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Uncovering the Impact of Technology-driven Services on Boosting Farmer Producer Organizations (FPO) Growth: A Glimpse into the Promising Future of Indian Agriculture, with a Focus on the Potential of Information and Communication Technology (ICT): A Review

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ABSTRACT

Farmer-producer organizations (FPOs) are vital for supporting agricultural communities by tackling individual farmers' challenges. Information and Communication Technology (ICT) not only improves FPO management but also has the potential to significantly enhance the performance and profitability of these organizations, driving the knowledge-based economy. This study uses a literature review as the research methodology to understand and harness the potential of ICT in FPO management. The study found that ICT applications such as precision farming, farm management software and mobile technology are leading to unprecedented advancements in farming practices. Effective integration programs could be designed to help farmers incorporate ICT more efficiently and increase the returns from their farming businesses. These programs may include capacity building, registration, business planning, MIS development, connections to the value chain, administrative expenses and costs for progress monitoring essential for FPO development. The application of ICT enhances the performance and profitability of FPOs, demonstrating a promising future.

Key words: Challenges, Farm produce, Farmers, ICT, Marketing.

The Indian agricultural sector faces significant challenges, with farmers struggling with low prices and a lack of market information. This research explores the impact of technology-driven services on boosting the growth of Farmer Producer Organizations (FPOs) in Indian agriculture, which play a crucial role in uniting individual farmers and improving their income. Farmers Producer Organizations (FPOs) support small and marginal farmers by providing access to resources and market linkages, reducing production costs and making farmers more competitive. It also mentions the need for help in governance, market linkage and working capital management in rural areas. The modernization of agricultural marketing is highlighted as crucial for the sector's development, focusing on promoting alternative marketing systems, establishing effective farmer-purchaser linkages and leveraging digital marketing. Additionally, the text mentions Maharashtra's recent e-trading platform for agricultural produce to streamline marketing and provide real-time prices based on market demand and supply.

The growth of ICT in developing countries offers new technologies and opportunities for accessing information in impoverished regions. Pilot programs in India, Bangladesh and sub-saharan countries are exploring innovative approaches. Diversifying into high-value commodities and enhancing market access through Farmers' Producers Organizations (FPOs) are crucial for the journey towards Viksit Bharat@2047. Adopting new and advanced technological solutions in agriculture may be essential to meet future food demands (Manonmani *et al.,* 2022). ICT could facilitate agricultural adoption and extension services in developing countries (Aker, 2021). Providing adequate policy and institutional support to FPOs is essential for their productivity and economic self-sustainability, ensuring sustainable livelihoods for farmers. Digitizing all FPO activities end-to-end can significantly enhance operational efficiency, transparency, decision-making and improve farmer incomes and well-being (Arunachalam, 2024). Utilizing Information and Communication

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Technology (ICT) in farming and business practices indicates the learning and growth of FPOs. Technology-driven farming will soon attract the next generation to pursue agricultural jobs. This method will help farmers understand market demand through predictive forecasting (Chandra, 2022). Machine learning plays a crucial role in image processing solutions for food technology. It enhances the assessment of food quality, including factors like nutritional composition, processing suitability, aesthetics and consumer appeal (Begum and Hazarika, 2021).

This paper highlights the importance of Farmer Producer Organizations (FPOs) and the role of Information and Communication Technologies (ICTs) in enhancing their effectiveness. It emphasizes how ICTs help reduce transaction costs, improve market participation and commercialize agrarian output, thereby increasing farmers' income. Additionally, it discusses how ICTs assist in overcoming various challenges faced by FPOs, such as managing weather, technology, price and other risks and how they contribute to the country's socio-economic development.

Our study aims to investigate the impact of ICT on the development of farmer-producer organizations (FPOs). It provides insights and solutions to their current challenges so that member farmers will be encouraged to use e-agricultural services.

The objectives of the study are as follows:

1. To identify information and communication technologies that are available for use in the management of FPOs.
2. To investigate the impact of ICT-enabled services on the farmer-producer organization's (FPO) development.
3. To ascertain the challenges associated with using ICT tools to manage FPO as a fully imitable resource.

The researcher conducted the research using a literature review as a methodology. A literature review identifies and assesses all relevant literature on a topic. It forms the foundation of knowledge development, provides guidelines for policy and practice and has the potential to produce new ideas. The work was carried out at MIMA Institute of Management, Pune, Maharashtra, India, in 2024 (1 year).

We have posed three key research questions in this study.

RQ1: What Information Communication technologies (ICT) are available to manage FPO?

RQ2: How will farmers and BODs benefit from ICT for FPO Management?

RQ3: What are the challenges associated with using ICT in managing FPO?

