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A Systematic Review of Cloud-based Mobile Pisciculture Farming Readiness Factors: A Path Towards Alleviating Unemployment in Developing Countries

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Abstract
This paper systematically reviews the readiness factors crucial for adopting cloud-based mobile farming IoT systems in the pisciculture sector of developing countries. It explores the readiness factors that must be considered for adopting a cloud-based mobile farming IoT system in the pisciculture sector of developing countries. The study synthesizes findings from over 40 selected articles, highlighting key factors such as the need for robust technological infrastructure, including reliable internet connectivity and mobile networks. It also underscores the importance of capacity building through education and training for farmers, ensuring they can effectively use these technologies. Institutional support from governments and NGOs, access to funding, and alignment of technologies with local cultures and practices are identified as essential. The study also emphasizes the necessity of developing clear regulatory frameworks to address data security and privacy concerns. This research provides readiness factors that can guide the successful adoption of cloud-based mobile farming IoT systems, which could significantly contribute to economic growth and reduce unemployment in the aquaculture sector of developing countries. Based on the limitations of the methodology adopted in this study, this study proposes that additional research should focus on developing a model based on the identified factors and test the hypothesized theories, as well as scope down into more specific research areas.

Keywords: Systematic Review, Cloud-based Mobile Pisciculture, Farming Readiness, Developing Countries, Alleviating Unemployment

1. Introduction

Globally, it is widely recognized that the vitality of a nation is rooted in the energy and ambition of its working population. Africa boasts the world's most youthful population, with over 70% of its sub-Saharan regions being under the age of 30 (Abay et al., 2020). This substantial demographic of young individuals presents a unique opportunity for the advancement of the continent, provided that these emerging generations are fully empowered to unlock their maximum potential (Ayim et al., 2022). However, this reality hides significant disparities within the region. Youth unemployment ranges from nearly 30% in Northern Africa, where nearly every other working-age woman is without a job, to 11% in sub-Saharan Africa, with no significant gender-based variation (Youth employment in Africa, 2023). It is important to note that unemployment provides an incomplete picture of the lack of decent employment opportunities, as it does not consider job quality. In Southern Africa, the relatively low youth unemployment rates are partly due to the fact that many cannot afford to remain unemployed and thus must enter precarious, often low-productivity employment to secure an income. Additionally, the emphasis on wage employment sectors has overshadowed the potential opportunities in family farming and household enterprises, which can provide immediate income for youth in rural areas.

It has been established that with enhanced investment and improved regulatory frameworks, farming initiatives can offer substantial employment opportunities for numerous young individuals (Abay et al., 2020). Engaging in Pisciculture can be a profitable endeavor that not

only ensures the provision of sustenance for families but also enhances financial stability (Umeh et al., 2020). Nonetheless, the adoption of contemporary technological advancements, such as cloud-based mobile farming systems, is imperative to fully exploit the potential of farming and surmount obstacles to employment in the pisciculture business ecosystem. In recent times, there has been a growing interest in the adoption of cloud-based mobile farming systems in sub-Saharan Africa (Emeana et al., 2020). These systems possess the capacity to revolutionize the agricultural sector in the region by providing farmers with real-time information and tools to amplify productivity, optimize resource management, and ultimately alleviate unemployment in the pisciculture business ecosystem (Simelane et al., 2015). However, the successful implementation of such systems necessitates meticulous consideration of various readiness factors specific to the context of sub-Saharan Africa.

2. Research Gap

When operating a fish farm, managers, owners, and other staff collect data on feedings, mortalities, water samples, and production estimates. However, much of this information is recorded and organised using paper records or basic computer programmes that are not specifically designed for fish farming (Mustapha et al., 2021). This creates a gap in terms of effectively utilising modern information and communication technologies to enhance fish farm productivity and overcome employment barriers in the pisciculture business ecosystem (Omotesho et al., 2019). Cloud-based mobile farming systems have the potential to bridge this research gap by offering real-time data collection, analysis, and decision-making tools that are tailored specifically for the pisciculture industry (Twumasi et al., 2021).

