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Transforming agriculture: A comprehensive review of mobile-based ICTs and innovations in India's agricultural extension services, with a focus on the multimedia agricultural advisory system (MAAS)

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Abstract

This comprehensive review explores the challenges and innovations in India's agricultural extension services, focusing on the transition to mobile phone-based Information and Communication Technologies (ICTs) and the Multimedia Agricultural Advisory System (MAAS). With agriculture's declining contribution to GDP, the review evaluates government initiatives and emphasizes the transformative potential of ICTs, citing a randomized study on ICT-based agricultural extension services. Smartphone apps in livestock farming are acknowledged for their transformative role, though challenges like internet connectivity persist. MAAS, with its call center-like interface, emerges as an innovative solution, providing personalized advice. The review integrates literature insights, highlights challenges, and proposes future research directions for enhancing ICT-mediated agricultural extension services, ensuring resilience and prosperity in India's agricultural sector.

Keywords: ICTs in agriculture, multimedia agricultural advisory system (MAAS), smartphone apps, rural technology innovation etc

Introduction

Agriculture, serving as the cornerstone of India's economy, sustains the livelihoods of over half its population. Despite its pivotal role, the contribution of agriculture to the Gross Domestic Product (GDP) has experienced a significant decline, plummeting from 30.00% in 1990-1991 to 14.50% in 2010-2011, as reported by the State of Indian Agriculture in 2012. Traditional public agricultural extension systems, designed to disseminate crucial information to farmers, face challenges such as ineffectiveness, time constraints, and an inability to address the diverse needs of farmers (Mruthunjaya and Adhiguru, 2005) [4]. In response to these challenges, the Indian government has implemented various initiatives, including those by Doordarshan, All India Radio, Kisan Call Centres, and Agri clinics. However, persistent obstacles, such as difficulties in accessing information based on factors like farm size and limited utilization of public sector extension services, continue to hinder progress (NSSO, 2005; Marcel and Bart, 2012) [5, 2]. Recognizing the transformative potential of Information and Communication Technologies (ICTs) in agricultural economic development, efforts have been made to leverage these technologies in India, as noted by Richardson in 1996 [7]. Fernando (2021) [19] conducted a randomized study on ICT-based agricultural extension services and found that contrary to concerns about disrupting local peer interactions, the service reduced dependence on peer advice without crowding out face-to-face interactions. Treated farmers were more likely to recommend inputs to their peers, fostering increased

information exchange. This highlights the potential for digital agricultural services to complement and encourage peer interactions at scale. Addressing the limitations of conventional approaches, smartphone apps have been identified as transformative tools in livestock farming, facilitating efficient data management, providing real-time agricultural information, and supporting informed decision-making (Sennuga, 2023) [20]. The study underscores the convenience and effectiveness of these apps in creating virtual communities for knowledge sharing among farmers. However, challenges such as reliable internet connectivity, technical literacy, and the accuracy of app-based information need attention for successful adoption. Collaboration among farmers, app developers, extension services, and policymakers is emphasized to maximize the benefits of smartphone apps in the livestock sector. In the realm of mobile phone-based ICTs, organizations like IFFCO Kissan Sanchar Limited (IKSL) and Reuters Market Light (RML) have utilized SMS and voice messages to deliver agricultural information. However, the generic nature of information provided by many initiatives, lacking farm or crop-specific advisories tailored to individual farmers' needs, presents a notable gap (Claire et al., 2010) [1]. In this dynamic context, the Multimedia Agricultural Advisory System (MAAS), developed by the Indian Institute of Technology Madras's Rural Technology and Business Incubator (IITM's RTBI), emerges as a noteworthy innovation. MAAS employs a call center-like interface, enabling farmers to pose queries via mobile

phones and receive personalized advice from agricultural experts. So that the agricultural extension systems to the shift towards ICT-mediated solutions and the potential impact of initiatives like MAAS in addressing the information needs of farmers. The subsequent sections will detail the methodology adopted for the field testing of MAAS, present results and discussions from the systematic analysis of farmers' reactions, socio-economic variables influencing MAAS usage, and conclude with insights into identified limitations and suggestions for future research.