The researcher used a literature review approach to answer RQ 1, RQ2 and RQ3 and attempted to evaluate the studies relevant to ICT use in FPO. Conducting a thorough review as a research method establishes a solid basis for advancing knowledge and promoting theory development (Webster and Watson, 2002). A range of online databases from 2010 to August 2024 were searched, containing the words ICT for Agriculture Development and ICT for FPO Development in their title and phrases to provide a comprehensive listing of journal articles (Flow Chart 1).

Stage 1

Identification of Review

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Stage 2

Electronic search in databases using keywords

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Stage 3

Title and abstract reviews of identified papers (97 articles)

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Stage 4

Apply inclusion and exclusion criteria.

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Stage 5

Papers selected for review (31 articles)

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Stage 6

Create data extraction files.

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Stage 7

Descriptive and schematic analyses

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Stage 8

Reporting

Flow Chart 1: Structured literature review.
Source: Adapted from Malaviya and Kant (2015) and further refined per our study needs.

RQ1: What Information Communication technologies are available for use in the management of FPO?

Existing Information and Communications Technologies identified.

Information and communications technology supports storing, processing, disseminating and communicating data and information. Mobile phones have bridged the gap between farmers and buyers, allowing direct communication and access to market prices, weather information and global market data. Ayim *et al.* (2022) reported that current trends in innovative ICT solutions are mobile phones, computers, television, radio and advanced technologies such as artificial intelligence, blockchain, Internet of Things (IoT), cloud computing and big data analytics. Khan *et al.* (2022) reported that farmers perceived the information from ICT as moderately sufficient, which can enhance adoption and improve farm production. ICTs improve agricultural performance, profitability and risk management by providing crucial information and services for farmers and FPOs to connect to value chains. Today, ICT applications encompass a wide range, including precision farming, farm management software and mobile technology, revolutionizing farming practices.The public and private sectors have launched numerous initiatives to harness the potential of ICT, such as ITC-e-Choupal, IFFCO, Tata

Consultancy Services, Mahindra Kisan Mitra, Kisan Call Center, KVK-SMS service, e-NAM, Village Resource Centers (VRCs) and others, in providing agricultural advisory services for agronomic practices, weather forecasts and market prices to disseminate information for agricultural development (Manjeet and Kumar, 2019). Precision farming is one of the most significant ICT applications in agriculture. By utilizing GPS, GIS, drones and precision farming techniques, farmers can optimize resource use and maximize yields. This technology delivers data on soil health, humidity, temperature and more, enabling informed decisions regarding irrigation, fertilization and crop management.

With the exploration of the initial literature review, the following technologies have the potential to impact FPO operations positively.

1. Development of a mobile or web-based app for farmer onboarding and management.
2. Computer vision, spectral imaging and AI are utilized for quality checking, grading and sorting.
3. Establish a centralized digital platform for efficient resource management.
4. Create a digital procurement app for recording farmer-wise purchases on their smartphones.
5. Implement digital tracking and geofencing to aggregate and store farm produce, ensuring accurate inventory recording.
6. Enable e-auctions and e-marketplaces for FPOs to discover the best prices through transparent bidding.
7. Implement barcoding and scanning of lots to enable produce tracking from the farmer to the end buyer.
8. Install sensors to monitor conditions such as temperature and humidity and send alerts if any issues occur.
9. IoT sensors are used on machines to track operational data and enable predictive maintenance.
10. Provide digital platforms for real-time price information and enable price discovery through auctions and bids.
11. Create digital product catalogs with details on variety, quality, availability and pricing and integrate digital platforms for processing and value addition.
12. Recording raw material inflow and outflow of processed goods digitally enables real-time inventory tracking.
13. Implement digital traceability systems to track the journey of produce from farm to finished goods, enabling food safety and quality control.
14. Using digital sales transactions to create transparency and traceability allows banks and NBFCs to provide invoice financing and bill discounting to FPOs.
15. Utilize digital marketing to enable FPOs to discover the best prices for their produce.
16. Use technology platforms to connect FPOs to a network of vetted transporters and logistics providers.
17. Install IoT sensors on transport vehicles to track location, route adherence and temperature, ensuring the quality and safety of perishable produce in transit.
18. Implement e-POD (proof of delivery) through digital signatures to increase the efficiency of FPOs' receivable collection.
19. Utilization of digital traceability systems to enable tracking of input batch numbers in case of quality issues.
20. Digitize payments and transfer them digitally to farmers Aadhaar-linked bank accounts.
21. Utilization of the Unified Payments Interface (UPI) to enable FPOs to make and receive payments seamlessly across different banks and platforms.
22. Development of a digital platform for input supply and distribution, enabling farmers to place input orders *via* a mobile app and digitally book and pay for farm machinery.
23. Implement digital record-keeping for FPOs to analyze input sales data, identify trends, better forecast demand and optimize inventory.
24. Disseminate training and capacity-building content to farmers through digital channels.
25. Use digitization to offer soil testing, pest management and crop advisory services.
26. Deliver personalized, real-time advice to farmers through a digital platform.
27. Apply predictive analytics to agronomic data to provide planting date recommendations, yield forecasts and harvest date alerts.
28. Using image recognition technology to diagnose pests and diseases.