Furthermore, cloud-based mobile farming systems can enable remote monitoring and control of fish farms, enhance disease detection and prevention, optimise feed management, and provide farmers with market information and networking opportunities (Mustapha et al., 2021). Additionally, the adoption of cloud-based mobile farming systems can lead to increased efficiency and productivity in pisciculture, thereby creating employment opportunities and contributing to economic development in rural areas. Therefore, there is a need for a readiness model to assess the preparedness of developing countries in adopting a cloud-based mobile farming IoT system in the pisciculture sector, as suggested by articles that emphasise the need for such a model.

Multiple studies have underscored the necessity of a readiness model to provide guidance for the integration of technology in the agricultural domain, particularly within developing nations. One such study conducted by Der et al. (2024) emphasises the significance of readiness factors in the effective implementation of technological solutions in the agricultural context. Another study by Pal et al. (2020) concentrates on the readiness of smallholder farmers to embrace agricultural technologies in developing countries. These researchers propose a conceptual framework that combines technological, organisational, and individual readiness factors to evaluate farmers' preparedness for adopting new technologies. Moreover, Abdullahi et al. (2021) conducted a study indicating that a readiness model is imperative for the adoption of cloud-based mobile farming systems in the pisciculture sector. Given the challenges and opportunities highlighted, this study aims to develop a readiness model to evaluate the preparedness of countries in sub-Saharan Africa for adopting a cloud-based mobile farming IoT system in the pisciculture sector. Additionally, it examines the system's potential to mitigate unemployment within the business ecosystem by identifying the key readiness factors essential for its successful implementation in developing countries.

Although there may be slight distinctions between pisciculture and aquaculture, both terms were employed within the context of the study aimed at identifying the factors contributing to the successful implementation of Cloud-based Mobile technology. Pisciculture and aquaculture are agricultural practices involving the cultivation of aquatic organisms for various purposes, including food production, recreational activities, and commercial ventures. In both practices, intentional interventions are made to improve production, such as stocking, feeding, and predator protection. Additionally, both pisciculture and aquaculture have experienced substantial growth in recent years due to the rising demand for seafood and the necessity to alleviate pressure on natural fisheries. Moreover, both practices rely on specialised compound feed to satisfy the high dietary protein requirements of farmed fish species (Kaushik et al., 2008).

3. Methodology

This study employed a systematic literature review as its research methodology, aiming to understand the readiness factors necessary for implementing a cloud-based mobile farming system in the pisciculture sector within developing countries. This method involved a thorough search, analysis, and synthesis of relevant articles to provide a comprehensive and unbiased overview of existing literature, identifying shared themes, patterns, and gaps (Senivongse et al., 2017).

The review protocol included a comprehensive search strategy using databases like Google Scholar, ScienceDirect, and IEEE Xplore, with keywords such as "readiness model," "cloud-based mobile farming," "pisciculture," "developing countries," and "unemployment." Inclusion criteria focused on relevance, focus on developing countries, and publications within the past 10 years. Articles were evaluated based on titles, abstracts, and full texts, with a snowballing approach and manual reference list searches identifying additional relevant studies.

The data from selected studies were synthesized and analyzed to identify common themes and key factors, with quality and rigor assessed using PRISMA guidelines (Welch et al., 2022). The screening process involved evaluating articles based on relevance, methodology, findings, and outcomes, conducted by two independent reviewers for consistency. The review utilized over 40 articles from reputable sources, providing a strong foundation for subsequent analysis and discussion.

3.1 PRISMA Flowchart Description

Identification: All articles were identified through database searches using specific keywords.

Screening: Articles were screened by titles and abstracts to assess relevance.

Eligibility: The full texts of potentially relevant articles were evaluated based on specific criteria.

Inclusion: Studies that met all criteria were included in the final meta-analysis.