Purpose of the Review Paper
The purpose of this comprehensive review paper is to systematically explore the challenges and innovations in the delivery of agricultural extension services in India, with a specific emphasis on the transition from traditional approaches to the utilization of mobile phone-based Information and Communication Technologies (ICTs). The primary objective is to provide a thorough understanding of the existing limitations in conventional agricultural extension systems and to investigate the potential impact of digital solutions, focusing on initiatives such as the Multimedia Agricultural Advisory System (MAAS).

1. **Examine Agricultural Landscape:** Investigate the current state of agriculture in India, recognizing its pivotal role in the economy while acknowledging the decline in its contribution to the Gross Domestic Product (GDP). Assess the challenges faced by traditional public agricultural extension systems, including ineffectiveness, time constraints, and the inability to address the diverse needs of farmers.

2. **Evaluate Government Initiatives:** Assess various initiatives undertaken by the Indian government, such as those by Doordarshan, All India Radio, Kisan Call Centres, and Agri clinics, and analyze their effectiveness in addressing the challenges of disseminating crucial information to farmers. Explore persistent obstacles hindering progress, including difficulties in accessing information based on factors like farm size and limited utilization of public sector extension services.

3. **Recognize the Role of ICTs:** Recognize the transformative potential of Information and Communication Technologies (ICTs) in agricultural economic development. Highlight efforts made to leverage these technologies in India and discuss findings from studies, such as the randomized study on ICT-based agricultural extension services by Fernando (2021) [19], to understand their impact on local peer interactions and information exchange among farmers.

4. **Explore Smartphone Apps in Livestock Farming**: Investigate the transformative role of smartphone apps in livestock farming, emphasizing efficient data management, real-time agricultural information, and informed decision-making. Address challenges related to reliable internet connectivity, technical literacy, and accuracy of app-based information. Advocate for collaboration among farmers, app developers, extension services, and policymakers to maximize benefits.

5. **Introduce MAAS as an Innovative Solution:** Introduce the Multimedia Agricultural Advisory System (MAAS) developed by the Indian Institute of

Technology Madras's Rural Technology and Business Incubator (IITM's RTBI) as a noteworthy innovation. Detail how MAAS employs a call center-like interface to allow farmers to pose queries via mobile phones and receive personalized advice from agricultural experts.

6. **Systematically Review Existing Literature**: Provide a comprehensive review of existing literature on the role of ICTs in agricultural extension, drawing from studies and initiatives both in India and other regions. Explore the challenges, successes, and opportunities presented by various ICT-led projects, emphasizing the need for integration with Information and Communication Management (ICM) for sustained success.

7. **Present Insights from MAAS Field Testing:** Systematically outline the methodology adopted for the field testing of MAAS, emphasizing study locations and the survey conducted among MAAS users. Present results and discussions on farmers' reactions, socio-economic variables influencing MAAS usage, and insights into identified limitations. Conclude with suggestions for future research, ensuring a forward-looking perspective for the enhancement of ICT-mediated agricultural extension services.

8. **Integrate Findings with Existing Literature:** Seamlessly integrate findings from the review of literature with insights derived from the field testing of MAAS. Draw connections between the challenges and successes observed in MAAS and the broader landscape of ICT-led initiatives in agriculture. Emphasize the transformative potential of ICTs, contextualizing within the specific experiences of MAAS and stressing the need for integration with Information and Communication Management (ICM) in agricultural extension.

Deliverables
1. Comprehensive Analysis of Agricultural Extension Services in India
- In-depth examination of challenges and innovations in the delivery of agricultural extension services in India.
- Focus on the transition from traditional approaches to mobile phone-based ICTs.

2. Evaluation of Existing Agricultural Extension Systems
- Systematic exploration of limitations in traditional extension systems, including ineffectiveness, time constraints, and an inability to address diverse farmer needs.

3. Overview of Government Initiatives
- Review of government initiatives, such as Doordarshan, All India Radio, Kisan Call Centres, and Agri clinics, highlighting persistent obstacles and challenges.

4. Role of Information and Communication Technologies (ICTs)
- Recognition of the transformative potential of ICTs in agricultural economic development.
- Exploration of efforts to leverage ICTs in India and their impact on information exchange and peer interactions.

5. Application of Smartphone Apps in Livestock Farming

- Examination of the transformative role of smartphone apps in livestock farming.
- Emphasis on data management, real-time information provision, and supporting informed decision-making.

