devices, budget, policies, training, mobile applications, internet connectivity, IoT, innovative technologies and data analytics are significant for the adoption of 4IR by small-scaled rural farms (Schirpke et al. 2019). Small-scale rural farms should have the budget to buy the required digital infrastructure, digital devices, and internet access (Hassoun et al. 2023; Schirpke et al. 2019). Furthermore, small-scale rural farmers should set aside a budget to train their staff to operate 4IR tools (Gagliardi et al. 2022; Spanaki et al. 2021). The availability of digital infrastructure, digital mobile, internet connectivity and digital literacy for staff may influence the adoption of 4IR (Campuzano et al. 2023; Hassoun et al. 2023; Schirpke et al. 2019).

The model also postulates that policies play a pivotal role in the adoption of 4IR in small-scale farms. This means government policies should be aligned and support the adoption of 4IR technologies by small-scale rural farms (Dlamini et al. 2023). Furthermore, the government should ensure that government policies on smart farming are implemented and monitored to reap the fruits of 4IR for agriculture (Schirpke et al. 2019). On the other hand, small-scale rural farms should implement innovative technologies as a precursor for 4IR adoption to assist in real-time data collection (Jiménez et al. 2022; Elijah et al. 2021). Furthermore, small-scale rural farmers should have intelligent tools that will be used to analyse data in real-time to predict and make well-informed decisions on how to manage existing, often constrained resources efficiently (Joy et al. 2022). Lastly, if these components are disregarded, small-scale rural farms are likely to fail in adopting 4IR for their day-to-day activities.

Conclusion

This study aimed to develop a 4IR adoption framework for small-scale rural farmers to adopt 4IR tools for managing their resources and promoting smart agriculture. To achieve this aim, a systematic literature review approach was employed to identify critical components significant to 4IR adoption for rural farming. To achieve this aim, an initial total of 317 articles were extracted from four major databases, including IEEE Xplorer, ProQuest, ScienceDirect and Web of Science. Key terms like ‘Fourth Industrial Revolution’ AND ‘Small-Scale Farming’, ‘4IR’ AND ‘Small-Scale Farm’ and related terms as alluded to in the methodology section were used to extract the articles for inclusion. After a thorough synthesis and refining, only 36 articles were included in the final analysis for this study. Thereafter, major challenges that affect small-scale rural farmers in adopting 4IR smart technologies were explored, namely the lack of digital infrastructure, internet connectivity, digital literacy, data analytics, and budget constraints. To adopt 4IR effectively and successfully for agriculture, it is essential for small-scale rural farmers and all the key stakeholders like government agencies and NGOs to address these challenges. Constructive alignment between formulated policies on 4IR adoption for small-scale farmers and practical implementation and monitoring is fundamental to the success of such initiatives for sustainable farming and food security for the region.

This study had its limitations. Since the study relied purely on the systematic literature review approach, there is a need to explore a qualitative empirical research strategy using interviews to capture the voices and lived experiences of small-scale rural farmers in the region. This will complement and enrich this research. Similarly, a quantitative method will provide a fertile statistical test of the results and synthesis of the proposed research model. Thus, future studies should explore these avenues to effectively establish viable mechanisms and solutions to overcome the identified challenges confronting small-scale rural farmers in their endeavours to adopt 4IR smart technologies.

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