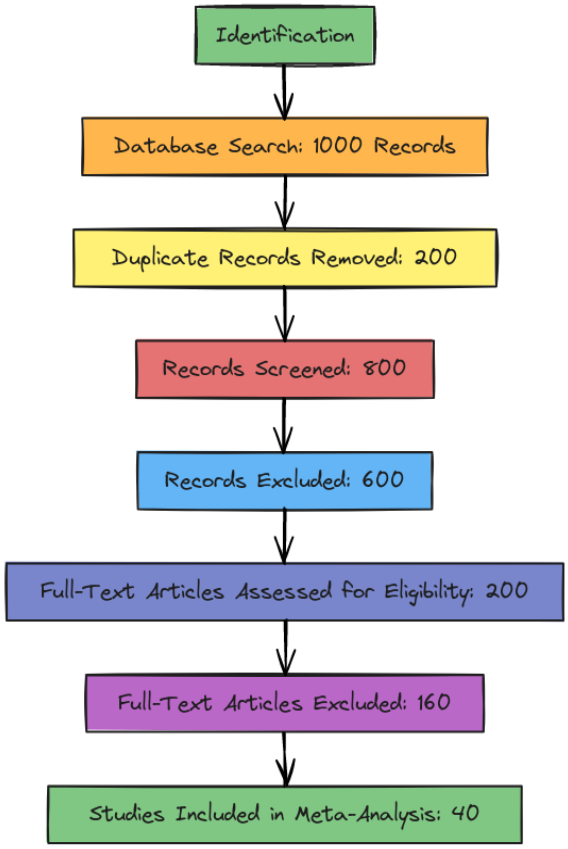

Figure 1. PRISMA Flowchart

4. Meta-Analysis Output

Based on the Quality Evaluation (QE) criteria applied to the reviewed studies, the assessment reveals several insights into the quality and rigor of research methodologies employed:

- **Quantitative Evidence (QE1):**

QE1 focuses on the inclusion of quantitative data analysis in studies. All reviewed studies scored either 1.5 or 2 on QE1, indicating a consistent use of quantitative methods. This suggests that the studies rely on numerical data to support their findings, using techniques such as statistical analysis, numerical modeling, or data-driven approaches. The scores reflect a strong emphasis on empirical evidence and quantitative rigor, essential for substantiating claims and drawing reliable conclusions in fields like aquaculture and agricultural technology.

- **Investigation of Pros and Cons (QE2):**

QE2 assesses whether the studies adequately explore the advantages and disadvantages of their topics. The majority of studies scored 2 on QE2, indicating thorough investigations into the pros and cons related to their research areas. This criterion underscores the importance of presenting

a balanced view of findings, considering both strengths and limitations in methodologies, technologies, or applications studied. Studies scoring lower might have provided some discussion but potentially with less depth or breadth in exploring the full spectrum of pros and cons.

- **Comparability of Methods (QE3):**

QE3 evaluates the comparability and robustness of the methods employed across the studies. All reviewed studies scored 1 or higher on QE3, indicating that their methodologies are considered robust and suitable for their research objectives. This criterion suggests that the studies use methodological approaches that are comparable in terms of reliability and validity. A score of 1 implies sufficient methodological adequacy, whereas higher scores indicate stronger methodological justification or validation, ensuring consistency and reliability in research methodologies.

- **Justification of Study Outcomes (QE4):**

QE4 focuses on whether the studies justify their outcomes based on their chosen methodologies. The majority of studies scored 1.5 or 2 on QE4, indicating satisfactory justifications for their study outcomes. This includes explaining how their methodologies align with and support the conclusions drawn from the research findings. Scores in this criterion reflect the clarity and thoroughness with which studies articulate the rationale behind their outcomes, addressing any methodological limitations or uncertainties. Lower scores might suggest areas where additional clarity or detail in the methodology explanation could enhance the overall robustness of study conclusions.