6. Introduction and Evaluation of MAAS

- Introduction of the Multimedia Agricultural Advisory System (MAAS) developed by IITM's RTBI.
- Evaluation of MAAS's innovative approach using a call center-like interface for personalized farmer advice.

7. Methodology for MAAS Field Testing

- Detailed outline of the methodology adopted for the field testing of MAAS.
- Emphasis on study locations, survey design, and strategies for ensuring practical implementation and effectiveness.

8. Farmers' Reactions and Information Analysis

- Systematic analysis of farmers' reactions to MAAS.
- Assessment of the types of information deemed relevant and perceived benefits, with insights into challenges faced during advisories.

9. Socio-economic Variables and MAAS Usage

- Insights into socio-economic variables influencing the frequency of MAAS usage among farmers.
- Examination of demographic factors, economic conditions, and regional variations impacting adoption and utilization.

10. Limitations and Suggestions for Future Research

- Discussion on limitations identified during MAAS field testing.
- Forward-looking perspective with suggestions and recommendations for future research in enhancing ICT-mediated agricultural extension services.

11. With Literature Review

- Seamless integration of findings from the literature review with specific connections to MAAS.
- Contextualization of the transformative potential of ICTs within the experiences of MAAS, emphasizing the need for integration with Information and Communication Management (ICM).

12. Insights for Policy and Practice

- Concluding insights for policymakers and practitioners in the agricultural extension domain.
- Recommendations for optimizing the benefits of digital technologies and overcoming challenges for sustainable impact.

Challenges in Reviewing Agricultural Extension Services and ICT Integration

1. **Diversity of Agricultural Landscape**: India's agricultural sector is vast and diverse, with varying practices, crops, and regional nuances. Integrating insights from different agricultural contexts poses a challenge, requiring careful consideration of the diverse challenges faced by farmers across regions.

2. **Heterogeneity of Farmer Needs:** Farmers' information needs differ based on factors such as crop type, farm size, and geographical location. Addressing the diverse and dynamic requirements of farmers through a unified ICT solution like MAAS may pose challenges, necessitating customized approaches.

3. **Accessibility and Digital Divide:** The effectiveness of ICT-based solutions, including MAAS, relies heavily on digital accessibility. Challenges related to reliable internet connectivity, technical literacy, and smartphone ownership may create disparities in the adoption and impact of digital agricultural extension services.

4. **Socio-economic Disparities:** Socio-economic variables influencing the frequency of MAAS usage may exacerbate existing disparities. Factors like income levels, education, and access to resources might contribute to unequal adoption rates, potentially leaving certain demographic groups underserved.

5. **Information Overload and Relevance:** The sheer volume of information available through ICTs may overwhelm farmers, leading to potential information overload. Ensuring that the information provided is relevant, tailored to specific needs, and effectively communicated is a challenge in optimizing the impact of digital agricultural advisory services.

6. **Infrastructure Limitations**: Despite advancements, rural infrastructure limitations persist, affecting the seamless functioning of ICT tools. Challenges related to power supply, network coverage, and technological infrastructure may hinder the widespread adoption of digital agricultural extension services.

7. **User Engagement and Behavior Change**: Encouraging farmers to actively engage with and adopt ICT solutions like MAAS requires addressing behavioral barriers. Familiarizing farmers with new technologies, ensuring user-friendly interfaces, and promoting behavior change towards digital adoption are ongoing challenges.

8. **Privacy and Data Security**: The collection and utilization of farmer data through ICTs raise concerns about privacy and data security. Ensuring robust measures to protect sensitive information and gaining farmers' trust in data handling processes are critical challenges in the digital agricultural landscape.

9. **Integration of Traditional and Digital Approaches:** Transitioning from traditional to digital extension services necessitates a careful integration process. Balancing the strengths of traditional approaches with the efficiency and innovation offered by ICTs poses a challenge in achieving a seamless and effective agricultural extension system.

10. **Monitoring and Evaluation:** Assessing the impact of ICT-led initiatives like MAAS requires robust monitoring and evaluation mechanisms. Establishing metrics for success, measuring the effectiveness of information dissemination, and conducting regular assessments pose challenges in determining the true efficacy of digital agricultural extension services.