ICTs improve agricultural performance and profitability, mitigate risks and provide essential information and services for farmers and FPOs to connect to value chains. They facilitate knowledge management and help FPOs improve management, increase efficiency and boost productivity to generate additional income through premium pricing for farm produce.

RQ2: How will farmers and BOD benefit from ICT for FPO management?

Most farmers in the country are small and marginal and using new technologies, such as ICTs, can improve their production and marketing capabilities. Digital innovators are developing solutions to help FPO farmer members enhance their operations. More research and capacity building are needed to implement ICT and develop FPO. E-agriculture, or ICT in agriculture, uses technology to improve information and communication processes in farming, which is crucial for crop cultivation, water management, pest control and post-harvest handling. The ability of FPo to create and maintain linkages outside is linked to the success of the FPo in the long run (Nikam *et al.,* 2019). Information and Communication Technology (ICT) promises to transform various aspects of our lives, including knowledge dissemination, social interaction, economic and business practices, political engagement, media, education, health, leisure and entertainment (Singh *et al.,* 2015).

The findings of Rahman *et al.* (2015) suggest that educating and training farmers about ICT in Bangladesh can increase their usage of ICT-based media. Similarly,

Agu *et al.* (2013) in Nigeria reported that providing information to rural areas is crucial for agricultural and rural development, particularly for empowering women. In rural Tanzania, Mng'ong'ose *et al.* (2018) found challenges with adopting ICT in agriculture due to a lack of knowledge, tools, expertise and government support. Ahsan *et al.* (2022) noted inadequate training support for ICT in the Dhaka district. They emphasized the importance of mobile devices, internet connectivity, updated ICT applications and farmer databases for modern agricultural practices. Mohamed *et al.* (2023) suggested that policies should be redesigned and funding allocated for infrastructure, capacity building, skill development and ICT-based innovations. They also emphasized the importance of conducting promotional and marketing activities to encourage people to learn more about the app and its features, which will support its widespread use.

Majumdar and Singh (2019) found that farmers using ICT receive a higher net price than non-users. Education and land holding type also impact ICT use. Jayashree *et al.* (2023) noted that managing constraints in farming, marketing and input delivery is critical for sustainable growth. Saxena (2021) reported that the farmer members who constitute the FPC's board need more skill and expertise, support from the CEO and the promotion of an NGO becomes inevitable. Shah (2022) highlighted the potential of ICT in networking the agriculture sector locally and globally.

Gorai *et al.* (2022) emphasized the importance of members' attitudes towards their FPO and cooperation in maintaining group stability. Singh *et al.* (2021) highlighted the potential benefits of introducing mobile phones and services in agriculture, improving decision-making for farmers, traders and producers. Remember: Nandhini *et al.* (2023) found that adopting blockchain technology increased farm income. Jayashree *et al.* (2023) highlighted the benefits of mobilizing farmers for group action. ICT can provide vital information for farming, including weather, plant disease and soil conditions (Lahan and Deka, 2019). When dealing with an ICT program, preparing the appropriate ICT infrastructure and eliminating barriers to using ICT in FPO are essential. This will create an environment that fosters creativity through practical planning and policy-making for extensive ICT use. Pre-emergence pretilachlor applied *via* Unmanned Aerial Vehicle (UAV) is effective for early weed control in direct-seeded rice, reducing labor intensity (Paul *et al.,* 2023).

RQ3: What are the challenges associated with using ICT in managing FPO?

The journey toward digital transformation in agriculture is challenging due to several implementation and adoption hurdles associated with digital solutions. Collaboration between FPOs and Digital Innovators (DIs) encounters multiple challenges that require thoughtful consideration and strategic planning. Tiwari and Upadhayay (2021) indicated that operational and economic constraints were the major obstacles faced by the FPO members. Most FPOs rely on external technical assistance to manage their business operations and make critical decisions. Various factors affect the use of modern ICT, such as age, education, farm size, traditional media and mobile phones (Lahan and Deka, 2019). Kumar *et al.* (2020) revealed that the inability to raise adequate or required funds was the central problem faced by the FPCs in their growth.

Saidu *et al.* (2017) found that inadequate ICT facilities, lack of personnel, insufficient infrastructure, power supply and farmers' perceptions obstruct the implementation of ICT in agricultural growth in developing countries. More research is needed to enhance the fruitful implementation of ICT in agriculture. Providing an extensive environment for forming FPOs and ensuring sustainable development of income-oriented farming is crucial, leading to overall socio-economic development and welfare for FPO members. Upgrading the FPO system, incorporating new technologies and offering required services to retain members is essential for the *via*bility and sustainability of FPOs.