4.2 Summary:

Overall, the findings suggest a high quality of research across the reviewed studies, as indicated by consistent QE scores across QE1 to QE4. The emphasis on quantitative evidence, thorough investigation of pros and cons, robust methodological comparability, and satisfactory justification of study outcomes collectively contribute to the credibility and reliability of research findings in the domains of aquaculture, IoT applications, and cloud computing in agriculture.

5. Discussion of Findings from the Systematic Review

During the literature review conducted in accordance with the PRISMA guidelines, a number of key readiness factors were identified for evaluating the readiness of sub-Saharan African countries to embrace a cloud-based mobile farming system in the pisciculture sector. The review highlighted various readiness factors that significantly influence the assessment of countries in sub-Saharan Africa in terms of their preparedness to adopt a cloud-based mobile farming system. These factors encompass a diverse array of technological, organisational, and environmental aspects that are crucial in determining the prospective success of implementing such systems.

5.1 Technological Infrastructure Factor

One of the key factors that must be considered is the technological infrastructure that already exists in developing countries. This encompasses the availability and accessibility of internet connectivity, mobile networks, and the overall digital infrastructure that is necessary for the functioning of cloud-based mobile farming systems. Without reliable internet connectivity, access to mobile devices, and a stable power supply, farmers encounter significant challenges in fully harnessing the benefits offered by cloud-based mobile farming systems (McKinsey, 2024). These obstacles hinder their ability to access real-time information that is crucial for making informed decisions, effectively communicating with market stakeholders, and efficiently managing their farms. Furthermore, inadequate technology infrastructure limits the scalability and reliability of cloud-based mobile farming systems, thereby impeding their capacity to cater to a large user base or handle data-intensive operations seamlessly (Kakamoukas et al., 2021). Consequently, it is essential for developing countries to prioritise investments in enhancing technology infrastructure within the aquaculture sector. This includes initiatives that aim to expand internet accessibility, ensure a consistent and dependable power supply, and strengthen the overall technological framework to support the widespread adoption and effective utilisation of cloud-based mobile farming systems. Such endeavours not only empower farmers with the necessary tools for success but also contribute to the advancement and sustainability of the aquaculture industry on a broader scale (Kaushik et al., 2008).

5.2 Capacity Building and Education Factor

Capacity building and education play a vital role in the successful adoption of cloud-based mobile farming systems in aquaculture. It is imperative to equip farmers and other stakeholders with the necessary knowledge and skills to effectively utilise and manage these technologies. This entails providing training on the operation of IoT devices, interpretation of sensor-generated data, and the ability to make informed decisions based on insights provided by cloud-based mobile farming systems (Ndiaye et al., 2023). Additionally, capacity-building initiatives should prioritise enhancing farmers' digital literacy and entrepreneurship skills. It is also crucial to provide them with access to relevant educational resources and support services. By doing so, farmers can harness the potential of cloud-based mobile farming systems, enhance productivity and profitability, and contribute to the overall growth and development of the aquaculture sector in developing countries. The significance of data security and privacy in cloud-based mobile farming systems in aquaculture cannot be underestimated (Karim et al., 2022). Farmers require assurance that their data, including sensitive information like financial records and production data, is securely stored and safeguarded against unauthorised access or breaches. Implementing robust security measures, such as encryption and authentication protocols, is essential to ensure data integrity and confidentiality.

5.3 Institutional Support Factor

The literature emphasises the significance of institutional support from governmental and non-governmental organisations in facilitating the adoption of cloud-based mobile farming systems. Government agencies, research institutions, and agricultural extension services should play an active role in providing technical guidance, policy support, and financial incentives to encourage farmers to adopt and use these technologies (Der et al., 2024). This support can include subsidies or grants for purchasing IoT devices, training programmes on the use of cloud-based mobile farming systems, and facilitating access to reliable internet connectivity in rural areas. The need for collaboration and partnerships in implementing cloud-based mobile farming systems in aquaculture is crucial. Successful implementation of cloud-based mobile farming systems in aquaculture requires collaboration and partnerships among various stakeholders, including farmers, technology providers, government agencies, research institutions, and industry associations (Zero et al., 2024). These stakeholders need to work together to share knowledge, resources, and expertise, and to ensure that the adopted technology meets the specific needs and challenges of the aquaculture industry. Assessing the readiness of farmers for adopting cloud-based mobile farming IoT systems in developing countries is essential for successful implementation (Jain et al., 2014). This includes the provision of policies, regulations, and financial incentives that promote the integration of these technologies in the pisciculture sector.