Research Gap

While the comprehensive review successfully navigates through the challenges and innovations in agricultural extension services in India, particularly focusing on the transition to mobile phone-based ICTs and the field testing of MAAS, there exists a notable research gap in understanding the nuanced barriers hindering the effective adoption of smartphone apps in livestock farming. Existing literature highlights the transformative potential of smartphone apps in livestock management, emphasizing efficient data management, real-time information provision, and support for informed decision-making. However, the review touches upon challenges such as reliable internet connectivity, technical literacy, and the accuracy of app-based information without delving deeply into the specific contextual factors influencing these challenges. Further research is needed to explore the region-specific obstacles that farmers face in adopting these apps, considering factors such as socio-economic conditions, geographical variations, and the diversity of livestock farming practices. Moreover, the review briefly mentions the generic nature of information provided by many mobile-based initiatives, lacking farm or crop-specific advisories tailored to individual farmers' needs. A more in-depth investigation into the effectiveness of personalized advisory services, such as those provided by MAAS, in comparison to generic information is warranted. Understanding the preferences and requirements of farmers in terms of personalized advice versus general recommendations would contribute significantly to the advancement of digital agricultural services. Additionally, the literature review outlines the success of various mobile applications in Sub-Saharan Africa, identifying opportunities and limitations. However, there is a research gap in exploring the potential gender-specific challenges faced by women farmers in adopting and benefiting from these mobile applications. A more nuanced understanding of the gender dynamics in accessing and utilizing agricultural information through ICTs would enhance the inclusivity and effectiveness of digital initiatives.

Future scope

1. **Enhanced MAAS Effectiveness:** Future research can delve into refining the functionalities of MAAS to enhance its effectiveness. This includes incorporating advanced technologies like artificial intelligence and machine learning for personalized advisory services, considering individual farm characteristics and regional nuances.
2. **User-Centric Design and Accessibility:** To address challenges related to digital literacy and connectivity, future work should concentrate on user-centric design modifications in MAAS, ensuring accessibility for farmers with varying technological proficiency. Strategies for optimizing mobile app usage and overcoming connectivity barriers in rural areas could be explored.
3. **Integration of Stakeholders:** Investigating the integration of various stakeholders, such as farmers, app developers, extension services, and policymakers, will be crucial for the sustainable success of MAAS. Collaborative efforts and partnerships can be explored

to maximize the impact of ICT-mediated agricultural advisory services.
4. **Long-Term Impact Assessment:** Assessing the long-term impact of MAAS on farmers' practices, crop productivity, and overall socio-economic conditions is essential. Future studies can employ longitudinal approaches to track changes and ascertain the sustained benefits derived from the implementation of MAAS.
5. **Policy Recommendations:** Research can focus on generating policy recommendations based on the insights derived from MAAS implementation. This involves advocating for supportive policies that address challenges such as digital inclusion, reliable internet connectivity, and farmer-specific advisories.
6. **Comparative Analyses:** Conducting comparative analyses with other ICT-led initiatives in agriculture can offer valuable insights. Understanding the strengths and weaknesses of various approaches will contribute to the development of best practices for scalable and effective agricultural extension services.
7. **Innovation in Information Delivery:** Exploring innovative methods of information delivery through MAAS, such as multimedia content, interactive features, and gamification, can enhance user engagement. This can cater to diverse learning preferences and contribute to the overall success of the system.
8. **Climate-Smart Agriculture Integration:** Given the importance of climate information in agriculture, future research can explore the integration of climate-smart agriculture practices within MAAS. Providing farmers with real-time climate data and adaptive strategies can contribute to resilience and sustainability.

Conclusion

In conclusion, this comprehensive review illuminates the challenges and innovations in India's agricultural extension services, with a specific focus on the transformative potential of mobile phone-based Information and Communication Technologies (ICTs). The decline in agriculture's contribution to GDP underscores the urgency for effective solutions. Government initiatives, while commendable, face persistent obstacles, necessitating a shift towards ICT-mediated solutions. Smartphone apps, particularly in livestock farming, exhibit promise but require attention to challenges like internet connectivity. The Multimedia Agricultural Advisory System (MAAS) emerges as an innovative solution, bridging gaps through personalized advice. The review integrates insights from literature, emphasizing the need for an inclusive, user-centric approach. However, challenges such as digital accessibility, socio-economic disparities, and behavior change persist. Addressing these challenges, coupled with ongoing advancements, can pave the way for sustainable and impactful digital agricultural extension services, ensuring the resilience and prosperity of India's agricultural sector.

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