Bala *et al.* (2022) highlighted that FPOs face infrastructure and information asymmetry challenges, affecting policy and credit coverage. Chauhan *et al.* (2021) emphasized the need for FPO leaders to enhance entrepreneurial and business management skills and acquire knowledge related to processing, value addition and ICT in agricultural marketing. Mishra *et al.* (2020) and Nagaraji *et al.* (2023) highlighted constraints in using ICT tools for agricultural purposes, including a lack of knowledge, poor equipment and inadequate infrastructure. Patil *et al.* (2017) identified difficulties extension personnel face, such as poor internet connection and lack of training.

The study by Anand *et al.* (2020) found that most farmers need more power supply and better internet connections. They also need more knowledge, confidence and access to training programs for using ICT tools. Access to ICT requires computer equipment, software and the internet, with higher access predicted to increase IT use. Most farmers use popular ICT tools like the internet, email, mobile phones, Word and PowerPoint, but tools related to data practices are rarely used. There is a need for farmers to be more competent and confident when using ICT tools. It is better to adopt digital technologies based on need, maturity and familiarity (Nagaraji *et al.,* 2023). Hassan *et al.* (2023) reported that despite Bahrain's high level of digital infrastructure readiness, farmers still need to be ready to adopt sophisticated devices and complex applications such as crop sensing tools, the Internet of Things (IoT) and AI.

In their study, Patil *et al.* (2017) examined the difficulties faced by extension personnel when using ICT tools. They identified several issues: poor internet connection, lack of training, inadequate knowledge, power supply problems and limited computer facilities. Physical problems included issues such as eye, hand and back pain. Social challenges encompass less time spent with children and parents and reduced participation in social events. Economic hurdles

involved low income and high costs. Additionally, technological problems included insufficient information and age-related factors. Palaiah *et al.* (2016) reported that it is essential to educate farmers on the use of ICT tools like the internet, conferencing and agricultural DVDs through training and by making these ICT tools available in rural areas. Rashtrapal *et al.* (2022) found that farmer members contribute inadequately due to the poor economy, inadequate finances, lack of transport, distance to the market and storage facilities and lack of access to office buildings. However, using these technologies in rural areas could accelerate progress (Shreshtha *et al.,* 2021). The future of AI in the animal sector is uncertain, but the growing demand for AI in various industries will also promote its development in the animal sector (Aharwal *et al.,* 2021).

Implication of study

The research aims to support farmer-producer organizations (FPOs) by establishing management and administration systems, governance standards, statutory compliance and enhancing credibility. It will identify training needs for the Board of Directors and staff, focusing on vision and mission, value creation, marketing and member welfare. Additionally, the research will determine the training needs of the FPOs' Board of Directors and how ICT will be used to emphasize knowledge sharing, capacity building and sustainable farming practices. The primary focus of the research is on building the capacity of the Board of Directors and farmer members through ICT to manage FPOs. Developing the skills of the Board of Directors and member farmers of FPOs will empower farmers, promote sustainable practices and contribute to the overall growth and development of India's agricultural sector through ICT.

Limitations

The primary constraint of FPOs is the need for more professional management. It is essential to equip the Board of Directors (BOD) members of FPOs with the necessary understanding and orientation to lead their FPOs effectively. Sensitizing FPO members about the workings of the FPO and linking FPOs to the market is challenging. Keeping records, conducting meetings and ensuring compliance among FPO members and BODs requires extra effort.

CONCLUSION

Information and Communication Technology (ICT) can positively impact the operations of Farmer Producer Organizations (FPOs). It can accelerate FPO development, facilitate knowledge management, improve farmer skills and enhance agricultural production, making FPOs economically *via*ble and self-sustaining. Effective integration programs can be designed to help farmers incorporate ICT more effectively and achieve greater returns from their farming businesses. Motivating farmers and the board of directors to support ICT-enabled environments is essential. Despite technological advancements in Maharashtra, FPOs and farmers have not significantly benefited from ICT. There is a need for awareness, training and the implementation of ICT integration in FPO management. FPOs should integrate more ICT tools and guidance into their day-to-day work. This research will assist the board of directors of FPOs in selecting and implementing ICT tools adequately.

A comprehensive study of the articles cited in this paper and related articles focused on using ICTs to improve agricultural performance and profitability, mitigate risks, provide essential information and services for farmers and FPOs and help boost FPOs, which is critical to the *via*bility and sustainability of FPOs.

Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from using this content.

Informed consent

The Committee of Experimental Animal Care approved all animal procedures for experiments and the University of Animal Care Committee approved handling techniques.

Conflict of interest

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