5.4 Investment and Funding Factor

Another critical factor that has been identified is the availability of investment and funding opportunities for farmers and entrepreneurs who are interested in implementing cloud-based mobile farming systems. Access to financial resources and support mechanisms is crucial for overcoming economic barriers to the adoption of this technology (Chang & Lan, 2021). Insufficient investment and funding can create barriers for farmers in terms of accessing the necessary resources and technologies required for the adoption of cloud-based mobile farming systems. These barriers may include the high cost of IoT devices, lack of internet connectivity infrastructure, and limited access to training and technical support. Therefore, the availability of financial support and investment opportunities can significantly enhance farmers' readiness to adopt cloud-based mobile farming systems in aquaculture. The role of policy and regulation is crucial in facilitating the adoption of cloud-based mobile farming IoT systems in developing countries. Policy and regulation can create a favorable environment for the adoption of these systems by addressing issues such as data privacy and security, technology standardization, incentives for farmers, and support for infrastructure development. Moreover, policy and regulation can promote collaboration among different stakeholders and facilitate the sharing of knowledge and best practices. Training and Capacity Building for Farmers in Adopting Cloud-Based Mobile Farming IoT Systems in Developing Countries (Karim et al., 2022).

5.5 Local Context and Culture Factor

Understanding and integrating traditional practices, community dynamics, and cultural

norms are essential for the successful implementation of cloud-based mobile farming systems in the pisciculture sector (Wang et al., 2023). The willingness of farmers to adopt cloud-based mobile farming IoT systems in developing countries is heavily influenced by the local context and culture. Factors such as traditional farming practices, socio-economic conditions, and cultural beliefs can impact the acceptance and adoption of new technologies. Therefore, it is important to consider the local context and culture when designing and implementing cloud-based mobile farming systems in aquaculture. To address the issue of unemployment in the pisciculture business ecosystem, it is necessary to develop a readiness model for adopting a cloud-based mobile farming IoT system in developing countries. This model should consider factors such as financial constraints, infrastructure limitations, training, and capacity building needs, policy and regulation considerations, as well as the local context and culture (Ayele et al., 2022). Overall, a readiness model for adopting a cloud-based mobile farming IoT system in developing countries should address factors such as financial support and investment opportunities, policy and regulatory frameworks, infrastructure development, training and capacity building programmes, and cultural sensitivities (Park et al., 2023). Furthermore, it should also take into account the specific needs and challenges of the pisciculture business ecosystem, such as water resource management and disease control (Chen et al., 2023).

5.6 Market Access and Networking Factor

Understanding and integrating traditional practices, community dynamics, and cultural norms are essential for the successful implementation of cloud-based mobile farming systems in the pisciculture sector. The willingness of farmers to adopt these systems in developing countries is greatly influenced by local contexts and cultures. Factors such as traditional farming practices, socio-economic conditions, and cultural beliefs have a significant impact on the acceptance and adoption of new technologies. Recent studies highlight the importance of aligning new technologies with traditional practices and respecting cultural norms, as this leads to higher adoption rates (Kumaraperumal et al., 2022; Bacco et al., 2018). Furthermore, to address challenges like unemployment in the pisciculture business ecosystem, a readiness model must take into account financial limitations, infrastructure constraints, training, and capacity-building requirements, policy and regulatory considerations, as well as the local context and culture (Srivastava et al., 2020). Collaboration and partnerships among different stakeholders, including farmers, technology providers, government agencies, and research institutions, play a crucial role in sharing knowledge and resources, ensuring that the adopted technology aligns with the specific needs of the aquaculture industry (Gutiérrez et al., 2014). Additionally, market access and networking opportunities facilitated by cloud-based mobile farming systems are of vital importance. These technologies can bridge the gap between farmers and markets, providing real-time market information and networking platforms to enhance economic opportunities for pisciculture businesses (Chang and Lan, 2021).

5.7 Regulatory Measures Factor

Understanding and integrating traditional practices, community dynamics, and cultural norms are essential for the successful implementation of cloud-based mobile farming systems in the pisciculture sector. The willingness of farmers in developing countries to adopt these systems is heavily influenced by local contexts and cultures. Factors such as traditional farming practices, socio-economic conditions, and cultural beliefs have a significant impact on the acceptance and adoption of new technologies. Recent studies emphasise the importance of aligning new technologies with traditional practices and respecting cultural norms, as this leads to higher adoption rates (Ahmed et al., 2023; Eze et al., 2023). Furthermore, a readiness model for the pisciculture business ecosystem must consider financial constraints, infrastructure limitations, training and capacity-building needs, policy and regulatory considerations, and the local context and culture to address issues such as unemployment (Chisenga et al., 2023).

Collaboration and partnerships among various stakeholders, including farmers, technology providers, government agencies, and research institutions, are crucial for sharing knowledge and resources. These collaborations ensure that the adopted technology meets the specific needs of the aquaculture industry (Dlamini et al., 2023). Moreover, market access and networking opportunities facilitated by cloud-based mobile farming systems are of paramount importance. These technologies bridge the gap between

farmers and markets by providing real-time market information and networking platforms, thereby enhancing economic opportunities for pisciculture businesses (Sharma et al., 2023). Additionally, a clear regulatory framework is essential to ensure the successful and ethical adoption of modern agricultural technologies. Addressing data privacy, security concerns, and compliance with international standards is crucial for the secure implementation of cloud-based mobile farming systems. These regulatory measures protect sensitive information and build trust among farmers, fostering a supportive environment for technological advancements (Ramos et al., 2023).

6. Conclusion

In conclusion, the evaluation of factors determining the readiness for cloud-based mobile pisciculture farming in developing countries reveals several vital dimensions for technology adoption and effectiveness. Firstly, recent studies underscore the significance of technological infrastructure (Matsveichuk & Sotskov, 2023), emphasizing the need for reliable internet connectivity and accessible mobile networks. These factors are critical for real-time data access and communication, which are essential for informed decision-making and efficient farm management. Insufficient infrastructure limits the scalability and dependability of cloud-based systems, thereby impeding their potential to significantly enhance agricultural productivity (Ghutke & Agrawal, 2021). Secondly, capacity building and education play pivotal roles (Ndiaye et al., 2023), underscoring the importance of comprehensive training in utilizing IoT devices, interpreting sensor data, and developing digital literacy. Such training empowers farmers to harness the potential of cloud-based systems for improved productivity and profitability in aquaculture. Furthermore, institutional support is crucial (Der et al., 2024), with both governmental and non-governmental organizations encouraged to provide technical guidance, supportive policies, and financial incentives, such as subsidies for IoT devices and training programs, to foster widespread adoption.

Collaboration and partnerships among stakeholders are equally significant (Said et al., 2021), facilitating knowledge sharing, efficient resource allocation, and customized technology applications that address the specific needs of the aquaculture industry in developing contexts. Lastly, a robust regulatory framework is indispensable (Dayioğlu & Turker, 2021), guaranteeing data privacy, security, and technology standardization. This cultivates trust among farmers and creates an environment conducive to technological innovation and adoption. To unlock the transformative potential of cloud-based mobile pisciculture farming and drive sustainable economic growth and socio-economic development in developing countries, it is crucial to prioritize investments in technological infrastructure, capacity building, institutional support, collaboration, and regulatory frameworks. This study recommends future research to develop a model testing the hypothesized theories informed the identified factors. Additionally, it suggests focusing on more specific research areas.

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